

**CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
FACULTY OF ECONOMICS AND MANAGEMENT**



**Provozně ekonomická
fakulta**

AGRARIAN PERSPECTIVES XXXII.

HUMAN CAPITAL AND EDUCATION IN AGRICULTURE

PROCEEDINGS

of the 32nd International Scientific Conference

September 6 – 7, 2023

Prague, Czech Republic

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Faculty of Economics and Management

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**PROCEEDINGS - of the 32nd International Scientific Conference Agrarian Perspectives XXXII.
Human Capital and Education in Agriculture**

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Publisher

Czech University of Life Sciences Prague
Kamýcká 129, Prague 6, Czech Republic

Papers in individual sections are sorted by authors' names in alphabetical order.

Publication is not a subject of language check.

All papers passed a double-blind review process.

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ISBN 978-80-213-3309-3; ISSN 2464-4781 (Online); ISSN 1213-7960 (Print); ISSN 1213-7979 (CD-ROM)

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FOREWORD

Agriculture has always been the backbone of human civilization, providing sustenance, livelihood, and the basis for economic growth. In today's rapidly evolving world, where technology, climate change and changing demographics have a significant impact on agricultural practices, the need for a skilled, informed, and adaptable human capital has never been more urgent. Human capital is, therefore, crucial for finding ways to deal with all the challenges effectively and fulfil the mission of agriculture, both in terms of production and non-production functions.

It is already a tradition that the conference Agrarian Perspectives, reflecting topical issues and trends, takes place every year in September at the Czech University of Life Sciences in Prague. This year's 32nd "Agrarian Perspectives" conference, held on the 6th and 7th of September 2023, is focused on the topic of Human Capital and Education in Agriculture. It aims to point out the importance of human capital for the further sustainable development of agriculture and emphasize the role of education in this process.

The conference intends to contribute to the discussion of what is essential for forming agricultural experts and how scientific disciplines from the fields of economics, management, social and natural sciences can contribute to a better understanding and solving problems that face current agriculture. This traditional event serves as a forum for researchers, educators, practitioners, and policy makers to come together and discuss from different perspectives the significant and sometimes somewhat omitted relationship between human capital and agriculture.

We strongly believe that the conference will create an inspiring environment for all participants and will contribute not only to the scientific knowledge in this area, but also to the deepening of personal contacts and cooperation.



doc. Ing. Karel Tomšík, Ph.D.

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SELECTED ASPECTS OF SUSTAINABLE AGRITOURISM OFFER IN THE CZECH REPUBLIC AND SLOVAKIA – PILOT RESEARCH

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Annotation: Agritourism as part of agriculture is also affected by the economic crisis, environmental problems, and social tensions. The development of agritourism positively impacts both the productive and non-productive functions of agriculture. Sustainability is the driving force behind contemporary agriculture and, by extension, agritourism. Rural tourism, and hence agritourism, is close to the sharing economy. Therefore, this area should also be managed by erudite professionals who know the behavioral patterns of agritourism users. This pilot study seeks to evaluate the current agritourism offered in the Czech Republic and Slovakia and identify key success attributes of farms that communicate sustainability through a booking platform. The choice of the platform for analysis and the essential identification of the requirement of potential agritourism users is based on a primary questionnaire survey. For the actual analysis of sustainability and success factors, text mining analysis was used in the paper. The most preferred booking platform in the Czech Republic is currently Booking.com. The most significant interest is short-term stays, especially from families and couples. The main success factors of the selected sustainable farms, based on the ratings of the users of the booking platform, include authenticity, tasting of drinks and local products, entertainment for children, and the possibility of relaxation. Authenticity and locality of production are among the most important sustainability factors perceived by agritourism users in the Czech Republic and Slovakia. Without catering, a shared kitchen is vital for agritourism users. Agritourism is an educational tool with great potential that needs to be sufficiently exploited. The results of this pilot study represent a springboard for further research in the sharing economy of agro and gastronomy tourism. The results also present the need for more training for agritourism managers, emphasizing communicating the offer and the use of booking platforms.

Key words: Agritourism, Education, Reviews, Sustainability, Tourism, Trend

JEL classification: Q01, Q13, Z32

1. Introduction

For most economies, tourism and agriculture are significant contributors to nations' employment and economic development (Zacal et al., 2019). The immediate impact is on regional development, employment, business, and services such as trade, transport, and culture; infrastructure, the environment and education are also affected. In the Czech Republic, rural destinations occupy a special place where key factors for visitors can be found (Šíp et al., 2020). Tourism is a potential remedy for a declining rural economy and an essential factor for regional rural development (Cawley and Gilmor, 2008; Kajan and Saarinen, 2013; Saeporsdottir and Hall, 2020).

Tourism is a global trend. At the same time, global trends require a shift towards sustainability (Olsson et al., 2014; Kontogianni and Alepis, 2020). Therefore, sustainability and education have been a priority in the last decades (Gullino et al., 2018). UNWTO has long been trying to promote sustainable tourism, and its initiative also recognizes rural areas

for their commitment to sustainability in all aspects with the Sustainable Development Goals (Spencer and Nsiah, 2013; Ólafsdóttir, 2021; UNWTO, 2022). Agritourism can be an excellent example of how to perceive sustainable tourism in practice. Blangy and Wood (1993, p. 32) defined agrotourism as "responsible travel to natural areas that conserves the environment and sustains the well-being of local people". Farmers often present an accommodation offer that represents an additional opportunity for their income (Salim et al., 2022). They can then present this accommodation through, for example, online accommodation booking agents.

Visitor satisfaction is a critical factor in the sustainability and competitiveness of a destination in the long term (Mazanec et al., 2007; Iniesta-Bonillo et al., 2016). For tourism destinations, competitiveness is essential. Every company or destination should find a better approach to competing with others by offering product improvements to gain a competitive advantage (Go and Govers, 2000). However, customer satisfaction itself can vary. Research by Stumpf and others (2022) confirmed the hypothesis that overall visitor satisfaction varies by region. Research has suggested that destinations compare themselves to competitors and manage the quality of visitor satisfaction. The research assertion is in line with Kozak (2022), who confirms that comparing a destination with other similar destinations allows comparison of their performance with competitors. Therefore, destinations should improve their products to a level that will give them a competitive advantage (Go and Govers, 2000). Buhalis (2003) defines five characteristics that relate to a destination: destination potential (attractiveness), accessibility and complementary services, amenities, available packages, and on-site activities. Middleton and Clarke (2001) add images and perceptions of the destination and price.

A study by Baipai et al. (2021) revealed that most research focuses on the characteristics of farmers, farms, and their surroundings in identifying success factors of sustainable agritourism. Research focuses on the characteristics of tourists in terms of demographic profile, motivation, and preferences. The study recommended further research in this regard.

Information about customer satisfaction can be found through user reviews. However, in recent years, customer behaviour has been changing based on reviews and opinions of other consumers. These reviews are mediated online through digital platforms such as Booking.com, TripAdvisor, etc. Digital technologies have been recognized as significant drivers of the ongoing digital revolution (Rüßmann et al., 2015), and digital platforms have been identified to create new business models (UNCTAD, 2019). These tools create value in the platform economy. In this case, consumers are motivated to help others formulate their opinions and evaluations of products and services (Hennig-Thurau et al., 2004; Mariani and Borghi, 2018). Conversely, consumers gather information to align their preferences with existing economic offers (Dellarocas, 2003; Oliveira et al., 2019) and minimize the risk associated with the purchase process (Cheung and Lee, 2012). In tourism, farm managers must satisfy customers while remaining competitive (Kandampully et al., 2018).

The paper's main objective is to evaluate the current offer and identify key sustainability attributes within Czech and Slovak sustainable agritourism. The following sub-objectives will form the result of the work:

- identification of the most preferred booking platform in the Czech Republic,

- identification of the most preferred length of stay in the Czech Republic,
- identification of sustainable accommodation capacities in the Czech Republic and Slovakia through the most preferred online booking platform,
- selection of accommodation facilities (farms) providing agritourism services in terms of sustainability,
- find success factors of selected sustainable farms and identify user ratings through data mining.

2. Materials and Methods

To assess the current offer and identify key sustainability attributes within agri-tourism, it was first necessary to determine which booking platform is most preferred and then what is the most preferred length of stay for potential domestic users of agri-tourism services. A questionnaire survey was used for these findings. The questionnaire survey was carried out between May and September 2022. Four hundred eighty-nine respondents participated in the questionnaire survey, who were selected based on a quota selection by gender and age within the capital city. Prague was selected for data collection as the place with the highest purchasing power and a high expectation of interest in agritourism. In the case of urban residents, there are instances where they opt for short-term (weekend) trips and Mikrut (2017) points out that residents of large cities prefer short trips to nearby destinations. The surveys were conducted electronically, in person, and through online calls.

After the questionnaire survey results showed that Booking.com was the most preferred booking platform for the selected sample of respondents, further analysis was carried out on this platform. This analysis relates to the sub-objective, i.e., the identification of sustainable accommodation capacities in the field of agritourism in the Czech Republic and Slovakia. A supply was generated according to the preferred length of stay, which was the result of the questionnaire survey. This served as a data input for the text analysis method. This systematic and objective method involves analyzing and interpreting text (in this case, the offer and guest reviews) to extract relevant information (Lacy et al., 2015; Graneheim et al., 2017; Vaismoradi, 2013). Identification of key elements of the offer included: length of stay, accommodation facilities, dining options or shared kitchen options, local ingredients on offer, beverage, and food tasting options, accommodation facilities, relaxation options, farm-to-nature connections, and opportunities for authentic farming experiences. Identification of key elements of demand expressed in the form of reviews for each accommodation included:

- sentiment,
- satisfaction with the offer,
- focus on the reserves or absence of certain elements, and
- the importance of each key element of the offer.

Identifying key elements was followed by analyzing and categorizing this data by reviewing the offers according to themes and logical structure. The authors sought to create an overview of the key elements that could represent success factors for these sustainable farms on Booking.com. Based on the analysis and categorization of the text, the information

obtained was interpreted, and an attempt was made to draw relevant conclusions. These results were then discussed using other sources and approaches based on them; recommendations for agri-tourism managers about their training were drawn.

3. Results and Discussion

The identification of the most preferred booking platform and preferred length of stay was supported by our research. The question was part of a more extensive survey on accommodation services in the spa industry, so respondents were also selected based on their place of residence – Prague. The capital of the Czech Republic still has the most considerable purchasing power and can thus compete with clientele from abroad, which the researchers compared and the fact that tourists from big cities prefer short trips to the countryside (Mikrut, 2016). Four hundred eighty-nine respondents took part in the survey. The research sample includes 50.28% women and 49.72% men. Most respondents were 35-44 years old, precisely 25.57% of the respondents. In terms of economic activity, most of the respondents were employees (61.93%). This was followed by people from the ranks of entrepreneurs and self-employed, where this number of respondents was 13.07% of the respondents. Students accounted for 10.51%. This was followed by others (6.82%), unemployed (3.98%), and on maternity leave (3.69%).

The chart focusing on the use of Internet portals shows that most respondents prefer the services of Booking.com. This portal is preferred by 84.4 % of respondents. Following Booking.com is Trivago.com, which is preferred by 60.6 % of respondents, and the third most used booking portal is Agoda.com, which is preferred by 40.6 % of respondents.

Preference for length of stay shows that the greatest interest, 74.15 % is for short stays. In contrast, long-term stays represent only 20.17 %. Twenty respondents (5.68 %) have a neutral towards the length of stay. Some research studies confirm the trend of short stays (Gričar and Bojnec, 2019).

The most preferred online booking portal is Booking.com. Booking.com provides online booking services and acts as an intermediary, or "agency model", between guests who want accommodation and the accommodation provider. The platform incorporates its own research and sustainability aspects and its own user rating parameters. According to research done directly by Booking.com (2021), up to 61% of people want to travel sustainably after the global pandemic Covid-19. Travelers acknowledge that the Covid-19 pandemic has changed their attitude toward life, which should lead to positive effects on the environment. 73% of respondents would likely choose the accommodation that had sustainability practices in place, and 37% of respondents would like online travel booking sites to offer a sustainable travel filter. Almost 50% of respondents think that travel agents should provide the ability to filter sustainable offers. In Europe, France, Italy, Spain, Denmark, and Germany are most interested in sustainable accommodation. Booking.com, therefore, introduces the option of a "sustainable accommodation" filter, and the next part of the thesis will focus on this selection.

Based on this platform, the accommodation capacities that this company has in the Czech Republic and Slovakia are presented. The capacities are presented in terms of sustainable accommodation types. Specific sustainable capacities are presented in Table 1.

Table 1. Sustainable accommodation capacities in the Czech Republic and Slovakia (in pieces)

Destinations	Czech Republic	Slovakia
Type of accommodation:		
Apartments	1815	827
Guesthouse	941	233
Hotels	701	203
Vacation Homes	365	162
Homestays	97	40
Chalets	86	70
Villas	68	27
Lodges	40	28
Country Houses	37	13
Hostels	27	16
Campgrounds	25	5
Bed and Breakfast	16	12
Luxury tents	13	1
Holiday parks	10	5
Farm Stays	8	1
Resorts	7	7
Boats	5	0
Motels	4	2
Capsule Hotels	1	0
Total	4266	1652

Source: Booking.com, own processing, 2023

Of the total accommodation capacity of the Czech Republic, which is 15 784, 27.03 % is sustainable. In Slovakia, out of the total accommodation capacity of 6 996, 23.61 % is sustainable. Of all the accommodation capacities, the Czech Republic has some representation in each type of sustainable accommodation. Slovakia has no representation, in terms of sustainability, of boats and capsule hotels. Again, the status of sustainable farms on the Booking.com platform could be stronger. This platform offers only eight sustainable farms in the Czech Republic, which amounts to 0.19 % of the total sustainable capacities and 0.05 % of the total capacities, and in Slovakia, it offers only one sustainable farm, which amounts to 0.06 % of the total sustainable capacities and 0.01 % of the total capacities.

As mentioned, 39 farms and 8 (20.51 %) sustainable farms are available from Booking.com in the Czech Republic. Slovakia offers only three farms, of which 1 (33.33 %) is sustainable.

Based on the above tables, the thesis has data on the capacity of the Booking.com platform in terms of sustainable farms. Out of the total number of farms in the Czech Republic and Slovakia (47), only nine farms are registered as sustainable on Booking.com. There may be many more farms on offer on this platform, but these farms may need to be more classified, meaning that, for example, a farm is in the category of apartments.

In Table 2, all nine farms are categorized according to the added value they offer to their customers to stay in the form of experiences. The Table also includes customer reviews. The average customer rating is calculated directly by Booking.com. The average rating

is calculated based on the average of all reviews left by customers for a particular property. The individual ratings reflect the guest experience at the accommodation and form part of the average rating (Booking.com). The overall score is also included in Table (2).

Table 2. Sustainable farms and their evaluation

Name of the Sustainable Farm	Extra Fun and Relaxation	Guest ratings
Statek Keblice (CZ)	Yes (horse riding, bicycling, wellness)	9.4
Hotel Horse Riding – Jezdecký areál Tršice (CZ)	YES (horse riding, bicycling, wellness)	8.6
Penzion Pišlikdum (CZ)	Yes (horse riding, bicycling)	9.6
Buchtův statek (CZ)	Yes (horse riding, bicycling)	9.1
Farma Slunečný dvůr (CZ)	YES (horse riding)	9.3
Kozí Farma U Nýdrlů (CZ)	Yes (bicycling)	9.2
Farma Zelená Ruža (SK)	Yes (wellness)	9.1
Statek Krkavčí hora (CZ)	YES (horse riding)	9
Statek Křinice (CZ)	Yes (bicycling)	8.7

Source: Booking.com, own processing, 2023

The farms offered by Booking.com are highly rated, with an average score of 9.11 %, so the best farms were also selected based on the added value they offer to their customers. In terms of added value, Keblice Farmhouse and Horse Riding – Tršice offer the richest program. A more modest program is offered to guests by Křinice Farmhouse or Krkavčí hora Farmhouse.

The highest-rated farm and guesthouse were Pišlikdum, rated 9.6 points by Booking.com's rating algorithm. It is followed by Keblice Farmhouse, which was rated 9.4 points. In Third place is the Slunečný dvůr Farmhouse, which was given 9.3 points by the algorithm. The lowest-rated farms with an algorithm score below 9 were Horse Riding and Křinice Farmhouse. Raven Mountain has an algorithm rating of 9.

This sub-objective specifically focuses on a complex set of evaluative. There are a total of 1040 evaluators in the farm completions. A specific overview of the groups of evaluators is provided in Table (3).

Table 3. Overview of evaluators

Evaluators	Křinice	Krkavčí hora	Zelná Ruža	Kozí farma U Nýdrlů	Slunečný dvůr	Pišlikdum	Tršice	Keblice
Family	6	222	51	0	76	20	26	6
Couple	34	198	55	5	25	5	51	9
Group of friends	7	17	10	1	6	4	5	5
Individual	11	42	7	2	2	2	35	6
Business trip	9	26	7	2	5	0	32	8
Total	67	505	130	10	114	31	149	34

Source: Booking.com, own processing, 2023

It is clear from the Table that farms are most interested in families and couples. An interesting part of the Table is the business trips, where people on a business trip choose a farm for their stay.

For interest, this work also examined the average number of days spent on the farm for each farm and the category of the group staying. These values (number of nights) can be seen in Table (4).

Table 4. Average number of days spent on the farm by guest category

Farms									
Type of guests	Křinice	Krk. Hora	Zelená Ruža	U Nýdrlů	Slun. Dvůr	Pišlikdum	Tršice	Keblice	Average
Family	3.5	2.7	3.8	0	4.3	3.5	2,7	3	2.94
Couple	1.4	2.6	3.2	3.8	2.9	2,6	2,5	3	2.94
Group of friends	2.4	3.2	2.5	2	1.5	3	1	1	2.94
Individual	2.5	2.6	1.6	4	2	4	3.4	2.3	2.8
Business trip	1.6	1.8	2.5	1	2.5	0	3	2.5	2.9

Source: Booking.com, own processing, 2023

Based on this Table, the author's research confirms that current guest preferences include more short stays. On average, guests spend three nights on the farm.

Based on the evaluators, mainly those who offered a written review, a Table (5) is compiled. The first part of the Table (5) identifies the most important factors that the evaluators write about. The second part of the Table (5), in turn, focuses on specific farms and positive and negative reviews in terms of their number, and in the third part of the Table (5), it is already possible to see, on a scale from most to least frequent, the individual factories that are important to the evaluators.

Table 5. Resulting identification of success factors for evaluators

Type of review	
Positive reviews	Negative reviews
1. Authenticity	14. Weak Wi-Fi signal
2. Wine and beer tap	15. Bathroom outside the room
3. Entertainment for children	16. Absence of refreshments on the farm
4. Wellness facilities	17. Absence of in-room amenities (TV, coffee maker, double bed)
5. Possibility of shared kitchen	18. Communication with the accommodation
6. Refreshments and restaurant	19. Absence of restaurant
7. Local products	20. Limited contact with animals
8. Cleanliness	21. Unsecured parking
9. Coffee machine in room	22. Absence of a shared kitchen
10. Breakfast available	23. No breakfast option
11. Availability of animals	24. No card payment possible
12. Friendly staff	
13. Local experiences (horseback riding, walking, etc.)	

Specificity of the evaluation	
Farm	Case number
Křínice	Positive: 1, 11, 12 Negative: 16, 15, 22, 23
Krkavčí hora	Positive: 1, 5, 8, 11, 12 Negative: 17
Zelená Ruža	Positive: 1, 3, 4, 5, 6, 8, 9, 10, 11 Negative: 17
Kozí farma u Nýdrů	Positive: 1, 7, 10, 11, 12, 13 Negative: 22
Slunečný dvůr	Positive: 1, 2, 3, 6, 7, 11, 12, 13 Negative: 14, 16, 17, 22, 24
Pišlikdum	Positive: 1, 2, 3, 8, 7, 10, 11, 13 Negative: 22
Tršice	Positive: 1, 4, 7, 8, 10, 11, 13 Negative: 14, 16, 17, 18, 19, 20, 22
Keblice	Positive: 1, 3, 4, 5, 3, 9, 10, 11 Negative: 21
Frequency of reviews (1 - frequent frequency)	
Positive reviews	Negative reviews
1. Authenticity	1. Absence of a shared kitchen
2. Availability of animals	2. Absence of in-room amenities (TV, coffee maker, double bed)
3. Breakfast available	3. Absence of refreshments on the farm
4. Entertainment for children	4. Weak Wi-Fi signal
5. Local products	5. Bathroom outside the room
6. Cleanliness	6. Communication with the accommodation
7. Friendly staff	7. Absence of restaurant
8. Local experiences (horseback riding, walking, etc.)	8. Limited contact with animals
9. Wellness facilities	9. Unsecured parking
10. Possibility of shared kitchen	10. No breakfast option
11. Refreshments and restaurant	11. No card payment possible
12. Wine and beer tap	
13. Coffee machine in room	

Source: Booking.com, own processing, 2023

From the user review texts examined, it became apparent that within the positive responses, the greatest concern was that the stay be authentic for visitors. This is a long-standing phenomenon, as authors such as Judd and Fainstein (1997) and MacCannell (1999) see the essence of travel as finding authenticity, and Novy (2011) confirms this. Przywara (2013) adds in terms of economics and business opportunities that the desire for authentic experiences leads to creating new products, and the concept of "like a locale" is experienced in travel. Food and refreshments are another important part of the reviews. The reviews show that people appreciate the originality and local products within the farm's snack menu, but at the same time, in the absence of snacks, they are disappointed. In today's form of tourism, people often travel for food as well, as confirmed for example by (Long, 2004), and food often directly completes one of the main experiences of tourists (Kivela and Crofts, 2006). Food can also become a main motivator of a tourist's trip (Halls and Mitchell, 2005). And it turns out that this phenomenon is also long-term, as confirmed by Seaman (2022). Local products appear to be one of the highlighted landmarks within the refreshment sector. Some research also confirms that this phenomenon, in the form of the popularity of the localness of ingredients, is typical in different parts of the world (Lozanski, 2020 and Seaman et al., 2023). Common cuisines also seem to be an interesting component of the reviews. In the case of shared kitchens in the accommodation, guests appreciate it,

but in the absence of shared kitchens, they are dissatisfied. There is logic to this as well, as there may be an absence of any form of refreshment in the accommodation, and then guests may find a kitchen to prepare their own meals useful. Furthermore, some guests were not satisfied with the communication offered by the accommodation. Communication with clients is one of the most important parts of the tourism industry (Melovic, 2023), where social networking can work great in communication (Wen-Kuo, 2023). Some guests were not satisfied with the way of payment options in the accommodation facility, where some facilities did not allow card payments. Yet, it is the convenience of the payment system that is increasingly seen as an advantage for tourist destinations (Ramos, 2022).

According to Vaishar and Št'astná (2020), the COVID-19 pandemic has created an opportunity for the development of rural tourism aimed primarily at domestic tourists with the possibility of expansion to foreign clientele. In addition to greater safety, rural areas can offer greater added value to their visitors in terms of culture, history, nature, or gastronomy. According to the authors, cooperation between stakeholders in this area is important. For example, agritourism is attractive because it offers experiences in the field of agriculture and tourism, where agricultural products can be enjoyed together with the services provided. In this case, agricultural (agro) holdings are synonymous with attraction. In the case of agritourism, it is very important to preserve local and soil resources and take care of the environment (Evgrafova et al., 2020). The issue of tourism, sustainability, educational safety, and environmental attractiveness seems to be linked by the concept of multifunctionality. Multifunctionality links sustainable agriculture, food security and territorial balance (Hollander, 2004). Multifunctional agriculture improves ecological stability and biodiversity (Félix et al., 2018), benefits a wide range of human populations (Bernués, 2019) and transcends natural hazards. Some farms can also produce renewable energy (Agus et al., 2020). Thus, multifunctional farms can offer different products and services, such as festivals, tastings, and farmers' markets, depending on customer demand and other agritourism activities (Niedbała et al., 2020; Fagioli et al., 2015). However, with so many activities, it is necessary to think about the sufficient space that the farm can offer and about the availability of personnel. Farms can also offer special educational activities that include courses or workshops, topics related to agriculture, but also dealing with rural crafts, cooking or excursions to the countryside (Chou et al., 2017). Educational activities can also be related to specific activities such as butter making or beekeeping. According to the author's research (2022), linking destination offers with travel agency services appears appropriate. Some people prefer to have a tailor-made trip, and it is travel agencies that can facilitate access to the destination's offer for some customers.

4. Conclusion

Booking.com is the most popular and popular booking portal. However, especially in recent years, there has been interest in the so-called Airbnb booking portal, which falls under the principles of the sharing economy, and this thesis has yet to work with this topic. Nevertheless, it appears, also from user reviews, that people are interested in sharing services. In the reviews, this was reflected specifically in the shared kitchen. Thus, there is room for further research here, where the environmental aspects and sustainability of accommodation within the sharing economy can be investigated specifically. Also, based on Booking.com data, in the Czech Republic and Slovakia, the largest supply of accommodation is in Apartments and Guesthouses or Vacation Homes, which are close to the sharing economy.

Another trend that has been confirmed in the work is the interest in short stays. Within this thesis, the average length of stay within farms has been shown to be three days across all levels of guests. Within the guest levels, families with children or couples are most interested in staying on farms. Where shortcomings can be seen is in the actual offer of farm accommodation on Booking.com. Some farms do not meet the principles of sustainability, and others are not registered as farms or as sustainable farms on Booking.com for change. For example, there is only one sustainable farm in Slovakia, which seems odd. In the Czech Republic, eight sustainable farms are offered through Booking.com. Here the author finds opportunities to improve education for both farms and guests. The farms could educate themselves more in online offerings, where they could start to cooperate with Booking.com and thus secure potential new clients. At the same time, guests on individual farms will also be educated through traditional and modern methods of farming and working in both crop and livestock production.

The main guests on the farms are families with children. In the context of sustainability, farms can be used to educate about sustainability and the understanding of nature and the environment as a source of factors for us and future generations that need to be protected. Authenticity also plays a big role in farm travel, where guests can live like the locals for a while and have similar experiences and situations. There is potential for education here, too, especially for farm guests who are originally from cities. On the farm, there is the opportunity to see a different life from the urban one and the chance to learn new things and a new understanding of the nature of nature. Finally, the dining experience is a very important part of the guest experience, with people being interested mainly in locally sourced produce and thus supporting local producers.

The work has therefore opened possibilities for further research and areas such as the sharing economy, agritourism and food tourism. Authenticity in tourism or destination security management is also an interesting topic. This survey was a pilot study within one booking portal, and other farms that do not use booking.com will be surveyed in the future. A similar survey is planned, which will be expanded to include other review sources and states, increasing the volume of respondents many times over. Future research is also planned to use selected software.

References

- Agus, C., Cahyanti, P. A. B., Suhartanto, B. and Noviyani, P. (2020). "Organic Waste Management and Integrated Bio-Cycle Farming System for Sustainable Development in Tropical Ecosystem", *Applied Mechanics and Materials*, vol. 898, pp. 45–50, DOI 10.4028/www.scientific.net/AMM.898.45
- Alloh, K. (2022). „Dopady pandemie Covid-19 na vybraný hotelový subjekt“, Faculty of Management, Czech University of Life Sciences Prague. (In Czech)
- Bernués, A., Alfnes, F., Clemetsen, M., Eik, L. O., Faccioni, G., Ramanzin, M., Ripoll-Bosch, R., Rodríguez-Ortega, T. and Sturaro, E. (2019). "Exploring social preferences for ecosystem services of multifunctional agriculture across policy scenarios", *Ecosystem Services*, vol. 39, 101002, DOI 10.1016/j.ecoser.2019.101002
- Bessièrre, J. (1998). „Local development and heritage: traditional food and cuisine as tourist attractions in rural areas“, *Sociologia Ruralis*, vol. 38(1), pp. 21-34, DOI 10.1111/1467-9523.00061

- Blangy, S. and Wood, M. E. (1993). “*Developing and implementing ecotourism guidelines for wildlands and neighboring communities*”, Ecotour-ism Society, ISBN 0963633104
- Booking, Booking.com’s 2021 Sustainable Travel Report Affirms Potential Watershed Moment, Amsterdam, 2023. [Online] Available: https://5bf1d946-e0b5-464d-82d0-45068b566389.usrfiles.com/ugd/5bf1d9_e7b24b53f6df44a2b8532854af292c18.pdf
- Booking, everything you need to know about guest reviews, Amsterdam, 2023, [Online], Available: <https://partner.booking.com/cs/pomoc/hodnocen%C3%AD-od-host%C5%AF/obecne/v%C5%A1e-co-pot%C5%99ebujete-v%C4%9Bd%C4%9Bt-o%C2%A0hodnocen%C3%AD-od-host%C5%AF>
- Buhalis, D. (2003). „*eTourism: information technology for strategic tourism management*, Pearson“, Financial Times/Prentice Hall, ISBN 0582357403, DOI 10.13140/2.1.2274.0804
- Cawley, M. and Gilmor, D. A. (2008). “Integrated rural tourism: Concepts and Practice”, *Annals of Tourism Research*, vol. 35(2), pp. 316–337, DOI: 10.1016/j.annals.2007.07.011
- Cheung, C. and Lee, M. (2012). “What drives consumers to spread electronic word of mouth in online consumer-opinion platforms?”, *Decision Support Systems*, vol. 53, pp. 218–225, DOI 10.1016/j.dss.2012.01.015
- Chou, R.-J., Wu, C.-T. and Huang, F.-T. (2017). “Fostering Multi-Functional Urban Agriculture: Experiences from the Champions in a Revitalized Farm Pond Community in Taoyuan, Taiwan”, *Sustainability*, vol. 9, pp. 2097, DOI 10.3390/su9112097
- Dellarocas, C. (2003). “The digitization of word-of-mouth: promise and challenges of online feedback”, *Management Science*, vol. 49 (10), pp. 1407–1424, DOI 10.1287/mnsc.49.10.1407.17308
- Eckhardt, M. and Bardhi, F. (2018). “The Sharing Economy Isn’t About Sharing at All“, *Harvard Business Review*. [online]. Available: <https://hbr.org/2015/01/the-sharing-economy-isnt-about-sharing-at-all>
- Evgrafova, L. V., Ismailova, A. Z., and Kalinichev, V. L. (2020). “Agrotourism as a factor of sustainable rural development IOP conference series: Earth and environmental science” *IOP Conference Series: Earth and Environmental Science*, vol. 421 (2), 022058, DOI 10.1088/1755-1315/421/2/022058
- Félix, G. F., Diedhiou, I., Le Garff, M., Timmermann, C., Clermont-Dauphin, C., Cournac, L., Groot, J. C. J. and Tittonell, P. (2018). “Use and management of biodiversity by smallholder farmers in semi-arid West Africa”, *Global Food Security*, vol. 18, pp. 76–85, DOI 10.1016/j.gfs.2018.08.005
- Fiume Fagioli, F., Diotallevi, F. and Ciani, A. (2015). “Strengthening the sustainability of rural areas: The role of rural tourism and agritourism” *Italian Review of Agricultural Economics*, vol. 69, pp. 155–169, DOI 10.13128/REA-16920
- Go, F. M. and Govers, R. (2000), “Integrated quality management for tourist destinations: A European perspective on achieving competitiveness”, *Tourism Management*, vol. 21(1), pp. 79–88, DOI 10.1016/S0261-5177(99)00098-9

- Graneheim, H., Lingren B. M. and Lundman B. (2017). "Methodological challenges in qualitative content analysis: A discussion paper", *Nurse education today*, vol. 56, pp. 29-34, DOI 10.1016/j.nedt.2017.06.002
- Gričar, S. and Bojnec, Š. (2019). "Prices of short-stay accommodation: time series of a eurozone country", *International Journal of Contemporary Hospitality Management*, Vol. 31 No. 12, pp. 4500-4519, DOI 10.1108/IJCHM-01-2019-0091
- Gullino, P., Battisti, L. and Larcher, F. (2018). "Linking Multifunctionality and Sustainability for Valuing Peri-Urban Farming: A Case Study in the Turin Metropolitan Area (Italy)", *Sustainability*, vol. 10, pp. 1625, DOI 10.3390/su10051625
- Gurau, C. and Ranchhod, A. (2020). "The sharing economy as a complex dynamic system: Exploring coexisting constituencies, interests and practices", *Journal of Cleaner Production*, vol. 245, pp. 118799, DOI 10.1016/j.jclepro.2019.118799
- Hall, M. L. Sharples, R., Mitchell, N. and Macionis, B. C. (2003). "Food Tourism around the World", Oxford, UK: Butterworth-Heinemann, ISBN 9780080477862
- Hennig-Thurau, T., Gwinner, K. P., Walsh, G. and Gremler, D. D. (2004). "Electronic word-of-mouth via consumer-opinion platforms: what motivates consumers to articulate themselves on the internet?", *Journal of Interactive Marketing*, vol. 18 (1), pp. 38–52, DOI 10.1002/dir.10073
- Hollander, G. (2004). "Agricultural trade liberalization, multifunctionality and sugar in the south Florida landscape", *Geoforum*, vol. 35, pp. 299–312, DOI 10.1016/j.geoforum.2003.11.004
- Iniesta-Bonillo, M. A., Sánchez-Fernández, R. and Jiménez-Castillo, D. (2016). "Sustainability, value, and satisfaction: Model testing and cross-validation in tourist destinations", *Journal of Business Research*, vol. 69(11), pp. 5002–5007, DOI 10.1016/j.jbusres.2016.04.071
- Judd, D. and Fainstein, S. (1999). "The Tourist City" Yale University Press, ISBN 0300078463
- Kajan E. and Saarinen J. (2013), "Tourism, climate change and adaptation: a review", *Curr Issue Tour*, vol. 16(2), pp. 167–195, DOI 10.1080/13683500.2013.774323
- Kandampully J., Zhang TC. and Jaakkola E. (2018). "Customer experience management in hospitality: A literature synthesis, new understanding and research agenda" *International Journal of Contemporary Hospitality Management*, vol. 30(4) DOI 10.1108/IJCHM-10-2015-0549
- Kivela, J. and Crotts J. C. (2006). "Tourism and gastronomy: gastronomy's influence on how tourists experience a destination", *Journal of Hospitality & Tourism Research*, vol. 30(3), pp. 354–377, DOI 10.1177/109634800628679
- Kontogianni, A. and Alepis, E. (2020), "Smart tourism: State of the art and literature review for the last six years", *Array* 6, 100020, DOI 10.1016/j.array.2020.100020
- Kozak, M. (2002). "Destination benchmarking", *Annals of Tourism Research*, vol. 29(2), pp. 497–519, DOI 10.1016/S0160-7383(01)00072-X

- Lacy, S., Watson, R. B., Riffe, D. and Lovejoy, J. (2015). “*Communication Studies Faculty Publications and Presentations*“, *Journalism and Mass Communication Quarterly*, vol. 92, no. 4, pp. 1-21, DOI 10.1177/1077699015607338
- Long, L. M. (2004). “*Culinary tourism*“, Lexington, KY: The University Press of Kentucky, ISBN 0813122929
- Lozanski, K. and Baumgartner, K. (2020). “Local gastronomy, transnational labour: farm-to-table tourism and migrant agricultural workers in Niagara-on-the-Lake, Canada”, *Tourism Geographies*, vol. 24, pp. 1-23, DOI 10.1080/14616688.2020.1765014
- Mariani, M. M. and Borghi, M. (2018). “Effects of the Booking.com rating system: bringing hotel class into the picture“, *Tourism Management*, vol. 66, pp. 47–52, DOI 10.1016/j.tourman.2017.11.006
- Mazanec, J. A., Wober, K. and Zins, A. H. (2007). “Tourism Destination Competitiveness: From Definition to Explanation?” *Journal of Travel Research*, vol. 46(1), pp. 86–95, DOI 10.1177/0047287507302389
- Melović, M., Baynazoğlu, M. and Šerić, N. (2023). “Family businesses in tourism – the use of digital technologies in times of uncertainty and crisis“, *Journal of Family Business Management*, Vol. 13, no. 1, pp. 185-209(25), DOI 10.1108/JFBM-06-2022-0086
- Middleton, V. T. C. and Clarke, J. (2001). “*Marketing in travel and tourism. Butterworth-Heinemann*“, Taylor & Francis Group an informa business, ISBN 9780080511108
- Mikrut K., (2016). “*Metropolitan Commuter Belt Tourism*“, Routledge, ISBN 9781315607221
- Niedbała, G., Jęczyk, A., Steppa, R. and Uglis, J. (2020). “Linking of Traditional Food and Tourism. The Best Pork of Wielkopolska—Culinary Tourist Trail: A Case Study”, *Sustainability*, vol. 12, pp. 5344, DOI 10.3390/su12135344
- Novy, J. (2011). “*Kreuzberg's Multi – and Inter-cultural Realities*“ Selling Ethnic Neighborhoods, ISBN 9780203172865
- Ólafsdóttir, R. (2021). “The Role of Public Participation for Determining Sustainability Indicators for Arctic Tourism”, *Sustainability*, vol. 13, pp. 295, DOI 10.3390/su13010295
- Oliveira, C., Brochado, A., Moro, S. and Rita, P. (2019). “Consumer perception of tourist experience through online reviews: the islands of the senses of Cape Verde“, *Worldwide Hospitality and Tourism Themes*, vol. 11, pp. 6, DOI 10.1108/WHATT-09-2019-0052
- Olsson, P., V. Galaz, and W. J. Boonstra. (2014). “Sustainability transformations: a resilience perspective”, *Ecology and Society*, vol.19(4), DOI 10.5751/ES-06799-190401
- Przywara., D. (2012). “Alternativní informační zdroje v cestovním ruchu mladých lidí“, Olomouc, 2012. diplomová práce (Mgr.). Palacký University Olomouc Faculty of Physical Culture, [online] Available: <https://theses.cz/id/thx9j8/> (In Czech)
- Ramos, L., M. and Sol M., F. (2022). "Tourism seasonality management strategies – what can we learn from payment data", *Journal of Hospitality and Tourism Insights*, vol.1, pp. 1-32, DOI 10.1108/JHTI-12-2021-0337
- Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P. and Harnisch, M. (2015). “Industry 4.0: the future of productivity and growth in manufacturing industries”,

Boston Consulting Group, [Online], Available: https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx. retrieved 14 October 2022, Accessed 14 October 2022.

Saeporsdottir, A. D. and Hall., C.M. (2020). “Visitor satisfaction in wilderness in times of overtourism: a longitudinal study“, *J Sustain Tour*, vol. 29(1), pp. 123–141, DOI 10.1080/09669582.2020.1817050

Salim, E., Mayer, M., Sacher, P. and Ravanel, L. (2022). “Visitors’ motivations to engage in glacier tourism in the European alps: Comparison of six sites in France, Switzerland, and Austria”, *Journal of Sustainable Tourism*, vol. 30, pp. 1–21, DOI 10.1080/09669582.2022.2044833

Seaman, A. N. and Schroeder, L. H. (2020), "Exploring the relationship between travel and online food souvenirs", *An International Journal of Tourism and Hospitality Research*, vol. 33, pp. 210-221, DOI 10.1080/13032917.2022.2040913

Šíp, J. a kolektiv. (2020). “*Venkovský cestovní ruch*“, Society of Scientific Tourism Experts, ISBN 978-80-210-9593-9. (In Czech)

Spencer, D. M. and Nsiah, C. (2013). “The economic consequences of community support for tourism: A case study of a heritage fish hatchery“, *Tourism Management*, vol. 34, pp. 221-230, DOI 10.1016/j.tourman.2012.04.003

Štumpf, P., Janeček, P. and Vojtko, V. (2022). “Is Visitor Satisfaction High Enough? A Case of Rural Tourism Destination, South Bohemia”, *European Countryside*, vol.14, no.2, pp.346-362, DOI 10.2478/euco-2022-0017

UNCTAD, Digital Economy Report, value creation and capture: implications for developing countries, 2019, [Online], Available: <https://unctad.org/publication/digital-economy-report-2019>

UNWTO, Best Tourism Villages of 2022 Named by UNWTO, 2022, [Online], Available: <https://www.unwto.org/news/best-tourism-villages-of-2022-named-by-unwto>

Vaishar, A. and Šťastná, M. (2020). “Impact of the COVID-19 pandemic on rural tourism in Czechia Preliminary considerations”, *Current Issues in Tourism*, vol. 25(1), pp. 1-5, DOI 10.1080/13683500.2020.1839027

Vaismoradi, M., Bondas. T. and Turunen, H. (2013). “Content Analysis and Thematic Analysis: Implications for Conducting a Qualitative Descriptive Study“, *Journal of Nursing & Health Sciences*, vol. 15, pp. 398-405, DOI 10.1111/nhs.12048

Wen-Kuo, Ch., Pantas H. S., Widya E., H. and Andri D., K. S. (2023). “How Instagram Influencers Contribute to Consumer Travel Decision: Insights from SEM and fsQCA”, *Emerging Science Journal*, vol. 7, pp. 16-37, DOI 10.28991/ESJ-2023-07-01-02

Zacal, R. G., Virador, L. B. and Canedo, L. P. (2019). “State of selected agritourism ventures in Bohol, Philippines” *International Journal of Sustainability, Education, and Global Creative Economic*, vol. 2(1), pp.9–14, DOI 10.1234/ijsegce.v2i1.50

ENVIRONMENTAL CHALLENGES IN THE ECUADORIAN AMAZON

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Annotation: To remark lessons that indigenous communities can teach about agrobiodiversity, conservation and sensitivity in natural environments, which can be useful for teaching in public universities. **Data/Methods:** Qualitative methods that includes participant observations, semi-structured interviews and seminars held at Charapacocha's Achuar indigenous community and other Kichwa communities, aiming at promoting public discussions on critical knowledge that can serve to university and students' connection with their homeland, languages and spiritualities, and in appreciation of their traditions and community agencies. We also discussed the issues with non-academic persons, especially from the Confederation of Indigenous Nationalities of the Ecuadorian Amazon (CONFENIAE), which has its headquarters in Union Base, near Puyo, and that has a branch of activities on intercultural education. **Results/Conclusions:** agrobiodiversity richness and the situation, problems, needs and aspirations of the community are identified, and a zoning of the territory is outlined. In the areas of opportunity generation, environmental management, human, social and political-administrative development, the community considers the main strengths are the practice of poultry farming, agriculture adapted to the environment, fish farming, sustainable agroforestry resources, the maintenance of culture and the development of handicrafts. The most significant weaknesses are lack of public health, concern to increase agricultural production for the market, indiscriminate logging, plant diseases, lack of personal interest in resource management, difficulties in marketing and supply chains, and long distances to any market. The greatest threat is considered to be the extension of the oil frontier over the territory. It is concluded that the intersectionality that affects the indigenous people is more serious because they are located in a territory in demand for oil exploitation; however, the cultural tradition of managing agrobiodiversity and resources of the Amazon Forest should be encouraged, respected and known in university studies through experiential experiences.

Key words: Indigenous communities, agrobiodiversity, intercultural education, public health, oil exploitation, decoloniality, Ecuadorian university

JEL classification: Q57, Q19

1. Introduction

The Ecuadorian Amazon region is occupied by 11 Indigenous groups that know, use and transform the forest in unique ways according to their own worldviews. Their knowledge could be considered in universities curriculum, both, for research proposes and for help to communities to build better economies. In Pastaza province, seven Ecuadorian Amazonian Indigenous people (Shuar, Achuar, Shiwiar, Andwa, Kichwa, Sapara, Wao) are a part of those 4.5% indigenous people that have preserved 80% of biodiversity in the word, considering the knowledge, agricultural practices and local resources to satisfy every family's needs (Begossi and Días de Ávila, 2003; Iwamura, et al., 2014; Mistry and Berardi, 2016), because biodiversity is the result of knowledge, convivence and agricultural practices of the Indigenous people in the forest in all over the world (Escobar, 2011), and is particularly important in a country that constitutionally protects plurinationality and officially seeks to promote a change in the productive matrix, from one that depends on polluting extractive activities to one that uses bio-knowledge and the wealth of native renewable resources.

In Indigenous communities, subsistence activities are agriculture, gathering, hunting, and fishing; the economy of other groups has diversified with the commercialization of agricultural and forest products, as well as paid employment (Thiede and Clark, 2019). Also, the close health-nature relationship can be understood through agrobiodiversity practices, the exercise of traditional medicine in shamanic knowledge systems, which involves territorial sanitation and legalization, land management and resource use; when these aspects are agreed in a co-management of protected areas and Indigenous territories, the health-territory relationship is also evident (Berlowitz, et al., 2023).

The biodiversity of the earth encompasses all existing forms of life and varies according to the different regions of the planet, but it is much greater in tropical and subtropical areas than in temperate or cold (frost) climate zones. This biological biodiversity, which is not static but dynamic, is responsible for maintaining the balance of the ecosystems that allow the human species to survive, which paradoxically has become the main threat to its destruction through acts such as arson, indiscriminate logging, climate change, etc. (Latham et al., 2014).

Ecuadorian Amazonian Achuar and Kichwa communities, as reproductive agents of a discourse of domination that articulates the construction of subjectivities, are simultaneously active actors in a space of struggles and social tensions. Indigenous communities construct its historical narrative by appropriating and reproducing the savage/civilized binary logic to reclaim its sense of belonging and social cohesion (Burgaleta et al., 2018). Presence of this communities in the jungle, supporting over 4000 mm of pluviosity per year, show the deep experience in agricultural systems into tropical rain forest.

We used a qualitative analysis of the reality in process, seminars held at Charapacocha's Achuar indigenous community and other Kichwa communities, recovery of oral history, participant observation, and semi-structured interviews applied to heads of families and community leaders. As results, we identified agrobiodiversity richness, struggles and aspirations of the communities who propose outlines of zones in the territory. The results allow us to affirm that the communities maintain their identity and their systems of knowledge of the Amazonian environment, on whose conservation they depend, factors that must be studied in universities in the Amazonian area that allow mitigating the effects of extractive and polluting activities that threaten the environment and culture in the region.

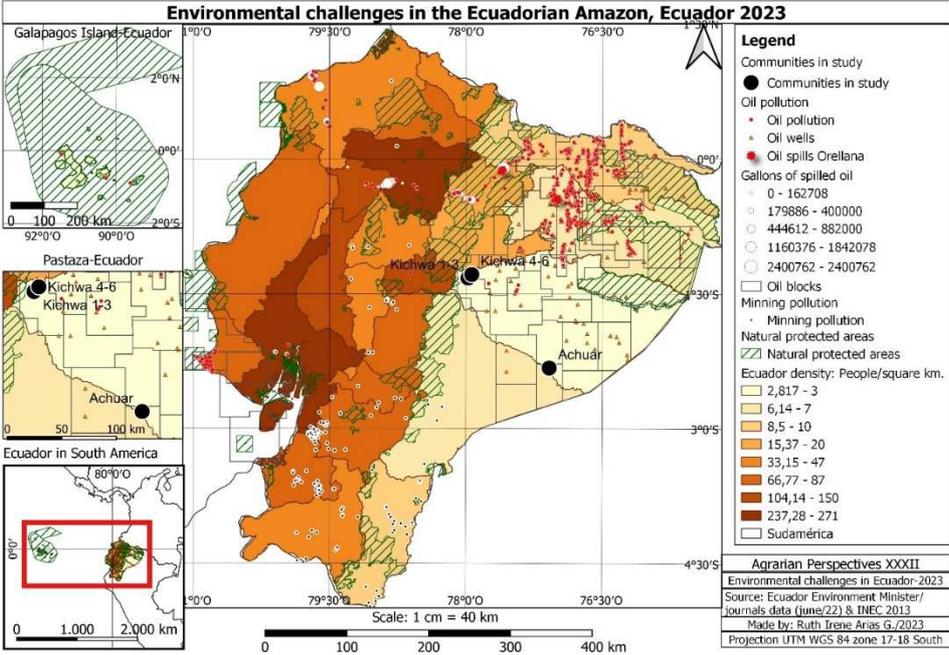
The aim of this research is to observe the lessons that Indigenous communities can teach about agrobiodiversity, conservation and sensitivity in natural environments, which can be useful for teaching in public education.

2. Materials and Methods

The study communities are located in Pastaza province; Charapacocha, the Achuar one, is near Pastaza River; the other kichwa communities studied are located in the southwestern portion of the "northern Amazonian corridor Lago Agrio-Tena-Puyo", in the Anzu River valley, a territory of ancient kichwa origin, a colonized area. The Anzu valley extends over two provinces, Pastaza and Napo. Each province has a capital city, which is an urban parish and cantonal capital; the main health services, education, banks, markets, as well as the public universities located in Puyo (Universidad Estatal Amazónica, founded in 2002) and Tena (Ikiam, founded in 2013) are located there. Major road networks and public transportation

link the provincial capital cities. The Amazonian region is occupied by oil camps, mining areas, contamination sites and natural protected areas, over indigenous communities (Figure 1).

Figure 1. Communities in study



Source: Made by author from data field

Among Amazonian cities, originally indigenous territories that were colonized, there are still communities in the rural sector. Six communities located in the ancestral territory of the native Ecuadorian Amazonian Kichwa nation are studied, from Tzawata, in the northeast, to Veinticuatro de Mayo in the southwest, located in the lower, middle and upper levels of the Anzu River valley; the communities have been settled since the end of the 19th century and come from the Napo province. The only exception is Unión de Llandia, which has a larger population of migrant farmers from the Inter-Andean region or Sierra, as a result of the colonization process of the 1960s. Achuar community has the origin in ancestral Jivaros families. They are rural communities, representative of indigenous people and express a vulnerability gap in relation to the development initiatives implemented by the governments and planning units.

Before the Covid-19 pandemic, the study included visits to the communities, seminars and workshops around styles of live and community planning, interviews with community authorities and semi-structured interviews with heads of household, with 62 quantitative and qualitative variables related to aspects of agriculture, social, economic, cultural and organizational dimensions. From the joint analysis of the data collected, the results of the strategic diagnoses of the social, organizational and integrated system are presented, with the structural and conjunctural keys.

Charapacocha, the Achuar community, is just accessible by river or air, so is not crossed by roads. The six Kichwa communities investigated are not accessible by roads neither: Tzawata has similar characteristics to the Chukapi community in the lower part of the valley. Wayuri,

Flor de Bosque and Boayaku have similar characteristics to the communities of San Rafael (Kushillu Urku), San Juan de Piatúa (Yayayaku) and Sacha Warmi (Shamato) in the middle portion. Veinticuatro de Mayo is located in the upper part of the valley. The remaining 12 villages in the Kichwa zone are not part of the study, eight of which are crossed by the road, including the two municipal capitals, with access to services, trade relations and land legality. The Llanganates National Park is located to the west, above the 1,400 m elevation.

3. Results and Discussion

Communities more near roads are specializing for markets with the agriculture production and fewer products, losing some ancestral varieties of *Manihot sculenta*, per example. While in remote communities there are 20 varieties, in the communities close to markets there are just four, demanded for markets. Communities however have around 50 alimentary species in cultivation. In all the communities in study, every family has alimentary sovereign based in associating cultivars called chacras. Usually there is only one chacra (60% of the cases), two chacras (30%) or up to 3 chacras (10% of the cases), with associated crops of yucca (*Manihot sculenta*), plantain (*Musa ssp.*), orito, papachina, sweet potato, potato (tuyu), pelma, cane, naranjilla, Chinese onion, white onion, chonta, orange, mandarin, avocado, zapote, cacao, pineapple, guaba, machetona, grapes, papaya, caimito, chilli, barbasco, medicinal plants, piripri, ginger, tomato and others. In Charapacocha, chacras were mentioned as being in use for up to 10 to 12 years, but they are usually left to rest after 5 or 6 years of production. In any case, they are used again up to two more times, once 3, 4, 5 or 6 years have elapsed, either as a subsistence farm or to establish peanut, corn, bean crops, with 2 annual harvests for corn and 3 for peanuts and beans, in proportions ranging from 20 pounds to 2 quintals of corn per harvest, 10 to 50 pounds of beans and the same amount for peanuts. In fact, they indicate peanuts, beans, maize, mandarins and oranges as the most important products for sale. No other technical assistance is reported.

The most prevalent farms or orchards, in terms of size, are about 60 m x 60 m, sizes can range from 20 x 20 to 80 x 80, without needing to be so regular. Once in production, the farm is harvested weekly for family consumption.

In general, there is little commercialization, so there is no agreement on the selling prices of the products, with the result that the selling prices in the community are more expensive than those offered in Puyo, an area with transport facilities. The price of the products and the difficulties and increase in the cost of air transport are affecting the possibilities of commercialization. The community thinks that access to tourism can facilitate local sales to tourists, in this case, production can increase at the level of the family plots and whether raw or prepared products can be offered.

The production of small animals is established especially with chickens, for consumption and for local marketing. During the workshop it was mentioned that there is a smaller production of cattle for marketing outside the community, but none of the respondents mentioned working with larger livestock. Another product that eventually tends to be sold outside the community is parrots, which are captured as chicks and then raised in the houses. Dogs are also bred for care and hunting.

In comparison, also in the province of Pastaza, the Kichwa community of Lorocachi, also in the lowlands of the Ecuadorian Amazon, reports 107 species cultivated in gardens,

of which 63 are food, 15 are medicinal, 6 are flavoring, 3 are cosmetic, 19 are ritual and one is toxic (Vacacela, 2013), evidence that in general the Amazonian indigenous nationalities have a broad domain over native plant species, and thus ensure the richness of biodiversity, as it encompasses culture and territory in local communities (Escobar, 2002; Álvarez and Shany, 2012; Martínez, 2012).

The Kichwa originally look with sadness on families that have fewer children because they have less possibility of sharing the joy of children, less wealth, prestige and possibilities of control over resources in the vast ancestral territory (Walrod et al., 2019). Compared to the 7% who self-identify themselves as indigenous at the national level (INEC, 2010), in the communities under study, according to the questionnaires applied, 31% self-identify themselves as mestizo population and 69% as kichwa, evidence of identity, of belonging to the original nation. The Achuar and the Kichwa culture are still alive in the communities, with their way of life, treatment of the environment, farms, cultural healing ceremonies and evidence of the ancestral territories in petroglyphs (Bautista-Valarezo et al., 2021). The settler farmers who live in the area have also contributed with their cultural traditions brought from diverse origins (Poirier and Neufeld, 2023).

The forest is an important source of food, handicrafts, construction and other resources. In the family territories, that is to say, in the family farms - which, although they are not under an individual legalized title, are accepted and respected by the other members and their possession and usufruct is guaranteed by the board of directors - there are resources for the collection of toquilla straw, turuji (ucsha), chapi (chincha), kundasc, Tuntuam, Awan, and animals such as paujil, toucan, sahino, night turkey, pahua, armadillo, guanta, danta, parrots, partridges, squirrels, turtledoves, monkeys.

There are medicinal plants such as cat's claw, sangre de drago, cedar itself, basil, avocado, lemon verbena, papaya, cinnamon, wild garlic, sour cane, ginger, guava.

All families collect mukindi (palm worms in achuar name or chontacuro in kichwa name) in any month of the year, with a frequency of one to two times per month up to 3 to 6 times per year, in quantities ranging from one to ten pounds; mushrooms and ungurahua in any month but especially in February and May respectively, are also collected by all families at least once a year; mushrooms will not reach one pound and in the case of ungurahua a basket or 30 to 40 pounds in weight is reported. The next most important mushrooms harvested are guaba de monte (September to January) and morete (any month, especially May) with 90% of occurrence, at least once a year. Chonta (January to March) and basket vines (any month) follow in order of importance with 80 % of collection in the families, once and 2-3 times a year respectively. Ranas (February), coco de monte (March) and uvillas (January) are collected in 70 % of households. Capulí (March) and coco de monte is collected in 50 % of the families. The least collected are bush peanuts, tagua leaves and turuji for construction, with 10 % each. At least one collection per year is always reported.

Of the products mentioned, only turuji, bush peanuts and frogs are not harvested from trees. Obviously the worms are collected from cut palm trunks, but in order to harvest many of the fruits, the trees are also cut down according to the surveys, so, with respect to the total number of families that harvest each fruit, Thus, with respect to the total number of families that harvest each fruit, we have that uvilla trees are felled in 100% of the cases, capulí 80%,

morete and guaba de monte 78%, ungurahua 70%, coco de monte 57%, cacao de monte 40%, chonta 38%, to collect lianas 13% of the cases are felled, and to collect tagua and pick mushrooms 10%.

The time spent collecting fruit depends more on the distance to the resource. The shortest times (half an hour to two hours) are indicated for lianas, chonta, frogs and mushrooms, if the resource is further away it takes longer, up to 3 to 5 hours. For tagua, ungurahua, uvilla a whole day is indicated for collection.

The communities with older colonization have a high rate of illiteracy, 34% Kichwa and 66% mestizos according to self-definition. In terms of education levels, the majority of informants who are heads of household completed primary education (45%). In Boayaku, a mestizo informant with completed higher education acquired a plot of land in the community after his retirement and was appointed president of the community in 2012. In Flor de Bosque another Kichwa teacher, with complete higher education, and his son, were admitted in 2012 as community members although they live in Quito; information from them offers a perception of better housing conditions. The Wayuri and Flor de Bosque families who remain in the Santa Clara municipal capital for their children's education report these housing conditions. The most widespread service is electricity, as opposed to sewage or sewerage. Telephone or internet does not exist, but Boayaku declared having the future possibility of community internet access by state provision. In Charapacocha, Achuar community, there are not electricity or other type of infrastructure for internet or connectivity.

In general, access to all resources is free and depends on the emphasis, the work that each family puts into obtaining them. There are no prevailing conflicts because resources are still considered to exist, although occasionally hunting sites may extend beyond the community territory, which could lead to unwanted conflicts with other communities. The extension of hunting territories even outside community boundaries leads to reflection on their vulnerability. Population growth and over-hunting and over-fishing, in fact, have shown that resources can be scarce in nearby areas and are therefore becoming increasingly distant. The community has discussed not overhunting and overfishing and looking for other strategies such as reforestation or replanting felled trees.

For hunting, cultivation and conservation proposes, communities consider to establish zones for urban expansions, recollection – fishing- cultivation and hunting, and zones for preserve sacred places and environment.

In general, analyzing conditions of life, Charapacocha finds the areas of opportunity generation, environmental management, human, social and political-administrative development, the community considers the main strengths are the practice of poultry farming, agriculture adapted to the environment, fish farming, sustainable agroforestry resources, the maintenance of culture and the development of handicrafts. The most significant weaknesses are lack of public health, concern to increase agricultural production for the market, indiscriminate logging, plant diseases, lack of personal interest in resource management, difficulties in marketing and supply chains, and long distances to any market. The greatest threat is considered to be the extension of the oil frontier over the territory. It is concluded that the intersectionality that affects the indigenous people is more serious because they are located in a territory in demand for oil exploitation; however, the cultural

tradition of managing agrobiodiversity and resources of the Amazon Forest should be encouraged, respected and known in university studies through experiential experiences.

4. Conclusion

In the face of sectoral and territorial policies, centralized and decentralized structures, both in management and planning, it is necessary to privilege and build a management model in which communities feel comfortable, secure, represented, with their voice, as subjects of their present and future, not as objects of external development plans. Communities have their own criteria that best represent their interests in collective and family well-being. The evaluation models must be dual: built from quality indicators, control and evaluation formulated by the communities, and, built in an accompaniment that allows to have a follow-up of the process to learn, unlearn, re-learn how to build solidarity territories for the well-being of the population.

Only the construction of management and evaluation models implies a great effort of openness, inclusion, democracy, diversity in the multidimensional space of the tropical rainforest, where all lives exist and interrelate with all cultures, in the course of time.

There are a lot of experiences, knowledge, sensitives that must be explored and integrated into academic discussions.

Acknowledgements

Thanks to Achuar and Kichwa Indigenous people, to their families in all communities who participated in the research and shared their knowledge and observations, and thanks to Amazonian State University, University of Helsinki and Academy of Finland.

References

- Álvarez, J. and Shany, N. (2012). “Una experiencia de gestión participativa de la biodiversidad con comunidades amazónicas” *Rev. Perú Biol.*, no. 19(2), pp. 223-232, ISSN 1561-0837
- Bautista-Valarezo, E., Duque, V., Verhoeven, V., Mejia, J., Hendrickx, K., Maldonado-Rengel, R. and Michels, N. (2021). “Perceptions of Ecuadorian indigenous healers on their relationship with the formal health care system: barriers and opportunities.” *BMC Complement Med Ther.* No. 2021(21): 65. [Online], 2021 Feb 18. DOI 10.1186/s12906-021-03234-0
- Begossi, A. and Dias de Ávila, F. (2003). “Wssd 2002, Latin America and Brazil: Biodiversity and Indigenous People.” *Environment, Development and Sustainability*, no 5(1), pp. 179-195, ISSN 1387-585X
- Berlowitz, I., García, E., Maake, C., Wolf, U. and Martin-Soelch, C. (2023). “Indigenous-Amazonian Traditional Medicine’s Usage of the Tobacco Plant: A Transdisciplinary Ethnopsychological Mixed-Methods Case Study.” *Plants (Basel)*. no. 12(2): 346. [Online], [Accessed: 2023 Jan 11]. DOI 10.3390/plants12020346
- Burgaleta, E., Rodríguez, N. and Martínez, M. (2018). “Identidades amazónicas en conflicto: el indígena dócil frente al insurrecto.” *Revista mexicana de sociología*, no. 80(1), pp. 139-166, ISSN 0188-2503

- Escobar, A. (2002). Globalización, desarrollo y modernidad. Planeación, participación y Desarrollo, 9-32. Medellín: Corporación región. Available: www.oei.es/salacti/escobar.htm, [Accessed: 19 June. 2021]
- Escobar, A. (2011). “Una minga para el posdesarrollo”. *Signo y pensamiento, enero-junio*, no. 30(58), pp. 306-312. Available: <http://www.redalyc.org/src/inicio>
- INEC (Instituto Nacional Ecuatoriano de Estadística y Censos). (2010), “*Base de datos de resultados del censo de población y vivienda 2010 en el software Redatam*”. Quito-Ecuador: INEC: CPV Ecuador 2010-Aplicación de R+SP xPlan (CELADE-CEPAL)
- Iwamura, T., Lambin, E., Silvius, K., Luzar, J. and Fragoso, J. (2014). “Agent-based modeling of hunting and subsistence agriculture on indigenous lands: Understanding interactions between social and ecological systems.” *Environmental Modelling and Software*, no. 58, pp. 109-127, ISSN 1364-8152
- Latham, J., Cumani, R., Rosati, I. and Bloise, M. (2014), “*Global land cover share (GLC-SHARE) database beta-release version 1.0-2014*”. FAO: Rome, Italy, 29
- Martínez, R. (2012). “Del tiempo insostenible y del sentido del tiempo en las comunidades Kichwa Canelos.” *Desacatos*, no.40, pp. 111-126, ISSN 1405-9274
- Mistry, J. and Berardi, A. (2016). “Environment. Bridging indigenous and scientific knowledge.” *Science*, no. 352(6291), pp. 1274-1275, ISSN 0036-8075
- Poirier, B. and Neufeld, H. (2023). “We Need to Live off the Land’: An Exploration and Conceptualization of Community-Based Indigenous Food Sovereignty Experiences and Practices.” *Int J Environ Res Public Health*. 2023 Mar, no. 20(5): 4627. [Online], 2023 Mar 6. DOI 10.3390/ijerph20054627
- Thiede C., and Clark, G. (2019). “Characterizing the Indigenous Forest Peoples of Latin America: Results from Census Data Brian.” *World Dev*. Author manuscript, Available in PMC 2021 January 01. DOI 10.1016/j.worlddev.2019.104685
- Vacacela, V. (2013). “Manejo y conservación de la agrobiodiversidad en sistemas de producción ancestral del pueblo Kichwa de Pastaza.” *Encuentro por la vida en armonía, el territorio y la multitud de vidas en plenitud de Pastaza*. Puyo, Ecuador
- Walrod, J., Seccareccia, E., Sarmiento, I., Pimentel, J., Misra, S., Morales, J., Doucet, A. and Andersson, N. (2019). “Community factors associated with stunting, overweight and food insecurity: a community-based mixed-method study in four Andean indigenous communities in Ecuador.” *BMJ Open*. 2018, 8(7): e020760. [Online], 2018 Jul 6. DOI: 10.1136/bmjopen-2017-020760

EDUCATION NEEDS FOR FARMERS IN EUROPEAN PRECISION AGRICULTURE FROM NEW ICT TECHNOLOGIES SUPPLIERS POINT OF VIEW

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Annotation: This study was conducted in 2022 with a survey of 25 new IT agro-technologies suppliers from seven European countries to answer the questions about their point of view on current new ICT provided to farmers, their professional training programmes offered to clients and then to define education needs of farmers to enhance the adoption of new ICT agro-technologies. Results show that though there are many training programmes offered by suppliers through different forms, farmers still lack technical skills and ICT technologies knowledge for a better application of new ICT agro-technologies due to the complexity of the products. Therefore, the adoption of new technologies in agriculture is clearly linked to a better education in this field.

Key words: precision agriculture, farmers' needs, education, agro-technologies suppliers, ICT

JEL classification: Q19, Y90

1. Introduction

New technologies, and more specially digital technologies, are now spreading in all fields of human activity, including agriculture (Birner et al., 2021). There is a common agreement among the agricultural society that innovative use of information and communication technologies (ICT) could be considered as a solution for agricultural development in order to feed an extra two billion people by 2050. The potential use of these technologies is rather broad, as they could really contribute to face the main problems of agriculture: environmental negative impacts on air, water and soil quality, biodiversity reduction, and also farm profitability, as well as the disappearance of a lot of farms and the decline of the agricultural population (Van Es and Woodard, 2017; Batter and Ehsani, 2006).

With an idea that the Fourth Industrial Revolution has the power to change things across a broad spectrum of the society and schools and other executives need to be ready, the Project “Future IT for farms” (ITFARM) funded by ERASMUS+ was launched in early 2022 with its primary objective of making science available to farmers so that they can understand it and be able to respond to the innovative demands of digital society. To do that, apart from demand side (as farmers), understanding the education needs of farmers and current training programmes provided by new agro-ICT suppliers (supply side approach) is a must.

Acting to reach the abovementioned purpose, a survey was therefore organised to investigate the new ICT agro-technologies suppliers point of view on current new ICT provided to farmers and their professional training programmes offered to clients, and then to evaluate and define the demand of farmers on training programmes.

2. Materials and Methods

The study was designed into three steps. The first step was to gather secondary data on an overview of ICT agro-technologies suppliers in precision agriculture in Belgium, Bulgaria, Czechia, Greece, Hungary, Ireland and Italy. The second step was designed for a primary data collection through a survey in above mentioned countries with a semi-open questionnaire. Based on the data of desk research and suppliers survey, the project partners conducted an analysis and wrote a final report with recommendations for improvements.

Sample size

For the primary data, from a semi-open questionnaire, at least three agro-techno input dealers/suppliers, involved in precision agriculture products value chain in each country were chosen, including:

- One input dealer;
- One service provider/consulting firm;
- One digital machine/robotics manufacturer (if any). In case there was no technology/machine/robotic manufacturer in the country, one additional dealer was needed.

A total of 25 technology suppliers were chosen for investigation, of which there were six from Belgium, four from Bulgaria, three from Czechia, three from Greece, three from Hungary and nine from Italy. Due to the difficulty of approaching and considering the size of the country, Ireland was an exceptional case to collect only two samples.

Data collection and analysis methods

The collection of secondary data took place through means of desk research in the first half of 2022. Key informant interviews (KPs) and focus group discussions (FGDs) tools were used for primary data collection from ICT technologies suppliers which was implemented from April to July of 2022. Qualitative method was applied to analyse the collected data.

Scope of the study

Considering the vastness of ICT application in agriculture, the study focused only on ICT technologies applied in precision agriculture.

3. Results and Discussion

a. Precision agriculture and ICT supplied in the studied countries

Precision agriculture (PA), also considered as precision farming, smart farming, site-specific crop management or satellite farming, is a farming management which uses information technology (IT) to ensure agricultural more productive and more profitable practices and environmental protection by adjusting the exact input level in the site-specific field of agriculture (Kritikos, 2020; Toriyama, 2020).

European precision agriculture started in the end of 1990s and early 2000s after almost twenty years of existence in the United States. Precision agriculture technologies have been then strongly developed since 2014 in the continent thanks to several promoted programmes of the European Commission and the participation on R&D of public and private sectors (BBC, 2021).

Following the strategy of EU regional policies, Belgium, Bulgaria, Czechia, Greece, Hungary, Ireland and Italy also participated in PA in the end of 1990s or early 2000s by an investment in crop production management such as mapping crop yields, systems for diagnosing the cultivation conditions and use of lightbar displays for fertilizer spreading. Since 2015, revolutionary progress in ICT imposed the second wave of PA in these countries (BRNO, 2021; Bogaert, 2015; Takács-György, 2017; ISPA, 2023). ICT, according to Bucci (2018) and Rouse (2005), is defined as a digital processing and utilisation of information by any communication device such as radio, television, cellular phones, network hardware and software, satellite systems or application to computers. This process comprises the storage, retrieval, conversion, and transmission of information by the use of electronic computers. The application of ICT in precision agriculture is very promising with an enormous advantage for the whole agro-production chain which could be a solution to feed enough a fast growing population while ensuring a sustainable environment (Bucci, 2018; Fernando, 2018; Zhuhadar et al, 2017).

From their first creation which focused on crop production management, PA technologies now spread widely to all sectors of agriculture including livestock, horticulture, arable land, and aquaculture. Agricultural machineries equipped with ICT devices are now also available for a better result of PA practices on the fields. Current ICT technologies supplied in European market include guidance systems as automatic control system (guidance and steering, GPS, drones, flow devices, etc.), variable rate technology, remote sensing and monitoring devices (yield monitoring, soil, water, climate) (Market data forecast, 2023).

From survey results of the study we found that almost all of latest ICT technologies are supplied in the studied countries for grass yield monitoring, animal behaviour, animal health and welfare, feed management, weight management, automatic milking systems, field mapping with GIS, yield monitor and data analysis, seeding management tools, weather connected stations etc. While Greece, Italy and Ireland suffer a considerable delay in the use of PA ICT technologies, Czechia and Belgium mark a better adoption compared to Bulgaria and Hungary thanks to large area farms and sufficient capital to acquire expensive technologies (Bucci, 2019). Apart from the main constraint of new ICT adoption in PA as small farm areas and short capital investment, the lack of technological knowledge and technical skills of farmers/ICT users is one key problem for low adoption of precision farming technologies in general and in the studied countries in particular.

b. Training provided by suppliers for ICT agro-technologies farmers/users

i. Overview of ICT education in agriculture

The application of ICT in agriculture has been rapidly increasing since several years which requires an urgent improvement of agricultural workers' skill and knowledge. Many education programmes have been launched in Europe to enhance agricultural workers' competence for digital transformation (Udemezue, 2019). Short and life-long courses are designed for many levels such as under and post grades at universities or basic/intermediate specific training at professional schools, training organisations, extension services, traineeships, Vocational Education and Training organization (VET). Participants as future farmers, farmers, students, trainers, advisers, etc. can choose different places for their learning suchlike farming community, advisers, educational and training organisations, farm suppliers, agricultural organisations, research and technology organisations (EIP-AGRI, 2020). Teaching forms are abundant, from traditional (face-to-face) to virtual classes, e-learning and blended training (Europarl, 2023). Learning topics are not only focused on a single subject but on a package as one side does not fit all for farmers' upskills purpose. However, the content level is usually too high for the users, which leads to an inefficient knowledge transmission. Education and training are organised under both formal and informal forms, of which formal education mode is mostly used to transfer advanced ICT technologies by experts due to their complexity that requires experts' knowledge (Venkatram and Sakthirama, 2018).

ii. Training provided by suppliers for ICT agro-technologies farmers/users in the a studied countries

New ICT agro-technologies have strong impacts on farmers' production effectiveness. Through the support system of ICT agro-technologies, farmers can take a better decision for their activities (such as time schedule according to weather forecasts), as well as improving their product quality (by using exactly the due input quantity). However, advanced ICT technologies are also well known due to their complexity which requires a basic technological knowledge and skills of users. Taking into account this important point, ICT agro-technologies suppliers in the studied countries therefore usually provide training for their clients (Table 1).

Table 1. Training provided by ICT agro-technologies suppliers

Country	Training form				
	Case-by-case	After-sale product	New product promoting training	Periodic technical repeated training	Others
Belgium	70% dealers to buyer farmers/users	30% dealers to buyer farmers/users	100% Manufacturers to dealers	Service providers to buyer farmers/users	Occasional by extension services to current and future buyers
Bulgaria	30%	20%	20%	20%	10% (extension service)
Czechia	Mainly	Mainly	Sometimes	N/A	N/A
Greece	Mainly	Mainly	N/A	Sometimes	N/A
Hungary	Mainly	Mainly	Sometimes	N/A	N/A
Ireland	Mainly	Mainly	N/A	N/A	N/A
Italy	>50%	33%	N/A	20%	N/A

Most of suppliers provide ICT agro-technology training to their clients except in Greece. In Belgium, trainings are clearly organised differently by type of clients. While 100% of large manufacturers occasionally provide training to dealers via demonstration events for a new product, small manufacturers and dealers organise training for farmers individually (70%) under the forms of case-by-case basis and after-sale product, or for groups (30%) as demonstration. In Bulgaria, Czechia, Hungary, Ireland and Italy, suppliers organise mixed forms of training including individual case, after sale services and new products demonstration. Manufacturers also organise themselves periodic trainings as demonstration events in order to introduce their new techniques in specific places.

Training for individuals is usually organised into two phases. The first phase plans as installing machines for farmers, the second phase will be implemented by telephone guidance during utilisation. Service providers organise periodic trainings to farmers with the facilitation of ICT machine suppliers who demonstrate their techniques.

The survey results also show that ICT technologies suppliers provide different kinds of training to their clients. This finding is similar to the previous study conducted by The European Innovation Partnership (EIP-AGRI, 2020). While large manufacturers usually give training through new ICT technologies demonstration events to their dealers, small manufacturers provide training directly to their clients as dealers and ICT technologies users. It is evident that machine suppliers are only offering training related to their products, while ICT users' knowledge and skills required to assess new technologies are not really concerned, though there is a purpose to simplify as much as possible ICT technologies to farmers/users.

Training is freely provided by ICT agro-technologies suppliers to their clients in Belgium but in other studied countries, suppliers are fully or partially paid for the training services, or financed by third parties, except in Greece where the cost is borne by the customers. If training is organised by extension services, participants might contribute a small fee in Belgium.

Trainings are mainly offered on demand with a duration less than one day (as a couple of hours or half a day) and sometimes one to two days. Trainings rarely take place for a duration of three days to one week at clients' places and they never last longer than a week (Table 2).

Table 2. Training duration provided by ICT agro-technologies suppliers

Country	Training duration			
	≤ 1 day	1-2 days	3 days-1 week	> 1 week
Belgium	Mainly	Sometimes		Never
Bulgaria	Mainly	Sometimes		Never
Czechia	Mainly	Sometimes		Never
Greece	Mainly	Sometimes		Never
Hungary	Mainly	Sometimes		Never
Ireland	Mainly	Rarely		Never
Italy	Mainly	Sometimes	Rarely	Never

c. Training/education lacking the most of ICT agro-technologies farmers/users

Trainings provided by ICT agro-technologies suppliers are focused to their products rather than the specific needs of farmers. All suppliers agreed that in the long run, the training programmes are profitable for their companies. Regarding to the areas of training that are lacking the most, it is needed to note that the main problem is the lack of qualified staff and specialization in some countries.

According to suppliers, there are too many ICT programmes on the market and it is difficult to know what farmers need to receive. However, all of respondents agreed that training on basic ICT tool use, farm management system, data management, high-tech products and tools, software, navigation, autonomous machines, sensors, cloud technologies, practical skills in digitization, and economic and environmental benefits of introducing agriculture 4.0 in the farming industry are farmers' needs.

4. Conclusions

Based on the findings from the desk-based and field-based research it is evident that the introduction of ICT technologies in precision agriculture is continuously progressing. While there are many different technologies available on the market, the demand is still not equal to the offer, as skills of the farmers are not yet sufficient to comply and meet the offer.

On the other hand, suppliers offering different ICT services and products are offering specific training limited to their products, *while there is still a lack of adequate and efficient training programmes for farmers providing knowledge and skills required to assess the need and importance of introducing new technologies in their activities.*

Training is considered to be important, as suppliers equip their clients with tools improving their decision making related to profit and effectiveness of the processes. Consequently, the adoption of new technologies in agriculture is clearly linked to a better education in this field.

It is recommended to ICT educational organisations and agricultural institutions for ICT promoting: 1) To establish relationships with selected ICT suppliers to prepare training material for related users and afterwards, to directly organise trainings as a consultancy;

2) To create a source of references on current existing ICT technologies and new tendencies so that both suppliers and farmers can access and easily update their information.

Acknowledgements

This paper presents results got thanks to the Erasmus + “ITFARM” project (IT for interconnection of social, economic and environmental aspects in agribusiness. Project number: KA220-ADU-F7018504, Project: Erasmus+ KA220-ADU, Duration: since 01-01-2022 till 01-07-2024) which includes partners from seven European countries.

References

- Batter, M. T. and Ehsani, M. R. (2006). “The economics of precision guidance with auto-boom control for farmers-owned agricultural sprayers”. *Computer and electronics in agriculture*. no. 53(1), pp. 28-44, ISSN 0168-1699
- Birner, R., Daum, T. and Pray, C. (2021). “Who drives the digital revolution in agriculture? A review of supply-side trends, players and challenges”. *Applied Economic Perspectives and Policy* 43, ISSN 1260-1285
- Bucci, G., Bentivoglio D., Finco A. and Belletti M. (2019). “Exploring the impact of innovation adoption in agriculture: how and where Precision Agriculture Technologies can be suitable for the Italian farm system?” *IOP Conf. Ser.: Earth Environ. Sci.* 275 012004. DOI: 10.1088/1755-1315/275/1/012004
- Bucci, G., Bentivoglio D. and Finco A. (2018). “Precision agriculture as a driver for sustainable farming systems: State of art in literature and research”. *Quality - Access to Success*. <https://www.semanticscholar.org/paper/Precision-Agriculture-As-a-Driver-for-Sustainable-Bucci-Bentivoglio/c2c932bc06956a3a88245522eb40908968418845>
- Digital Wallonia (2022). Bilan 2015-2018 vision and actions 2019-2024. Home page <https://content.digitalwallonia.be/post/20190626100319/Bilan-strategique.pdf>. [Accessed: 10 June 2022]
- EIP-AGRI (2020), EIP-AGRI Seminar: New skills for digital farming. Final report. <https://ec.europa.eu/eip/agriculture/en/publications/eip-agri-seminar-new-skills-digital-farming-final.html> [Accessed: 20 June 2023]
- EUROPARL (2023), Field skills, <https://www.europarl.europa.eu/thinktank/infographics/precisionagriculture/public/fields/skills.html> [Accessed: 22 June 2023]
- Fernando, M. G. N. A. S. (2018). “Teaching, Learning and Evaluation Enhancement of Information Communication Technology Education in Schools through Pedagogical and E-Learning Techniques in the Sri Lankan Context”. *World Academy of Science, Engineering and Technology, International Journal of Educational and Pedagogical Sciences*, no. 5(6)
- Greenberg, S. (2021). Birth of precision farming. <https://blog.bccresearch.com/birth-of-precision-farming>. [Accessed: 28 April 2023]

- ISPA (2023), Precision agriculture in Bulgaria. Rositsa Beluhova-Uzunova, Dobri Dunchev. Agricultural University-Plovdiv.
https://ispag.org/article_display/?id=609&title=Precision+Agriculture+in+Bulgaria.
 [Accessed: 28 April 2023]
- Kritikos, M. (2020). Precision agriculture in Europe: Legal, social and ethical considerations. European parliamentary research service. ISBN 978-92-846-1662-6. DOI 10.2861/278
- Market data forecast (2023), Europe Precision Agriculture Market.
<https://www.marketdataforecast.com/market-reports/europe-precision-agriculture-market>.
 [Accessed: 5 May 2023]
- Rouse, M. (2005). ICT (information and communications technology-or technologies).
Dostupno na: http://searchcio-midmarket. techtarget. com/definition/ICT (27.02. 2013.)
- Takács-György, K. (2017). Precision Agriculture in Hungary: Are perceptions far from the facts?. AgEcon Search, DOI 10.22004/ag.econ.283717
- Toriyama, K. (2020). “Development of precision agriculture and ICT application thereof to manage spatial variability of crop growth” *Soil Science and Plant Nutrition*, 66:6, 811-819, DOI 10.1080/00380768.2020.1791675
- Udemezue, J. C. (2019). “Training need on communication skills and icts in agricultural extension; an effective approach to rural development” *International Journal of Entomology and Nematology Research*. vol.4, no.2, pp. 15-26, ISSN 2399-1151
- Van Es, H. and Woodard, J. (2017). “Innovation in agriculture and food systems in digital age” *Global Innovation index 2017*. World Intellectual Property Organisation. Geneva
- Zhuhadar, L., Thrasher, E., Marklin, S. and de Pablos, P. O. (2017). “The next wave of innovation—Review of smart cities intelligent operation systems”, *Computers in Human Behavior*, no. 66, pp. 273-281, ISSN 0747-5632
- Venkatram, R. and Sakthirama, V. (2018). Transferring agricultural technologies – Need to supplement the formal learning with informal learning, *TVET@Asia*, issue 10, 1-13.
<https://tvvet-online.asia/issue/10/venkatram-et-al-tvet10/> . [Accessed: 22 June 2023]

EFFECTS OF THE SCHOOL SCHEME EDUCATIONAL MEASURES ON EATING HABITS OF CHILDREN IN SLOVAKIA

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Annotation: The objective of the paper is to assess the effect of the Accompanying Educational Measures (AEM) of the Slovak School Scheme on the change in average frequency of fruit and vegetable consumption among children in preschool establishments and primary schools participating in the fruit and vegetable subprogram from 2017 to 2022. The School Scheme aims to encourage children to adopt a healthy diet and lifestyle by distributing and providing fruits and vegetables to participating schools and implementing AEM, which can include activities such as farm visits, school gardens, cooking workshops, and games. The study used data from a 2022 survey of parents of children from a representative sample of 80 selected schools in Slovakia, including kindergartens, primary, and secondary schools. The analysis focused on 1,429 respondents whose children attended schools participating in the fruit and vegetable subprogram, with 42.9% from schools with at least one AEM intervention, and the remaining from schools without any intervention. The study employed a counterfactual approach and propensity score matching (PSM) to create a control group and estimate the average treatment effects of the AEM. The study found that the AEM conducted under the EU School Scheme in Slovakia had a positive effect on the frequency of consumption of fresh fruits and vegetables by children, particularly on fruit consumption among boys and older children. However, the effect on vegetable consumption was less consistent across regions and demographic groups. The findings suggest the need for more intensive implementation of AEM and tailoring to better address the unique needs and preferences of different groups of children.

Key words: fruit; vegetable; EU School Scheme; accompanying educational measures; children; Slovakia

JEL classification: D12, C14, C31, I28

1. Introduction

The EU School Fruit, Vegetables, Milk and Dairy Products Scheme has been implemented in the EU, including in Slovakia, since 2017/2018 as a joint program of previously separated schemes. The School Scheme provides fresh fruit and vegetables, milk, and dairy products to children in participating schools, with the aim of encouraging children to eat more of these products, which are essential for their healthy and balanced diet and healthy eating habits. In addition to promoting healthy eating habits among children, an important goal of the scheme is to support domestic producers of these products. Many EU countries have also their own initiatives aimed at promoting healthy eating habits among children. The EU countries have also implemented regulations aimed at improving the quality of school meals, such as setting limits on the amount of sugar, salt, and fat that can be included in school meals.

Children's eating habits will have a significant impact on their future consumption of agricultural products and the overall health status of the adult population. Therefore, it is crucial to provide children with education on healthy nutrition. According to a survey conducted by Eurostat (2019), only 12% of people in the EU reported consuming

the recommended intake of 5 or more portions of fruits and vegetables daily. Alarming, 33% of people in the EU reported not consuming any fruit or vegetables on a daily basis. To address this issue, the EU has implemented the School Scheme, which aims to promote healthy eating habits among children. This scheme supports the distribution of milk, fruits, and vegetables to children attending nursery, preschool, primary, and secondary schools across the EU. By providing these nutritious food options, the EU School Scheme encourages children to adopt a healthy diet and lifestyle.

Good nutrition and access to adequate food and healthcare are crucial factors in the growth and development of children and the long-term health of the adult population. Maintaining a healthy diet is essential for overall well-being and can significantly reduce the risk of non-communicable diseases such as cardiovascular diseases, overweight, and obesity, which are often associated with the consumption of unhealthy foods high in salt, sugars, and fats. According to the World Health Organization (2018) and recent studies like the one conducted by Ng et al. (2014), childhood and adolescent obesity remain significant global challenges in the 21st century. The prevalence of obesity in children and adolescents is alarming, with its onset often occurring during the preschool years and persisting into later adolescence and adulthood. Therefore, promoting healthy eating habits from an early age and maintaining them throughout life is a key policy objective for improving public health and preventing non-communicable diseases, including obesity (Story et al., 2018). Research has consistently demonstrated that access to nutritious food and nutrition education during early childhood is vital in shaping lifelong healthy eating behaviours (Rasmussen, 2006). It is through early exposure to healthy food choices and nutrition education that children can develop and maintain healthy eating habits that will benefit them throughout their lives.

The school environment plays an important role in the development of children's eating habits (Kachútová et al., 2019). Children spend half of their waking hours and consume at least one-third of their daily calories at school, making schools an ideal vehicle for providing obesity interventions for most children (Bleich et al., 2018; Bell and Swinburn 2004, Regan et al., 2008). Influencing the environment where children live, learn and play is necessary to improve the quality of what children eat and drink to support optimal growth, health, and development (Hendrie et al., 2017). Ip et al. (2017) report that school has a significant effect on student weight regulation. High-quality school meals have the potential to improve children's health, and the availability of healthy food positively affects the diet of schoolchildren (Bevans et al., 2011). According to Kristjansdottir et al. (2006) study, interventions to increase fruit and vegetable intake among children should aim at both environmental factors such as greater availability of fruit and vegetables, and personal factors as self-efficacy and knowledge levels concerning nutrition.

Several studies confirm preventive and health-promoting interventions in schools which help children to reduce the risk of developing chronic diseases in adulthood (Liu et al., 2019). Based on scientific studies, there is evidence that school meal programs improve fruit and vegetable consumption (e.g. Delgado-Noguera et al., 2011; Øvrebø et al., 2019; Kastorini et al., 2016) and support the availability of fruits and vegetables through school distribution (e.g. Beal et al., 2019; Schwartz et al., 2015). Literature findings on the effectiveness of free subsidized interventions may not be encouraging, as they show little or no effectiveness (Delgado-Noguera et al., 2011). However, it is important to implement different strategies in the school environment to support fruit and vegetable consumption in children (Colley

et al., 2018; DeCosta et al., 2017), as eating habits established in childhood and adolescence tend to transition into adulthood (Craigie et al., 2011).

Empirical studies have investigated strategies to improve children's healthy eating in schools (Hodder et al., 2020; Evans et al., 2012; Dudley, Cotton and Peralta, 2015). These studies suggest that some effective school-based interventions include increasing access to healthy foods in school settings, incorporating physical activity into the school day, providing education on nutrition and healthy lifestyle habits, and involving families and communities in the promotion of healthy behaviours.

To achieve the aims of the EU School Scheme, the distribution and provision of fruit and vegetables to children in participating Member States have been accompanied by the implementation of accompanying educational measures (AEM), although not obligatory by 2021/2022. These measures, as outlined in the EP (2016), are designed to educate and raise awareness among children about the importance of a balanced diet and the benefits of consuming a variety of foods. AEM activities can include lectures, support for farm visits, school gardens, tasting and cooking workshops, theme days, and games.

The objective of the present study is to assess the effect of the Accompanying educational measures within the Slovak School Scheme from 2017/2018 to 2021/2022 on the average daily frequency of fruit and vegetable consumption among children in preschool establishments and primary schools participating in the fruit and vegetable subprogram.

2. Data and Methods

We utilized data from a survey conducted in 2022, which involved parents of children from a representative sample of 80 selected schools in Slovakia, comprising kindergarten, primary, and secondary schools. Out of the 1,673 parents who provided responses regarding their child's eating habits, we focused on data from 1,429 respondents whose children attended schools participating in the fruit and vegetable subprogram. Our objective was to estimate the net effect of the Accompanying educational measures (AEM) on the average change in children's frequency of fruit and vegetable consumption between the years 2017 and 2022. Among the respondents, 613 children (42.9%) attended schools that implemented at least one AEM intervention, while 816 children (57.1%) attended schools without any intervention. We collected data on various indicators, including parents' perception of changes in their child's daily frequency of fruit and vegetable consumption, the type of school their child attended, the child's gender and age, the child's health status, parents' perception of their child's weight, the region in which they resided, the presence of household members under the age of 18, household income and social benefits, the body mass index (BMI) of the child, parents' education level, the size of the settlements, and the number of inhabitants in the settlement.

To analyse the effect of the Accompanying educational measures (AEM) intervention, we employed a quasi-experimental approach, counterfactual analysis. Propensity score matching (PSM) was utilized to create a control group, and Stata 17 software was employed to estimate the net effects of the AEM intervention.

Propensity Score Matching (PSM) enabled us to evaluate the effect of the AEM and minimize bias. We created two comparable groups: the treated group consisted of children from schools that implemented at least one AEM between 2017/2018 and 2021/2022, while the control

group comprised children with similar characteristics from schools that participated in the fruit and vegetable School subprogram but did not have any AEM. By applying PSM, we matched children from the treated group with those from the control group based on their characteristics, ensuring a more balanced comparison. The difference in the probability of achieving the outcome, in this case, the average change in fruit and vegetable daily frequency consumption reported by parents, between the treated and control groups represents the net effect of the AEM. It is crucial to use PSM in this context because comparing the outcomes of children from participating schools with AEM to those without AEM without considering their characteristics would introduce bias. As the implementation of AEM was not mandatory under the School program, its occurrence varied across schools due to factors such as school type and other individual heterogeneous factors.

Table 1. Variable description

Variable Type	Variable Name	Description
Treatment Variable	Participating school with AEM	Yes = 1; No = 0
Outcome Variable*	Parents' perception of the change in their child's daily frequency of fruit consumption (2022-2017)	Change in the frequency of the child's daily fruit consumption in 2022 compared to 2017: Increased = 1; No change = 0; Decreased = -1
	Parents' perception of the change in their child's daily frequency of vegetable consumption (2022-2017)	Change in the frequency of the child's daily vegetable consumption in 2022 compared to 2017: Increased = 1; No change = 0; Decreased = -1
Control variables**	Gender	Boys = 1; Girls = 0
	Region: Central Slovakia	Yes = 1; No = 0
	Region: Eastern Slovakia	Yes = 1; No = 0
	Region: West Slovakia (omitted)	Yes = 1; No = 0
	Age: 3-5 years old	Yes = 1; No = 0
	Age: 6-10 years old	Yes = 1; No = 0
	Age: 11 years old and above (omitted)	Yes = 1; No = 0
	Domicile	Urban = 1; Rural = 0
	Health status	Very good = 1; Other = 0
	Change in the parent's perception of the child's weight (2022-2017)	No change: 0 Decrease of the child's weight: -1, -2, -3, -4, -5 Increase of the child's weight: 1, 2, 3, 4, 5
	Number of household members with age under 18th	Count
	Long-term social benefits	None = 0; to 300 EUR = 1; 301-400 = 2; 401-500 = 3; 501-700 = 4; 701-900 = 5; More than 900 = 6
	Net monthly income of the household	To 400 = 0; 401-600 = 1; 601-800 = 2; 801 - 1 000 = 3; 1 001 - 1 500 € = 4; 1 501 - 2 000 € = 5; 2 001 - 3 000 = 6; more than 3000 = 7
Eating of home-made snack in school	Yes = 1; No = 0	
BMI	Body Mass Index calculated based on height and weight, adjusted for age and gender (continuous variable)	

Note: * The treatment effect is computed using count outcomes; ** after omitting correlated variables

We generated the propensity score, which is the conditional probability of a child's participation in the School Scheme, for the purpose of matching, using a logit model. Table 1 shows a description of the treatment, outcome, and control variables used to generate the propensity score. Based on the propensity score, the control group of children from participating schools without AEM (untreated) is drawn up to be as similar as possible to the treated group of children from participating schools with AEM (treated) to perform

a comparative analysis. The effect of AEM intervention is assessed using the Average Treatment Effect (ATE), which represents the expected difference in the outcome variable between the treated and control groups, after adjusting for confounding variables.

$$ATE = E[(Y_{1i} - Y_{0i})] = E\{E[(Y_{1i} - Y_{0i})|X]\} \tag{1}$$

where Y_{1i} represents the outcome variable for the treated group, Y_{0i} represents the outcome variable for the control group, and X represents the set of covariates that are used to adjust for confounding.

Equation (1) represents the expected difference in the outcome variable between the treated and control groups, averaging over all possible values of X . It provides an estimate of the average causal effect of the conducted AEM on the outcome variable in the entire population being studied, regardless of whether individuals received the treatment or not. This formula assumes that the treatment assignment is independent of the outcome variable, given the covariates. If this assumption holds, then the ATE provides an unbiased estimate of the causal effect of the conducted AEM.

3. Results and Discussion

We are evaluating the effect of Accompanying Educational Measures (AEM) conducted in schools as part of the School Program between 2017 and 2022 on the average change in the frequency of fruit and vegetable consumption by children from schools with AEM compared to those without it. The most common types of AEM implemented in schools that participated in the program during the period between 2017 and 2022 were tastings, followed by games and activities in school gardens, while lessons were less common (Table 2).

Table 2. Frequency of Accompanying educational measures by types, descriptive statistics

AEM types	Observations	Mean	Std. dev.	Min	Max
School gardens	613	.5236542	1.131044	0	3
Farm visits	613	.4845024	2.03286	0	9
Tasting	613	4.574225	2.888413	0	9
Lessons	613	.4845024	1.480319	0	6

Table 3 presents descriptive statistics for the outcomes and control variables of the overall sample of children, irrespective of their participation in the school subprogram for fruits and vegetables. The subgroup of children from schools participating in the subprogram is further divided by the presence of AEM interventions. The Wilcoxon rank sum test was used to examine differences in the characteristics of children from participating schools with and without AEM. The results indicate statistically significant differences in the average change in the frequency of fruit consumption among children from participating schools with and without education measurement. Significant differences were also found for region, age, long-term social benefits, and the number of household members under 18 years of age.

Correlated variables were eliminated, and the remaining control variables (Table 1) were included in the Logit model. The results of the Logit parameter estimates (Table 4) indicate that some control variables have a significant effect on children (school) participation in the School subprogram for fruit and vegetables with AEM, according to our expectations. There are regional disparities in children (school) participation in the School Scheme.

Differences between the groups of children from schools with and without AEM, as observed in the control variables (Table 2), could result from school option for AEM (self-selection). To avoid selective distortions, the PSM proposed by Rosenbaum and Rubin (1983) and the nearest neighbour matching is applied.

The estimation of the average treatment effects (ATE) shows the effects of AEM on the average change in the frequency of children's daily fruit consumption over the 2017-2022 school years.

Table 3. The average children's characteristics by participation in School subprogram fruit and vegetables and by conducted of AEM

Variable	Total	Children from school participating in the fruit, vegetables subprogram with the AEM		Children from school non-participating in the fruit, vegetables subprogram
		Yes (N = 613)	No (N = 816)	
	(N = 1673)			(N = 244)
Average change in the child's frequency of daily fruit consumption (2022-2017)	0.248 (0.501)	0.284 (0.492)	0.207 (0.495) ***	0.287 (0.533)
Average change in the child's frequency of daily vegetable consumption (2022-2017)	0.162 (0.516)	0.172 (0.496)	0.153 (0.518)	0.165 (0.56)
Gender	0.524 (0.5)	0.504 (0.5)	0.534 (0.499)	0.541 (0.499)
Region: Central Slovakia	0.208 (0.406)	0.223 (0.417)	0.175 (0.38) **	0.279 (0.449)
Region: Eastern Slovakia	0.24 (0.427)	0.259 (0.439)	0.255 (0.436)	0.139 (0.347)
Region: West Slovakia (omitted)	0.552 (0.497)	0.517 (0.5)	0.57 (0.495) **	0.582 (0.494)
Age: 3-5 years	0.132 (0.338)	0.109 (0.312)	0.141 (0.348) *	0.156 (0.363)
Age: 6-10 years	0.501 (0.5)	0.543 (0.499)	0.48 (0.5) **	0.463 (0.5)
Age: 11 years and above (omitted)	0.368 (0.482)	0.347 (0.477)	0.379 (0.485) **	0.381 (0.487)
Rural – Urban settlements	0.47 (0.499)	0.486 (0.5)	0.505 (0.5)	0.311 (0.464)
Health status	0.322 (0.467)	0.312 (0.464)	0.321 (0.467)	0.348 (0.477)
Change in the perception of the child's weight (2022-2017)	0.27 (0.844)	0.246 (0.88)	0.24 (0.787)	0.426 (0.92)
Number of household members with age under 18 th	1.968 (0.893)	1.848 (0.795)	2.016 (0.918) **	2.107 (1)
Long-term social benefits	1.562 (1.596)	1.476 (1.575)	1.586 (1.603) *	1.697 (1.617)
Household net monthly income	4.051 (1.749)	4.139 (1.643)	4.007 (1.853)	3.97 (1.65)
Eating homemade snack in school	0.957 (0.203)	0.98 (0.14)	0.936 (0.245)	0.967 (0.18)
BMI	17.612 (3.914)	17.453 (3.904)	17.708 (3.86)	17.686 (4.12)

Note: St. Dev. in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, based on the Wilcoxon rank sum test.

The estimated ATEs of conducted AEM (Table 5) show a positive effect on the change in average child's fruit consumption frequency, although the effect sizes differ across subgroups. The AEM had statistically significant positive effect (at the 10% level) on the average daily consumption of fruit for the overall sample. This positive effect was also observed specifically for boys and children in rural areas, indicating that the AEM interventions led to an increase in their fruit consumption frequency. However, for children in urban areas, the ATE is statistically significant at the 1% level, suggesting a stronger negative effect of the AEM on their average frequency of daily fruit consumption.

Table 4. Estimated parameters for Logit model. Children in schools participated in subprogram fruit and vegetables

Variable	Estimated parameter (SE)
Gender	-0.18 (0.123)
Region: Central Slovakia	0.589*** (0.162)
Region: Eastern Slovakia	0.421** (0.154)
Age: 3-5 years	-0.227 (0.224)
Age: 6-10 years	0.11 (0.145)
Residence	-0.038 (0.125)
Disease	-0.004 (0.133)
Change in the perception of the child's weight (2022-2017)	0.093 (0.075)
Number of persons under 18 years of age in the household	-0.293*** (0.077)
Long-term social benefits	0.015 (0.037)
Household net monthly income	-0.011 (0.04)
Eating homemade snack in school	1.466*** (0.371)
BMI	-0.01 (0.018)
Constant	-1.118 (0.583)
Log likelihood	-756.085
Prob > chi ²	0.000
Pseudo R ²	0.035
LRchi ²	64.26

Note: standard errors in parentheses; *, ** and *** indicate statistical difference at 10%, 5% and 1% level, respectively; N = 1142.

In terms of age groups, the ATE is negative but not statistically significant for children aged 3-5 years old, suggesting that the AEM may not be effective for this group in preschool establishment. For children aged 11 years and above, the ATE is not statistically significant, implying that the AEM may not have a significant effect on the change in fruit consumption for this age group either. However, for children aged 6-10 years old, the ATE is statistically significant at the 5% level, indicating a positive effect of the AEM on the average change in frequency of daily fruit consumption.

The effect of the AEM on the outcome variable of change in the average frequency of consumption of vegetables by children (Table 6), the ATEs show a mixed pattern. The overall ATE is positive but not statistically significant, suggesting that the AEM may have a limited effect on the change in vegetable consumption. However, the effect sizes differ across subgroups. The ATE is statistically significant at the 10% level for children in rural areas, indicating a positive effect of the AEM on the change in vegetable consumption frequency for this group. On the other hand, the ATE is negative and statistically significant

at the 5% level for children in urban areas, implying that the accompanying educational measures may have a negative effect on the change in vegetable consumption for this group. This result may be due to the low number of vegetable varieties and portions provided to children in schools within the School Scheme, as well as the AEM's insufficient attention to the assortment and forms of eating vegetables that are more appealing to children.

In terms of gender, the ATEs of the AEM on average change in the average frequency of consumption of vegetables by children show a different pattern for boys and girls. For girls, the ATEs are negative but not statistically significant, suggesting that the accompanying educational measures may not have a significant effect on the change in vegetable consumption for this group. However, for boys, the ATEs are positive and statistically significant at the 5% level, indicating a positive effect of the AEM on the change in vegetable consumption for this group.

In terms of age groups, the ATEs show a mixed pattern as well. For children aged 3-5 years old, the ATE is positive but not statistically significant. However, for children aged 6-10 years old, the ATE is statistically significant at the 1% level, indicating a positive effect of the AEM on the change in vegetable consumption for this group. For children aged 11 years and above, the ATE is negative but not statistically significant, suggesting that the AEM may not have a significant effect on the change in vegetable consumption for this age group.

Based on the results presented, it appears that AEM have a positive average treatment effect (ATE) on the change in children's frequency of fruit consumption in all three regions of Slovakia. However, the magnitude of the effect varies by age and gender of the child, as well as their urban/rural status. The effect sizes vary by region, with the largest effect seen in Eastern Slovakia. The results for vegetable consumption are less consistent. In West Slovakia, there is no significant effect of AEM on vegetable consumption, while in Central Slovakia, the effect varies by age and urban/rural status. In Eastern Slovakia, the effect is positive for boys and urban children, but negative for rural children.

We found that the AEM may be a useful intervention for promoting healthy eating habits in children, particularly regarding fruit consumption. These findings are consistent with previous research that suggests nutrition education can improve children's dietary intake and increase their consumption of fruits and vegetables (e.g., Evans et al., 2012). A systematic review by Van Cauwenberghe et al. (2010) found that school-based interventions that included nutrition education, increased availability of healthy foods, and/or changes to the school environment (e.g., school gardens) were effective in improving children's dietary habits. Golley et al. (2010) found that a school-based intervention that included cooking workshops, taste testing, and nutrition education led to significant increases in children's fruit and vegetable consumption. Our findings align with previous research that emphasizes the significance of comprehensive, multi-component interventions that tackle various factors influencing children's dietary habits. These factors may include the availability of healthy foods, parental support, and environmental cues (Swinburn et al., 2011).

Table 5. Average treatment effect (ATE PSM) of accompanying educational measures (AEM) on a change in child's frequency of children fruit consumption (treated vs. non-treated)

Change in fruit consumption	0.061* (1.66)	West Slovakia	0.017 (0.33)	Girl	0.064 (0.84)
				Boy	0.113* (1.72)
				Rural	0.082 (1.24)
				Urban	0.143 (1.53)
				3-5 years old	-0.081 (0.21)
				6-10 year old	0.073* (1.01)
		11 year old and above	0 (0.00)		
		Central Slovakia	0.078 (1.03)	Girl	0.1 (0.90)
				Boy	0.037 (0.31)
				Rural	0.154 (1.35)
				Urban	-0.13* (-1.77)
				3-5 years old	-0.023 (-0.14)
				6-10 year old	0.101 (1.00)
		11 year old and above	-0.031 (-0.19)		
		Eastern Slovakia	0.228*** (2.70)	Girl	0.193 (1.55)
				Boy	0.085 (0.84)
				Rural	0.156 (1.13)
				Urban	0.09 (0.82)
3-5 years old	-0.071 (-0.15)				
6-10 year old	0.186** (2.06)				
11 year old and above	0.318** (2.04)				

Note: z value in parenthesis; *, ** and *** indicate statistical difference at 10%, 5% and 1%, respectively.

The ATE of AEM on the change in children's vegetable consumption frequency is generally not statistically significant or even negative. This indicates that the extent or form of the AEM may be insufficient in effectively increasing vegetable consumption compared to its effect on fruit consumption. Previous studies have also reported mixed findings on the effectiveness of nutrition education in increasing vegetable consumption (e.g., Sharps and Robinson, 2016).

However, it's important to consider under the School Scheme regional differences in the effectiveness of the intervention and tailor the approach accordingly. Further research may be necessary to understand the factors influencing vegetable consumption, regional variations, the effectiveness of different forms and frequencies of AEM implementation, and to develop effective strategies for promoting healthy eating habits among children.

Table 6. Average treatment effect (ATE PSM) of accompanying educational measures (AEM) on a change in child's frequency of vegetable consumption

Change in vegetable consumption	0.030 (0.38)	West Slovakia	-0.025 (-0.50)	Girl	-0.117 (-1.68)
				Boy	0.072 (1.13)
				Rural	0.098* (1.43)
				Urban	-0.22** (-2.36)
				3-5 years old	-0.014 (-0.14)
				6-10 year old	0.003 (0.05)
				11 year old and above	-0.138 (-1.54)
		Central Slovakia	0.048 (0.56)	Girl	0 (0.00)
				Boy	-0.038 (-0.34)
				Rural	-0.108(-0.58)
				Urban	0.240 (3.10)
				3-5 years old	0.209*** (6.17)
				6-10 year old	0 (0.00)
				11 year old and above	-0.207 (-1.11)
		Eastern Slovakia	0.056 (0.62)	Girl	0.087 (0.67)
				Boy	0.191** (2.50)
				Rural	-0.051 (-0.49)
				Urban	0.293 *** (2.97)
				3-5 years old	0 (0.00)
				6-10 year old	0.171 (2.03)
				11 year old and above	0.113 (0.82)

Note: z value in parenthesis; *, ** and *** indicate statistical difference at 10%, 5% and 1%, respectively.

4. Conclusion

Based on the results of the study, AEM conducted under the EU School scheme in Slovakia has a positive effect on the change in the frequency of children's consumption of fresh fruits and vegetables. Specifically, we found that the AEM had a positive effect on the frequency of children's fruit consumption in all three regions of Slovakia, with larger effects observed among boys and older children. However, the effect on vegetable consumption was less consistent across regions and demographic groups, with some groups showing positive effects and others showing no significant effect.

These findings are consistent with previous research on the effectiveness of school-based interventions aimed at promoting healthy eating habits among children. The positive effect of the AEM observed in this study may be due to the variety of activities included in the intervention, which incorporated elements of nutrition education, experiential learning (e.g., farm visits and cooking workshops), and environmental changes (e.g., school gardens).

It is important to note that the effect of the AEM on vegetable consumption was less consistent across regions and demographic groups, suggesting that additional tailoring or customization of the AEM intervention may be necessary to better address the unique needs and preferences of different groups of children.

Additionally, future research may benefit from more detailed process evaluations to better understand the specific components of the AEM that were most effective in promoting behaviour change.

During the examined period in Slovakia, the educational measures accompanying the AEM were conducted in schools by approved suppliers of school fruit and vegetables. However, the AEM were not mandatory in the participating schools and were not provided to all children. The results of the study emphasize the importance of conducting AEM in all schools and ensuring that all children have access to them. Additionally, there is a need for more intensive implementation of AEM, including forms that involve the participation of children's parents.

In conclusion, the results of this study indicate that the AEM implemented through the EU School Scheme in Slovakia have the potential to positively influence children's dietary habits, specifically in terms of fruit consumption. However, further customization or adaptation of the intervention might be required to effectively address the specific needs and preferences of different subgroups of children.

Acknowledgements

This study was conducted using the database and partial results of the evaluation study of the Implementation of the School Scheme Fruit, Vegetables, Milk, and Dairy Products in Slovakia for the Slovak Ministry of Agriculture and Rural Development. We would like to express our gratitude to Jan Kobida and Zuzana Lazarekova for their technical assistance.

References

- Beal, T., Morris, S. S. and Tumilowicz, A. (2019). "Global patterns of adolescent fruit, vegetable, carbonated soft drink, and fast-food consumption: a meta-analysis of global school-based student health surveys", *Food and Nutrition Bulletin*, vol. 40, no. 4, pp. 444-459, DOI 10.1177/0379572119848287
- Bell, A. C. and Swinburn, B. A. (2004). "What are the key food groups to target for preventing obesity and improving nutrition in schools?", *European Journal of Clinical Nutrition*, vol. 58, no. 2, pp. 258-263, DOI 10.1038/sj.ejcn.1601806
- Bevans, K. B., Sanchez, B., Teneralli, R. and Forrest, C. B. (2011). "Children's eating behavior: the importance of nutrition standards for foods in schools" *Journal of School Health*, vol. 81, no. 7, pp. 424-429, DOI 10.1111/j.1746-1561.2011.00612.x
- Bleich, S. N., Vercammen, K. A., Zatz, L. Y., Frelief, J. M., Ebbeling, C. B. and Peeters, A. (2018). "Interventions to prevent global childhood overweight and obesity: a systematic review", *The Lancet Diabetes and Endocrinology*, vol. 6, no. 4, pp. 332-346, DOI 10.1016/S2213-8587(18)30045-1
- Colley, P., Myer, B., Seabrook, J. and Gilliland, J. (2018). "The impact of Canadian school food programs on children's nutrition and health: A systematic review", *Canadian Journal of Dietetic Practice and Research*, vol. 80, no. 2, pp. 79-86, DOI 10.3148/cjdpr-2018-010
- Craigie, A. M., Lake, A. A., Kelly, S. A., Adamson, A. J. and Mathers, J. C. (2011). "Tracking of obesity-related behaviours from childhood to adulthood: a systematic review", *Maturitas*, vol. 70, no. 3, pp. 266-284, DOI 10.1016/j.maturitas.2011.08.005

- DeCosta, P., Møller, P., Frøst, M. B. and Olsen, A. (2017). “Changing children's eating behaviour. *A review of experimental research*”, *Appetite*, vol. 113, pp. 327-357. DOI 10.1016/j.appet.2017.03.004
- Delgado-Noguera, M., Tort, S., Martínez-Zapata, M. J. and Bonfill, X. (2011). “Primary school interventions to promote fruit and vegetable consumption: a systematic review and meta-analysis”, *Preventive Medicine*, vol. 53, no.1-2, pp. 3-9, DOI 10.1016/j.ypmed.2011.04.016
- Dudley, D. A., Cotton, W. G. and Peralta, L. R. (2015). “Teaching approaches and strategies that promote healthy eating in primary school children: a systematic review and meta-analysis”, *International Journal of Behavioral Nutrition and Physical Activity*, vol. 12, pp. 1-26, DOI 10.1186/s12966-014-0154-x
- EP. European Parliament. (2016), Regulation (EU) 2016/791 of the European Parliament and of the Council of 11 May 2016 amending Regulations (EU) No. 1308/2013 and (EU) No. 1306/2013 as regards the aid scheme for the supply of fruit, vegetables, bananas and milk in educational establishments.
- Eurostat (2019). Nutritional habits statistics. [Online] Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Fruit_and_vegetable_consumption_statistics&oldid=412723, [Accessed: 16 Jan. 2023]
- Evans, C. E., Christian, M. S., Cleghorn, C. L., Greenwood, D. C. and Cade, J. E. (2012). “Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 y”, *The American Journal Of Clinical Nutrition*, vol 96, no.4, pp. 889-901, DOI 10.3945/ajcn.112.037465
- Golley, R., Baines, E., Bassett, P., Wood, L., Pearce, J. and Nelson, M. (2010). “School lunch and learning behaviour in primary schools: an intervention study”, *European Journal of Clinical Nutrition*, vol 64, no. 11, pp. 1280-1288, DOI 10.1038/ejcn.2010.151
- Hendrie, G. A., Lease, H. J., Bowen, J., Baird, D. L. and Cox, D. N. (2017). “Strategies to increase children's vegetable intake in home and community settings: a systematic review of literature”, *Maternal & Child Nutrition*, vol. 13, no. 1, e12276, DOI 10.1111/mcn.12276
- Hodder, R. K., O'Brien, K. M., Tzelepis, F., Wyse, R. J. and Wolfenden, L. (2020). “Interventions for increasing fruit and vegetable consumption in children aged five years and under”, *Cochrane Database of Systematic Reviews*, vol. 5, DOI 10.1002/14651858.CD008552.pub3
- Ip, P., Ho, F. K. W., Louie, L. H. T., Chung, T. W. H., Cheung, Y. F., Lee, S. L., ... and Jiang, F. (2017). “Childhood obesity and physical activity-friendly school environments”, *The Journal of Pediatrics*, vol. 191, pp. 110-116, DOI 10.1016/j.jpeds.2017.08.079
- Kachútová, M., Šátek, M. and Mlček, J. (2019). “Influence of School Environment on Dietary Habits of Children and Adolescents”, *Nutrients*, vol. 11, no 1, p. 96, DOI 10.3390/nu11010096
- Kastorini, C. M., Lykou, A., Yannakoulia, M., Petralias, A., Riza, E. and Linos, A. (2016). “The influence of a school-based intervention programme regarding adherence to a healthy diet in children and adolescents from disadvantaged areas in Greece: the DIATROFI study”, *J Epidemiol Community Health*, vol. 70, no. 7, pp. 671-677, DOI 10.1136/jech-2015-207256

- Kristjansdottir, A. G., Thorsdottir, I., De Bourdeaudhuij, I., Due, P., Wind, M., and Klepp, K.-I., (2006). “Determinants of fruit and vegetable intake among 11-year-old schoolchildren in a country of traditionally low fruit and vegetable consumption”, *International Journal of Behavioral Nutrition and Physical Activity*, vol. 3, no. 1, p. 41, DOI <https://doi.org/10.1186/1479-5868-3-41>
- Liu, Z., Xu, H. M., Wen, L. M., Peng, Y. Z., Lin, L. Z., Zhou, S., Li, W. H. and Wang, H. J. (2019). “A systematic review and meta-analysis of the overall effects of school-based obesity prevention interventions and effect differences by intervention components”, *International Journal of Behavioral Nutrition and Physical Activity*, vol. 16, no. 95, p. 12, DOI [10.1186/s12966-019-0848-8](https://doi.org/10.1186/s12966-019-0848-8)
- Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., ... and Gakidou, E. (2014). “Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013”, *The Lancet*, vol. 384, no. 9945, pp. 766-781, DOI [10.1016/S0140-6736\(14\)60460-8](https://doi.org/10.1016/S0140-6736(14)60460-8)
- Øvrebø, B., Stea, T. H., Te Velde, S. J., Bjelland, M., Klepp, K. I. and Bere, E. (2019). “A comprehensive multicomponent school-based educational intervention did not affect fruit and vegetable intake at the 14-year follow-up”. *Preventive Medicine*, vol. 121, pp. 79-85, DOI [10.1016/j.ypmed.2019.01.022](https://doi.org/10.1016/j.ypmed.2019.01.022)
- Rasmussen, M., Krølner, R., Klepp, K. I., Lytle, L., Brug, J., Bere, E., Due, P. and Behrendt, S. (2006). “Determinants of fruit and vegetable consumption among children and adolescents: A review of the literature. Part I: Quantitative studies”, *International Journal of Behavioral Nutrition and Physical Activity*, vol. 3, no. 1, p. 22, <https://doi.org/10.1186/1479-5868-3-22>
- Regan, A., Parnell, W., Gray, A. and Wilson, N. (2008). “New Zealand children's dietary intakes during school hours”, *Nutrition & Dietetics*, vol. 65, no. 3, pp. 205–10, DOI [10.1111/j.1747-0080.2008.00268.x](https://doi.org/10.1111/j.1747-0080.2008.00268.x)
- Rosenbaum, P. R. and Rubin, D. B. (1983). “The central role of the propensity score in observational studies for causal effects”, *Biometrika*, vol. 70, no. 1, pp. 41-55, DOI [10.1093/biomet/70.1.41](https://doi.org/10.1093/biomet/70.1.41)
- Schwartz, M. B., Henderson, K. E., Read, M., Danna, N. and Ickovics, J. R. (2015). “New school meal regulations increase fruit consumption and do not increase total plate waste”, *Childhood Obesity*, vol. 11, no. 3, pp. 242-247, DOI [10.1089/chi.2014.0114](https://doi.org/10.1089/chi.2014.0114)
- Sharps, M. and Robinson, E. (2016). “Encouraging children to eat more fruit and vegetables: Health vs. descriptive social norm-based messages”, *Appetite*, vol. 100, pp. 18-25, DOI [10.1016/j.appet.2016.01.028](https://doi.org/10.1016/j.appet.2016.01.028)
- Story, M., Kaphingst, K. M., Robinson-O'Brien, R. and Glanz, K. (2008). “Creating healthy food and eating environments: policy and environmental approaches”, *Annu. Rev. Public Health*, vol. 29, pp. 253-272. DOI [10.1146/annurev-publhealth-040617-013446](https://doi.org/10.1146/annurev-publhealth-040617-013446).
- Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L. and Gortmaker, S. L. (2011). “The global obesity pandemic: shaped by global drivers and local environments”, *The Lancet*, vol. 378, no.9793, pp. 804-814. DOI [10.1016/S0140-6736\(11\)60813-1](https://doi.org/10.1016/S0140-6736(11)60813-1)

Van Cauwenberghe, E., Maes, L., Spittaels, H., Van Lenthe, F. J., Brug, J., Oppert, J. M. and De Bourdeaudhuij, I. (2010). “Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and ‘grey’ literature”, *British Journal of Nutrition*, vol. 103, no. 6, pp. 781-797, DOI 10.1017/S0007114509993370

WHO (2018). Taking action on childhood obesity report, 2018, [Online], Available: <https://apps.who.int/iris/bitstream/handle/10665/274792/WHO-NMH-PND-ECHO-18.1-eng.pdf?ua=1>, [Accessed: 18 Jan. 2023]

DESIGNING AN EFFECTIVE USER INTERFACE FOR VR SIMULATION IN AGRICULTURAL MACHINERY ENVIRONMENTS

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Annotation: Human capital and education play a critical role in the success of agriculture, not just in production but also in non-production functions. Optimizing the user interface for virtual reality (VR) simulations in agricultural machinery environments requires understanding human behavior and cognitive processes, which can be achieved through education and training. Therefore, investing in human capital and education in agriculture is essential for addressing the industry's challenges and achieving its goals.

This paper aims to optimize the user interface for virtual reality simulations in agricultural machinery environments. The study utilized eye-tracking technology to assess the user experience (UX) of two types of menus: panel and radial menus. The study revealed that menus are essential for the digital product user experience, allowing for efficient navigation and content access.

Both types of menus were found to be above average in usability, with the panel menu significantly outperforming the radial menu. Heat maps showed that participants concentrated on only a portion of the buttons on the panel menu, while the radial menu had a more dispersed field of concentration.

Despite the advantages of the radial menu highlighted by some participants, Concurrent Think-aloud method (CTA) and Retrospective Think-aloud (RTA) interviews consistently indicated that the panel menu was more intuitive, visually appealing, and easier to use, as it was located near the point of interest, the tractor. On the other hand, the radial menu was functional but challenging, particularly when switching attention between the menu and the tractor or raising the hand.

Key words: UI, VR, Eye-tracking, panel menu, radial menu, usability, UX

JEL classification: L64, L86, O32

1. Introduction

By using VR simulators, researchers can safely test and refine human-machine interfaces without risking the safety of human workers. This approach allows for the optimization of new control systems, ensuring that they are user-friendly and efficient. Additionally, the use of VR simulators can provide valuable data on human behavior and decision-making in complex scenarios, which can inform the design of safer and more productive construction equipment. In this way, the combination of human capital and technology can lead to improvements in both productivity and safety in the construction industry. In a study evaluating advanced human-machine interfaces for hydraulic excavators, researchers found that immersive VR simulations improve efficiency and ergonomics without causing mental or physical strain on operators (Morosi and Caruso, 2021; Makarov et al., 2021; Dhalmahapatra et al., 2021).

VR consists of a computer-generated virtual environment where the user can interact with the environment and objects. Well-designed VR can help people immerse themselves

in what feels like a believable reality-like experience (Quesnel and Riecke, 2018). Although VR is not new, thanks to recent developments in immersive technologies, especially in visualization and interaction, VR is becoming increasingly attractive to scientists. The latest displays for VR head-mounted displays (HMDs), such as the HTC Vive or Oculus Rift, allow users to experience a high degree of immersion (Radianti et al., 2020) instead. The immersion describes the technical capabilities of a system; it is the physics of the system. The subjective correlate of embeddedness is presence. If a participant in VR perceives naturally using his or her senses, then the most straightforward inference the brain's perceptual system can make is that what is perceived is the participant's virtual environment (Slater and Sanchez-Vives, 2016).

Menus are an integral part of digital product user experience (UX), allowing users to easily navigate and find the features or content they need. It also gives users a sense of control over the app and makes it easier for them to interact with it. Studies have shown that a quality and intuitive menu can significantly improve a product's overall friendliness and usability and can be a critical factor in achieving success in the marketplace (Merritt and Zhao, 2021).

In the desktop application, the menu is created as a list of individual items to offer, where each item is associated with a specific command. Alternatives to this approach are pie menus, where each item is shaped like part of a pie and has the same proportion of the whole, making them efficient in terms of Fitts' law. These bids are usually designed to execute simple commands, with more complex tasks, such as multiple selections, which should be executed using other user interface elements (UI). These menus could be applied to VR, but the Fitts Act states that multiple aspects of VR offerings should be considered in development (Monteiro et al., 2019).

Fitts' law is used to evaluate human-computer interactions and to estimate movement time and difficulty index. However, Fitts' law is generally useful for measuring and estimating movement times between objects on the same axis or in the same dimension. In other words, the measurement axis can be either horizontal or vertical and cannot be used to measure both axes simultaneously (Nookhong and Kaewrattanapat, 2022).

User experience (UX) refers to a user when interacting with a product or service. This experience can be encountered in various activities, such as ordering food in restaurants, shopping, or commuting to work. However, the quality of the experience can vary depending on the context, as seen in the examples of a stressful morning car journey or a leisurely walk through a park. In contrast, usability is defined as the degree to which a particular entity can use a given system to effectively, efficiently, and satisfactorily achieve specific objectives within a well-defined context of use (Hassenzahl & Tractinsky, 2006). It encompasses three main factors related to the user's characteristics and objectives and the context of use: effectiveness, efficiency, and satisfaction. When evaluating usability, the goal is to ensure that aspects such as efficiency and effectiveness are consistent with the product under test (Quesnel & Riecke, 2018).

UI usability is essential because it assesses the product's pragmatic aspects related to the behavioral objectives that software must achieve. In the context of virtual reality (VR) games, usability evaluation should carefully consider the influence of VR features and gameplay goals (Radianti et al., 2020). For instance, a limited field of view can hinder the user's ability to step back and see the bigger picture in critical situations. This demonstrates the role of usability in achieving learning objectives in simulations

and real-world situations. However, different games may have different requirements, and user testing on focus groups is necessary for game development. Previous studies have shown that usability also affects assessing factors that enhance learning (Fernández-Manjón et al., 2011). Therefore, usability evaluation is crucial in improving the overall user experience and achieving the desired outcomes in simulation training for participants to concentrate on the task, not the menu.

Various interaction techniques have been developed in virtual and augmented reality. While object selection, manipulation, travel, and pathfinding techniques are already in existing taxonomies and have been described in considerable detail, application control techniques still need to be sufficiently considered. However, these are needed by almost every mixed reality application, e.g., alternative objects or options. They are also needed for all kinds of real-world applications. For this purpose, there are many different techniques for selecting from three-dimensional (3D) menus (Dachselt & Hübner, 2006).

According to a study by Gebhardt et al. (2013), the most common approach for selecting a technique for VR menu ray-cast type. Users can directly point to the object for selection using a virtual ray cast, as a "laser pointer" does in the real world. Another method is to use a virtual fingertip to select from a menu. This uses a one-to-one mapping method, which is very intuitively similar to the real world. The limitation of this method is that the user experiences great difficulty in perceiving depth in the virtual environment. In addition, the user can only select from menus within arm's reach.

The most immersive VR systems typically include HMDs and handheld controls. HMDs are used in specific areas of medical practice and education, but their use proliferates. This kind of technology is also being applied in other various fields. Using a headset, the user can move and rotate in 3D space as if there they are. Also, the digital environment responds directly to the user's movements. HMD technology can provide the user with complete immersion in the virtual environment (Salovaara-Hiltunen et al., 2019).

Our research mainly focused on developing and testing an effective user interface for virtual reality (VR) simulations in agricultural machinery environments based on previous research. Our study's objective was to optimize this UI's position and layout so that it could be tested afterward from the view of UX. Therefore, also compare and replicate the research but with augmentations from the way of our collective knowledge about the ideal position and coordinates of the panel menu, therefore using eye-tracking technology in the usability study.

We have not yet been able to identify a similar UX evaluation of VR technology used for simulations in agriculture, although similar machines are used. Therefore, research potential can be identified here.

The following sections summarize the necessary overview for familiarisation with the issue and introduce the essential background processes for the testing and data collection. We present the individual testing steps and then present the results with graphs and scale. We conclude with comments on the results and possible future research directions.

2. Materials and Methods

Our paper also reports on a study conducted by Monteiro et al. (2019) on 51 participants who were presented with two different types of menus in a virtual reality environment. The menus

were presented in four possible combinations and placed in two locations: fixed on a wall and attached to the user's hand. The study measured various factors, including menu usability, user satisfaction, interaction time, and the number of unnecessary steps. The results indicated that participants preferred the traditional panel menu in the virtual reality environment and performed better with it than with the radial menu. Therefore, the study highlights the importance of considering the type of menu and its location when designing menus for virtual reality environments.

Similar to the study conducted by Monteiro et al. (2019), our research involved a total of 50 participants. 40 was used to identify the appropriate menu position. A further 10 were used to test the actual environment. The object of the study was to identify a better solution between the two options. We look for errors and identify better solution based on their minimization. This allows us to rely on the methods presented by Nielsen (2012) and Virzi (1992), who present that it takes about five testers to identify 80% of usability errors.

Our sample included 18% women 82% men, with an average age of 24 years. Potential visual deficits were not addressed due to the focus of the study. 8 participants commonly wear glasses or contact lenses. None of the participants complained about any vision problems in the VR environment. 18 participants have used VR technology before, 2 of them work with it on a regular basis. The average length of the test trial and, thus, working in the VR environment lasted 24 minutes.

Thanks to the equipment available in our VR laboratory, we could utilize eye-tracking technology. Eye-tracking interfaces use real-time eye movements as a mode of user interaction. This interface can be valuable when other interaction modes are unavailable or not preferred, such as when users have severe motor impairments or when their hands are occupied with other tasks. Although eye-tracking may not be as precise as using handheld controllers in VR, it can be much faster than traditional input devices (Špakov et al., 2014; Sibert and Jacob, 2000). Techniques for visualizing scan paths, such as heatmaps, are useful for analyzing the way subjects process information (Goldberg & Helfman, 2010). By using a fap that shows the degree of fixation accumulation, researchers can gain insights into the patterns of visual attention exhibited by subjects while performing a task (Wang et al., 2014). A heatmap can reveal which areas received the most visual attention and which areas were ignored during the task (Cai, Sharma, Chatelain, & Noble, 2018).

Testing itself contained two testing processes. First, we focused on the panel menu and its position due to the more straightforward processing of the results from the scene. The first process of the testing had a general focus and helped to lock the menu in the proper position. The second process was first connecting the mentioned environment. Then select the machinery's attributes (model, color, equipment), in our case, a tractor.

The first testing consisted of several parts:

- Introduction;
- Introduction to the VR HW controls;
- Setting the menu parameters;
- Usability testing;
- Guided interview.

Participants were informed of the testing and reassured that they were not the ones being tested, but the environment and any missteps or controls were perfectly fine. VR technology

was unfamiliar to most participants and made them a little nervous about interacting with the tester in a virtual space. Participants were familiarized with the technology and taught how to operate menus, which was a central part of the testing. The participants made decisions about parameters in a specific order:

1. Distance of the menu from the user;
2. The size of the menu;
3. Height of the menu from the ground;
4. Scroll left/right;
5. Rotation.

Before beginning the main tasks of the study, it was important for participants to become familiar with the research environment. To achieve this, participants were first given a set of simple tasks to complete, allowing them to become more comfortable with the research environment and the tasks that were to come.

During VR user interface testing, the Concurrent Think-aloud method (CTA) is often used. This method allowed us to test different aspects of the user interface and get immediate valuable feedback from users. Once the UI testing is complete, there is a short phase during which the tester interacts with the test user to gain further insights into their experience of using the product. This process is called a guided interview or Retrospective Think-aloud (RTA) and is usually conducted immediately after testing (Prokop et al., 2020).

The equipment we used has the I-VT fixation, a classification algorithm based on velocity, which identifies eye movements by analyzing the velocity of directional shifts of the eye (Olsen, 2012).

After usability testing, the respondent completed a questionnaire using the standardized System Usability Scale (SUS) method, which consisted of 10 sentences to evaluate various aspects of usability. The questionnaire used a Likert scale to assess ease of use, confidence, inconsistencies, and need for technical assistance. SUS scores provide a measure of overall usability and are considered a valuable evaluation tool (Brooke, 1996, p. 194).

Measurement results are reported in Unity units, where 1 unit corresponds to 1 meter in real space. The default menu position was 1.5 meters above the virtual floor and 5 meters from the user. The results can be divided into two categories: relevant and irrelevant. The relevant parameters are the height of the menu located on the Y-axis and the distance of the menu from the user on the X-axis. The less relevant parameters are the slope of the menu along the Z-axis and the size of the menu. Participants were most comfortable with menu positions between 1.16-1.86 meters from the virtual floor. Regarding the distance from the user, the ideal intervals ranged from 4.7 to 5.2 meters. Less than half of the participants changed the default menu position.

The second testing process, as mentioned before, was based on the study conducted by Monteiro et al. (2019). In this research, the authors compared the panel and radial menus. Thanks to the virtual reality laboratory, which includes eye-tracking HMD Vive pro eye, we were able to get diverse data. We compared a static panel menu with a radial menu positionally locked to the hand. Participants used a ray cast to control the panel menu and a touchpad for the radial menu, with finger tracking.

The second testing (for both menus) consists of several parts:

- Introduction;
- Introduction to the VR HW controls;
- Usability testing;
- Guided interview;
- SUS

Menu parameters were taken from the first testing process. We took coordinates and made a panel menu, which corresponds with the panel menu from the study by Monteiro et al. (2019). The changes were made on the base of Fitt's law; we adjusted the buttons to a space in the body of the menu for shorter distances between buttons. The radial menu was based on the research of Salkanovic et al. (2020), which was the implementation and analysis of pie menus for mobile touch devices. Then we start the usability testing of both menus. Tasks were assigned in a specific order for the participant to perform:

1. Change the color of the tractor to red;
2. Change the type of the tractor to New Holland;
3. Change the equipment to a trailer;
4. Change all parameters mentioned before based on preferences, and please share experiences with a menu out load.

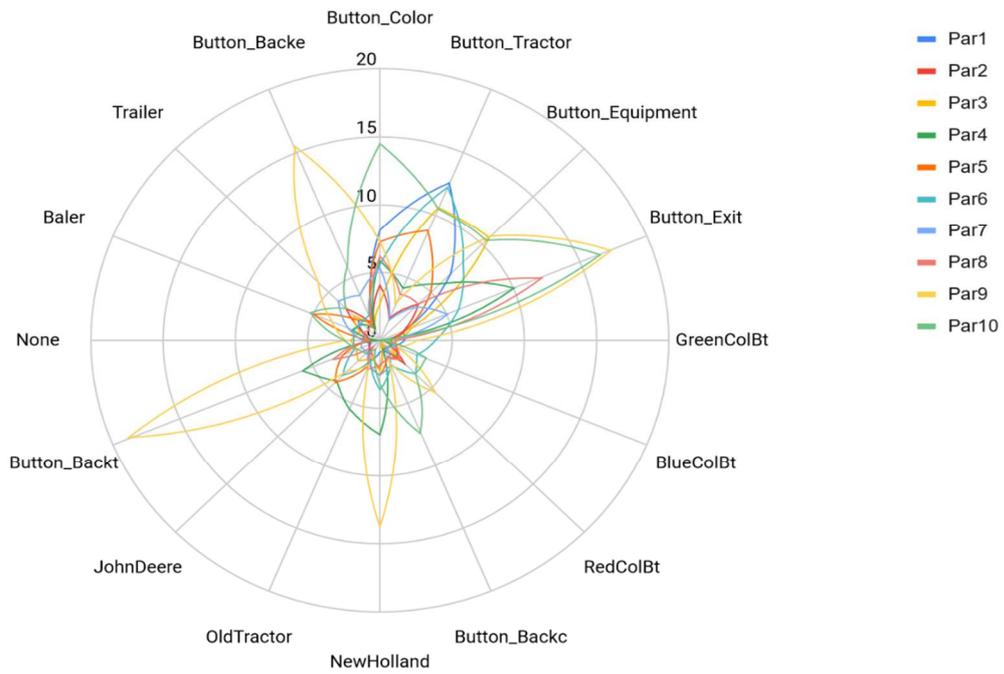
We collected heatmaps from every button in the radial menu and panel menu. We also collected the total fixation duration of participants looking at the buttons, then the first fixation time and first fixation length.

3. Results and Discussion

The testing demonstrated the value of using VR technology in user experience research. As VR technology continues to gain popularity, it presents exciting opportunities for improving simulations and other types of content. Although we know that the test sample of our participants was not significant, we believe this study is a gate to our more complex research in the future.

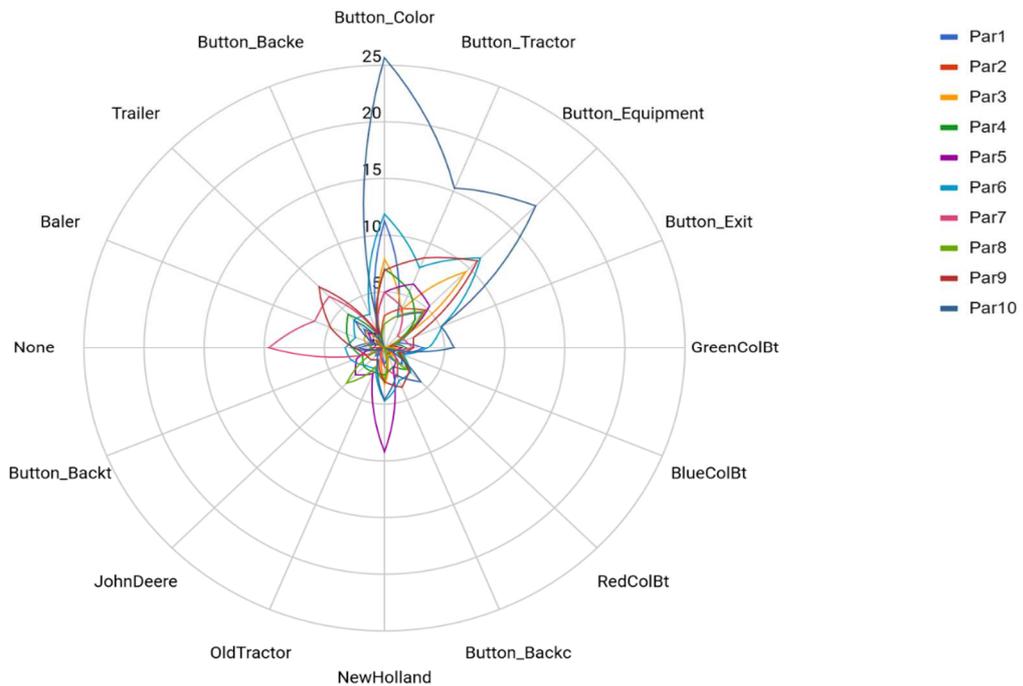
In terms of eye-tracking results, the heatmaps show that most participants only focused on the part of the button for the panel menu buttons. Most of the buttons in the panel menu had two or fewer points of higher concentration. In comparison, heat maps on buttons of the radial menu had a much more vast field and usually more than 2 points of higher concentration. When we look at the data of total duration on the buttons, we can say that participants spend much more time looking at buttons of the radial menu (see Fig. 1,2), which tells us the dispersion on the graph, where the middle line shows us duration in seconds. Most participants spend more than 5 seconds concentrating on the buttons. On the other hand, when testing the panel menu, most of the participants fit up to 5 seconds.

Figure 1. Total duration in seconds (Radial menu)



Source: own processing

Figure 2. Total duration in seconds (Radial menu)



Source: own processing

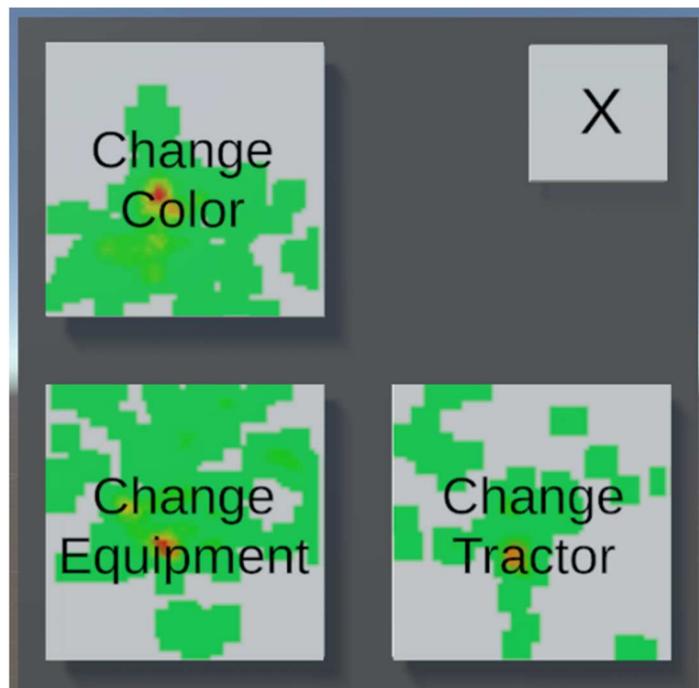
Observing both data sets, we can say that even though both menus do not have some great value, in most cases, the results are better for the panel menu. Furthermore, these results correspond to the obtained heat maps (see Fig. 3,4).

Figure 3. Heat map (Radial menu)



Source: own processing

Figure 4. Heat map (Panel menu)



Source: own processing

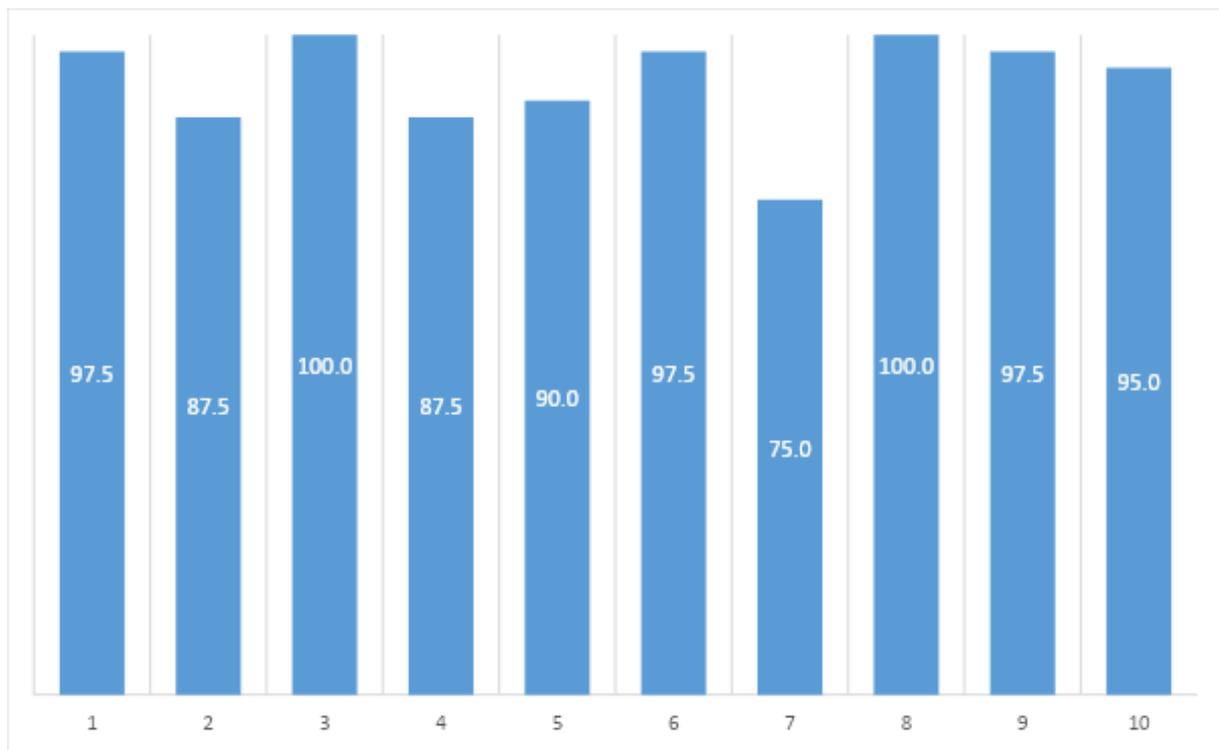
During the CTA and RTA, participants consistently mentioned that the panel menu was easier to handle, visually appealing, and intuitive. They appreciated having the menu close to the point of interest (the tractor). However, the radial menu was also deemed functional but

difficult to handle, especially when switching between the menu and tractor or raising the hand. Even though some participants compared the handling of the radial menu to phone-like activity, they did not consider it for an advantage.

The SUS value is scored on a scale from 0 (worst) to 100 (best), with scores below 68 considered below average and scores above 68 considered above average (Bangor, Kortum, & Miller, 2008). In our study, the arithmetic means SUS score of all 10 participants was 92 for the panel menu and 71 for the radial menu.

This indicates that both menus are above average in terms of usability. Mainly the panel menu indicates a significantly above-average score, even for individual participants (see Fig. 5). Where the bottom line shows the participant and the column shows the score.

Figure 5. Individual panel menu SUS survey results (SUS score)



Source: own processing

4. Conclusion

The successful optimization of the user interface for virtual reality simulations in agricultural machinery environments relies heavily on human capital and education in agriculture. Therefore our study aimed to optimize the user interface for virtual reality simulations in agricultural machinery environments. We utilized eye-tracking technology in our usability study to assess the user experience of the panel and radial menus.

We found that both the panel menu and the radial menu scored above average in usability, with the panel menu significantly outperforming the radial menu. Heat maps indicated that participants concentrated on only a portion of the buttons on the panel menu, while the radial menu had a more dispersed field of concentration. Additionally, participants spent more time looking at the buttons of the radial menu.

However, in CTA and RTA, participants consistently mentioned that the panel menu was more intuitive, visually appealing, and easier to use, as it was located near the point of interest, the tractor. In contrast, the radial menu was functional but challenging, particularly when switching between the menu and the tractor or raising the hand. Our findings suggest that the panel menu is more favorable regarding usability and user experience than the radial menu, despite some advantages highlighted by some participants.

Within our study, we encountered particular potential problems related to the use of specific research methods in the area of usability and UX but applied them to the VR environment. That is an environment in which the majority of users do not experience the same ease of navigation as when interacting with a conventional computer UI. A comprehensive verification of potential modifications to standard methods is beyond the scope of our study but remains an interesting prospect for possible future research in this area.

Acknowledgements

This work was supported by the Internal Grant Agency of the Faculty of Economics and Management CZU Prague (IGA FEM) - grant no. 2023A0010. The research was carried out in the VR and UX laboratories of FEM CZU, Prague.

References

- Brooke, J. (1996). "SUS - a quick and dirty usability scale", in P. Jordan, B. Thomas, B. A. Weerdmeester, and A. L. McClelland (eds.), *Usability Evaluation in Industry*, pp. 189-194. ISBN: 9780429157011
- Cai, Y. et al. (2018a). "SonoEyeNet: Standardized fetal ultrasound plane detection informed by eye tracking", in *2018 IEEE 15th International Symposium on Biomedical Imaging (ISBI 2018)*, pp. 1475-1478. <https://doi.org/10.1109/ISBI.2018.8363851>
- Dachselt, R. and Hübner, A. (2006). "A Survey and Taxonomy of 3D Menu Techniques", *The Eurographics Association*, pp. 89-99. <https://doi.org/10.2312/EGVE/EGVE06/089-099>
- Dhalmahapatra, K., Maiti, J. and Krishna, O. B. (2021). "Assessment of virtual reality-based safety training simulator for electric overhead crane operations", *Safety Science*, 139, p. 105241. <https://doi.org/10.1016/j.ssci.2021.105241>
- Goldberg, J. H. and Helfman, J. I. (2010). "Comparing information graphics: a critical look at eye tracking", *Proceedings of the 3rd BELIV'10 Workshop: BEyond time and errors: novel evaluation methods for Information Visualization, Association for Computing Machinery*, pp. 71-78. <https://doi.org/10.1145/2110192.2110203>
- Hassenzahl, M. and Tractinsky, N. (2006). "User experience - A research agenda", *Behaviour and Information Technology*, 25, pp. 91-97. <https://doi.org/10.1080/01449290500330331>
- Makarov, D. et al. (2021). "Usability assessment of compaction operator support systems using virtual prototyping", *Automation in Construction*, vol. 129, p. 103784. Elsevier. Available at: <https://doi.org/10.1016/j.autcon.2021.103784>

Merritt, K. and Zhao, S. (2021). “An Innovative Reflection Based on Critically Applying UX Design Principles”. *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 7, no. 2, p. 129. MDPI. Available at: <https://doi.org/10.3390/joitmc7020129>

Monteiro, P. et al. (2019). “Comparison of Radial and Panel Menus in Virtual Reality”. *IEEE Access*, vol. 7, pp. 116370–116379. IEEE. Available at: <https://doi.org/10.1109/ACCESS.2019.2933055>

Morosi, F. and Caruso, G. (2022), “Configuring a VR simulator for the evaluation of advanced human–machine interfaces for hydraulic excavators”. *Virtual Reality*, vol. 26, no. 3, pp. 801–816. Springer. Available at: <https://doi.org/10.1007/s10055-021-00598-z>

Nielsen, Jakob, Nielsen Norman Group, How Many Test Users in a Usability Study?, (2012). [Online], Available: <https://www.nngroup.com/articles/how-many-test-users/>, [Accessed: 20 Dec. 2022]

Nookhong, J. and Kaewrattanapat, N. (2022). “The Comparison of Techniques for Estimating and Measuring the Movement Time of the Right Thumb in a Curve on a Smartphone Based on Fitt’s Law”, *Journal of Advances in Information Technology*, vol. 13, no. 2. Available at: <https://doi.org/10.12720/jait.13.2.155-161>

Olsen, A. and Matos, R. (2012). “Identifying parameter values for an I-VT fixation filter suitable for handling data sampled with various sampling frequencies”, *Eye Tracking Research and Applications Symposium (ETRA)*, pp. 317–320. <https://doi.org/10.1145/2168556.2168625>

Prokop, M., Pilař, L. and Tichá, I. (2020). “Impact of Think-Aloud on Eye-Tracking: A Comparison of Concurrent and Retrospective Think-Aloud for Research on Decision-Making in the Game Environment”. *Sensors*, vol. 20, no. 10, p. 2750. MDPI. Available at: <https://doi.org/10.3390/s20102750>

Quesnel, D. and Riecke, B. E. (2018). “Are You Awed Yet? How Virtual Reality Gives Us Awe and Goose Bumps”. *Frontiers in Psychology*, vol. 9, p. 2158. Frontiers Media. Available at: <https://doi.org/10.3389/fpsyg.2018.02158>

Radianti, J. et al. (2020). “A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda”. *Computers & Education*, vol. 147, p. 103778. Elsevier. Available at: <https://doi.org/10.1016/j.compedu.2019.103778>

Salkanovic, A., Stojkovic, M. and Ljubic, S. (2020). “The Effect of Dwell Time on Swipe-based Pie-Menu Navigation Efficiency”. *International Journal of Online and Biomedical Engineering (iJOE)*, vol. 16, no. 15, pp. 4–22. iJOE. Available at: <https://doi.org/10.3991/ijoe.v16i15.17763>

Salovaara-Hiltunen, M., Heikkinen, K. and Koivisto, J.-M. (2019). “User experience and learning experience in a 4D virtual reality simulation game”, *International Journal of Serious Games*, vol. 6, no. 4, pp. 49–66. <https://doi.org/10.17083/ijsg.v6i4.305>

Sibert, L. and Jacob, R. J. K. (2000). "Evaluation of Eye Gaze Interaction Techniques", *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 7, no. 4, pp. 394–427.
<https://doi.org/10.1145/332040.332445>

Slater, M. and Sanchez-Vives, M. V. (2016). "Enhancing Our Lives with Immersive Virtual Reality", *Frontiers in Robotics and AI*, vol. 3, pp. 1–6.
<https://doi.org/10.3389/frobt.2016.00074>

Špakov, O., Isokoski, P. and Majaranta, P. (2014). "Look and lean: Accurate head-assisted eye pointing", *Eye Tracking Research and Applications Symposium (ETRA)*, pp. 35–42.
<https://doi.org/10.1145/2578153.2578157>

Virzi, R. A. (1992). "Refining the test phase of the usability evaluation: how many subjects is enough?" *The Journal of the Human Factors and Ergonomics Society*, vol. 34, no. 4, pp. 457–468. ISSN 1547-8181

Wang, Q., Chen, X., Liang, Y. and Huang, J. (2014). "An eye-tracking study of website complexity from cognitive load perspective", *Decision Support Systems*, no. 62, pp. 1–10.
<https://doi.org/10.1016/j.dss.2014.02.007>

STUDENTS' INCLINATION TO WORK IN AGRICULTURE: DOES RURAL ORIGIN MATTER IN PRE-WAR UKRAINE?

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Annotation: Already in pre-war times, the availability of skilled labour was a major development challenge for agricultural enterprises in Ukraine. Despite a high enrolment rate in primary and secondary education and despite the fact, that the Ukrainian state finances 22 (!) agricultural universities, agribusiness is increasingly affected by a mismatch between educational outcomes and the skills needs of the sector. This raises questions regarding efficiency of the agricultural education system as a whole. Moreover, even among agriculturally educated students enrolled at an agricultural university, a shift in career incentives from agriculture-related jobs to other sectors has been observed not only for Ukraine but also for other states of the former Soviet Union.

Our study investigates several aspects and framework conditions influencing the decision of future graduates for a career in agriculture. Based on findings from other countries, we expected students originating from rural areas to be more inclined to work in agriculture after graduation since they have already been embedded in rural lifestyles and have been at least partly familiar with agricultural production before they started to study at a university/college. Based on the same reasoning, we furthermore expected that students whose parents work in agriculture or own farmland or a farm are more in favour to work in agriculture than those whose parents do not.

The study is based on a survey, conducted online in February 2022 among 600 undergraduate and graduate students who study a diverse range of programs offered by 13 agricultural universities and 14 agricultural colleges (technological, managerial, humanities, veterinary). Bivariate tests of association and multivariate logit models are employed to identify direct links and interactions between aspects of respondents' rural origin on the one hand and their stated willingness to work in agriculture after graduation on the other hand.

While 64 percent of the responding students plan to work in agriculture after graduation, rural origin indeed does indeed make a difference: the frequency of students who grew up in a rural area was found to be 44% higher than that of students coming from cities ("relative risk"). A 41 percent higher rate of students with parents presently working in agriculture plan to work in agriculture compared to those whose parents don't. The relative frequency for students with parents owning agricultural land is 22 percent higher while the fact that parents are actually founders/owners of a family farm is not associated with higher rate of inclination towards working in agriculture.

Key words: Agricultural labour market, agricultural university, education, attraction towards agricultural jobs, Ukraine

JEL classification: I23, I25, J24, J43 Q19

1. Introduction

Already in pre-war times, the availability of skilled labor was a major development challenge for agricultural enterprises in Ukraine. Despite a high enrolment rate in primary and secondary education and despite the fact, that the Ukrainian state finances 22 agricultural

universities, agribusiness is increasingly affected by a mismatch between the flow of graduates from these educational institutions and the skills needs of the sector. Employers criticize the educational system to undersupply graduates with practical and other types of skills, as well as up to date knowledge (OECD, 2015). This raises questions regarding efficiency of the agricultural education system as a whole. Moreover, even among agriculturally educated students enrolled at an agricultural university, a shift in career incentives from agriculture-related jobs to other sectors has been observed not only for Ukraine but also for other states of the former Soviet Union (Unay-Gailhard et al., 2018).

This brief sketch of the current situation is influenced by a wide variety of factors, which are partly the result of a decades-long backlog of modernization in the Ukrainian education system, but are presumably - and this is where our study comes into play - also influenced by the changing lifestyles and career models of young people (or in our case agriculturally educated students). Already in peacetime, a skilled workforce is critical to the agricultural sector and the vitality of rural areas in ensuring resilient production systems and a livable future.

So, what influences the decision for a career in or outside of agriculture? Again, a number of different factors can be considered, as former surveys from other post-soviet countries propose: For instance, Sutherland (2008) addressed the question of rewards associated with agricultural employment on privatized state and collective farms in Russia. Looking again at Russia - now the Altai Region in Siberia - Unay-Gailhard et al. (2018) test two constructs, each of them encompassing various items: “Sociofamilial background” (expressed as human and financial capital accrued by parents) and “considerations throughout the life course” (expressed as work-life expectations, working-life quality and life satisfaction).

In reference to and as partial extension of the sociofamilial background construct of Unay-Gailhard et al., this contribution looks on two basic socioeconomic aspects and their potential influence on future job choice: First, we take a closer look at the “geographical origin”, or more precisely we ask in our survey if the respondent grew up in a rural or urban setting. This question is inspired by the underlying hypothesis that students originating from rural areas are more inclined to work in agriculture after graduation since they have already been embedded in rural lifestyles and have been at least partly familiar with agricultural production before they started to study at a university/college. Second, we also investigate the “role of parental imprinting”. Here we check if any of the parents is working in agriculture either as owner and manager of a family farm or as an employee in agriculture. Here again, we would expect, that the ambitions of students to choose a career path in agriculture may differ between those whose parents are working in agriculture and those whose parents have no professional attachment to agriculture. We do not have a fixed expectation about the direction of such influence but consider both possibilities: what they observe about their parents work in agriculture could either attract them towards or repel them from agriculture.

2. Materials and Methods

The population of interest comprises undergraduate and graduate students in agricultural colleges and universities which offer a variety of programs more or less related to agriculture. With support by the ministry of education 13 agricultural universities and 14 agricultural colleges were selected so as to cover students in the most popular programs (technological, managerial, humanities, veterinary). An online survey was conducted on the google surveys

platform in February 2022. Students were provided a link to the online survey platform by their teachers and asked to complete the survey at home. They were informed that participation is voluntary and that teachers have no access to the individual responses.

The survey instrument in Ukrainian language encompasses 120 multiple choice type items and 19 open response items. Thematically the survey addresses perception of the program they are actually in, their plans for further studying and for working as well as values and preferences for working life. The instrument also inquires sociodemographic characteristics.

The focus of this study is in on an item the translation of which reads "Would you like to work in agriculture after graduation?" with response choices "Yes" and "No". The item used characterizing rural origin is "In which type of settlement did you grow up?" with choices "Rural", "Town (<100 000 inhabitants)", and "City". For the analyses we combined the "Town" and "City" categories ending up with the two categories "Rural" and "Urban". Parental professional background is reflected by the item "Does anyone of your parents work in agriculture?" with Yes/No choice options.

As survey participation by gender and by age groups differed to non-negligible extent from the population of interest, i.e. from all students in agricultural colleges/universities, binary variables on these characteristics (m/f and ages up to 18 and over 18 years) were included as control variables.

Bivariate analyses are employed to investigate impacts of two independent variables on respondents' stated willingness to work in agriculture after graduation (Y): the respondents' origin (DO with levels rural or urban) and their parents' working sector (DP with levels agriculture or not agriculture). The indicator used to measure such impact is *difference of proportions* which is the difference in the share of "Yes" responses in the item "Do you want to work in agriculture?" between the two groups classified by the independent variable. Such analyses of relations between two binary variables are intuitively appealing but they can be misleading if other variables are associated with both, dependent and independent variables analyzed. Simpson's paradox, e.g., addresses cases in which even the direction, the sign, of association is reversed if important covariates are not accounted for. Hence, we complement the bivariate indicators of association with a multivariate model.

In the framework of a multinomial logit model we investigate the dependence of students' willingness to work in agriculture of both, the rural or urban origin of the student and parents work in- or outside agriculture. We account for the gender and age group of the student as further potentially relevant groupings.

We assume the probability $P(Y="Yes")$ of a student's choice on the item "willing to work in agriculture" to have a binomial distribution. The logit of the probability of "Yes", i.e. the logarithm of the odds, is modelled as a linear function in the following binary variables

- D_O for student's origin (1=rural, 0=urban),
- D_P for parent working sector (1=at least 1 parent in agriculture, 0= both outside agriculture)
- D_G for student's gender (1=male, 0=female), and

- D_A for student's age group (1=over 18yrs, 0=up to 18yrs):

$$\text{logit}[P(Y = Yes)] = \alpha + \beta_o D_o + \beta_p D_p + \beta_G D_G + \beta_A D_A \quad (1)$$

Estimation results of the multinomial logit model can be expressed as odds ratios and fitted values can indicate expected probabilities of willingness to work in agriculture for different groupings of students.

3. Results and Discussion

Our sample covers 636 students from 13 universities and 14 colleges in all parts of the country. 69% are enrolled in undergraduate courses, 31% in master courses. Respondents are enrolled in 42 different programs from six different fields: agricultural technology related (25%), food industry related (8%), non-agricultural technology related (6%), business and economics (20%), veterinarian (35%), humanities (6%). Whereas no random sampling was applied and the actual respondents self-selected themselves into the sample careful selection of target colleges, universities and programs facilitate to reflect the heterogeneity of the population of interest.

Table 1 informs about the distributions of the variables employed in the statistical analyses.

The bottom line of Table 1 shows that 64 percent of the responding students plan to work in agriculture after graduation. We first examine the relevance of students' regional origin and their parents work in separate analyses. Rural origin does indeed seem to make a difference: the lines showing totals of rural and urban origin indicate that the frequency of "Yes" was 77% among students who grew up in rural areas, but only 56% among students from urban areas. The difference of proportions of 77% - 56% = 21 percentage points is substantially larger than the zero percentage points which would be expected if inclination to work in agriculture were independent from students' origin. The fact that our data cannot be regarded as sufficiently close to a random sample rules out stringent inferential statements to replace the expression "substantially larger" but if we use formulae stemming from such stringent statistical context to provide an idea of the size of difference of proportions found in the sample (21%) relative to the uncertainty that is reflected in the frequency counts of "Yes-rural", "No-rural", "Yes-urban", and "No-urban" we obtain a (Wald) lower 95% confidence interval (e.g., Agresti, 2018, p. 29) of 14 percentage points which suggests that a difference of proportions of 21 percentage points is far enough from unity to regard a positive influence of origin on inclination to work in agriculture plausible.

Analogously we find that students with any parent working in agriculture are substantially more likely inclined to working in agriculture than those whose parents work elsewhere. The difference of proportions is (36%-14%=) 22 percentage points with a (Wald) lower 95% confidence interval of 15% which can be interpreted as sign of positive influence of agricultural engagement of parents.

Table 1. Distribution of variables used in the study

Origin	Parent(s) work	Gender	age	Yes	No	Total	Want to work in agriculture	
							Yes %	No %
Rural	Agricultural	Female	<=18	21	5	26	81%	19%
			>18	18	1	19	95%	5%
			<i>total</i>	<i>39</i>	<i>6</i>	<i>45</i>	<i>87%</i>	<i>13%</i>
		Male	<=18	15	7	22	68%	32%
			>18	21	2	23	91%	9%
			<i>total</i>	<i>36</i>	<i>9</i>	<i>45</i>	<i>80%</i>	<i>20%</i>
	total		75	15	90	83%	17%	
	Non-agricultural	Female	<=18	34	21	55	62%	38%
			>18	28	9	37	76%	24%
			<i>total</i>	<i>62</i>	<i>30</i>	<i>92</i>	<i>67%</i>	<i>33%</i>
Male		<=18	22	8	30	73%	27%	
		>18	35	5	40	88%	13%	
		<i>total</i>	<i>57</i>	<i>13</i>	<i>70</i>	<i>81%</i>	<i>19%</i>	
total		119	43	162	73%	27%		
Total				194	58	252	77%	23%
Urban	Agricultural	Female	<=18	16	5	21	76%	24%
			>18	10	2	12	83%	17%
			<i>total</i>	<i>26</i>	<i>7</i>	<i>33</i>	<i>79%</i>	<i>21%</i>
		Male	<=18	12	2	14	86%	14%
			>18	5	0	5	100%	0%
			<i>total</i>	<i>17</i>	<i>2</i>	<i>19</i>	<i>89%</i>	<i>11%</i>
	total		43	9	52	83%	17%	
	Non-agricultural	Female	<=18	66	73	139	47%	53%
			>18	45	40	85	53%	47%
			<i>total</i>	<i>111</i>	<i>113</i>	<i>224</i>	<i>50%</i>	<i>50%</i>
Male		<=18	30	21	51	59%	41%	
		>18	32	25	57	56%	44%	
		<i>total</i>	<i>62</i>	<i>46</i>	<i>108</i>	<i>57%</i>	<i>43%</i>	
total		173	159	332	52%	48%		
total				216	168	384	56%	44%
total				410	226	636	64%	36%

Source: authors' survey

The multinomial logit model described in the methods section was fitted to the contingency table displayed in Table 1 using the glm function from the stats package of R version 4.3.0. Estimated coefficients as well as residual deviance as a measure of overall model fit are presented in Table 2.

Table 2. Selected estimation results

Coefficients:								
	Estimate	Std. Error	z value	Pr(> z)				
(Intercept)	-0.1364	0.1397	-0.977	0.328625				
YouGrewUpRural	0.7341	0.1889	3.886	0.000102	***			
ParWorkInAgYes	1.0339	0.2501	4.134	3.56e-05	***			
sexMale	0.3095	0.1839	1.683	0.092377	.			
age>18	0.3927	0.1776	2.211	0.027014	*			
Signif. codes:	0	'***'	0.001	'**'	0.01	'*' 0.05	'.' 0.1	' ' 1
Null deviance: 71.649 on 15 degrees of freedom								
Residual deviance: 14.403 on 11 degrees of freedom								

Residual deviance provides a measure of how close fitted values are to the observed choice frequencies. The residual deviance of 14.4 with 11 degrees of freedom indicates that the fit of the model is acceptable.

Table 3 provides odds ratios (ϵ raised to the power of the respective coefficient estimate) with confidence limits. They can be interpreted as factors indicating how many times higher the expected probability of a “Yes” response is in the respective group relative to the reference group. An odds ratio of 1.0 would indicate equal likelihood in both groups, i.e. that the likelihood of inclination towards working in agriculture is independent from the respective variable. The expected value of 2.1 in the first line indicates that students from rural origin are – on average - 2.1 times as likely as (or equivalently 110% more likely than) students from urban origin to be willing to work in agriculture.

Table 3. Odds ratios describing effects of independent variables

	OR	2.5 %	97.5 %
YouGrewUpRural	2.1	1.44	3.0
ParWorkInAgYes	2.8	1.75	4.7
sexMale	1.4	0.95	2.0
age>18	1.5	1.05	2.1

As mentioned above in the context of differences of proportions the indicated confidence limits (as well as distributional measures and indicators provided in Table 2) must not be understood here in the way applicable in the context of randomized studies, meaning as estimates of the range containing the true value with a probability of 95 percent. However, we think that they may help to quickly gain an idea of the uncertainty of the indicated point estimates which readers could gain alternatively by examining the relative sizes of point estimates and e.g., standard deviations of these estimates.

The analysis suggests that having grown up in a rural settlement and – to an even larger extent - having parent(s) who work in agriculture increases the probability of students to plan a career in agriculture. For male students and students over 18 years of age the estimated

probability is still 40 and 50 percent higher than for female and younger students but here the uncertainty of the point estimates is relatively larger.

This study describes a first investigation into a comprehensive data set addressing factors which may affect the flow of academically trained labor into agriculture in Ukraine. One clear result is that students with at least one parent working in the agricultural sector, that means students who could and can directly observe and experience this kind of work are more likely inclined to work in agriculture themselves than students with no parent working in agriculture. This may mean that inhibitions to working in agriculture may have to do with ideas about agricultural work (not based on actually knowing this work) that are less attractive than what is actually experienced by students with direct experience of agricultural professions. Does this mean that the image of work in agriculture is worse than what is justified by reality? Results from Siberia reported by Unay-Gailhard et al. (2018) point into the direction that unfavorable concepts of work in agriculture oftentimes stem from vague assumptions rather than factual experience in the sector. Further analyses in our survey that addresses images, perceptions, values and attitudes of students will shed more light on this. Aside from positive impressions that students get from farming parents other reasons could be influential. Parents may be wishing that their children follow their professional footsteps and the students may be inclined to fulfilling their parents' wishes. Also this aspect will be further addressed based on our Ukrainian survey.

A similar reasoning as with regard to students with parents working in agriculture may be valid for those having experienced life in rural settlements in their childhood and earlier youth. Also these students were found to be more likely inclined to working in agriculture. Also here a possible explanation is that conception of rural life and life in agricultural regions are not as favorable as what people living in these areas actually experience.

4. Conclusion

Shortage of labor, particularly academically trained labor forms a challenge to Ukrainian agriculture and rural development. This is the case although a considerable number of agricultural universities and agricultural colleges exist. The survey among agricultural students which is used in the narrowly focused analysis presented here investigates attitudes, aspirations, values and views of students in agricultural universities, which are likely to be connected with their willingness to work in agriculture after finishing their studies.

Students who grew up in rural settlements and students with parents employed or self-employed in agriculture were found to be more likely to plan working in agriculture than students with urban background and those whose parents do not work in agriculture.

If hypotheses developed in this study about mechanisms behind these findings can be substantiated one strategy to improve the situation of severe shortage in agricultural labor could be to engage in information campaigning about numerous positive aspects of working in agriculture, a sector with enormous development potential in Ukraine.

The (relatively restrictive) specification presented cannot reflect the complex relationships between attitudes, aspirations, values and opinions of the respondents on the one hand and their inclination towards work in agriculture on the other hand. The results merely offer a focused snapshot of associations between two potential determinants of values and attitudes and a certain aspect of career plans. More comprehensive analyses involving several

interdependent and predetermined factors in a loglinear model are on the way. They will examine structural relationships between values, work-life expectations/aspirations, assessment of the labour market situation and the career-steps planned by the students.

Acknowledgements

The authors would like to express their gratitude to Ksenia Trachenko, Manager at UCABevent agency of the Association of “Ukrainian Agribusiness Club” for her support in conducting the survey of agricultural students in Ukraine.

References

Agresti, A. (2018). An introduction to categorical data analysis (3 ed.): John Wiley & Sons. ISBN: 978-1-119-40528-3

OECD. (2015). Identifying and Addressing Skills Gaps in Ukraine; Project summary of working group on skills development for agribusiness. Retrieved from https://www.oecd.org/eurasia/competitiveness-programme/eastern-partners/Skills_Gap_Assessment_Ukraine_ENG.pdf

Sutherland, L.-A. (2008). Post-Soviet Agricultural Employment: A Case Study of Employee Incentives in Krasnodar Territory, Russia. *The Journal of Peasant Studies*, vol. 35, no. 3, pp. 369-389. doi:10.1080/03066150802340404

Unay-Gailhard, Í., Bavorová, M., Bednaříková, Z., and Ponkina, E. V. (2018). “I Don’t Want to Work in Agriculture!” the transition from agricultural education to the labor market in Rural Russia. *Rural Sociology*, vol. 84, no. 2, pp. 315-349. doi:10.1111/ruso.12245

THE ECONOMIC LEVEL OF CZECH AGRICULTURE AS DETERMINED BY THE PRODUCTIVITY OF PRODUCTION FACTORS AND CLIMATE DEVELOPMENT

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Annotation: The article describes the development of land, labour and capital productivity in agriculture (2002-2020), characterizes the crop mix (the 10 most cultivated crops in the Czech Republic) with respect to climate change. The authors draw on data from the CZSO, MoA and IAEI. Index analysis and factor efficiency indicators are used. Labour productivity has more than doubled from 2008 to 2020. Productivity growth is driven by both the declining number of AWUs and rising industry output. Output in current prices increased by 46 %, while in kind it increased by 11 %. The growth in total output is driven by crop production. Land productivity is also increasing (up 9 % in constant prices).

Wheat, barley, rapeseed and fodder crops account for the largest percentage of income in the crop mix. Wheat has increased its share in the crops mix from 2002 (28.97 % of mix income) to 30.36 %. Potatoes have decreased their share of product mix income by 4 %. The production (tonnes) of all crops in the mix increased except barley, sugar beet and potatoes. The profitability of crop production in the Czech Republic is affected by hot summers, lack of rainfall and low capacity of irrigation systems.

Key words: efficiency, soil, labour, AWU, cost, agricultural production, crops

JEL classification: J24, Q54

1. Introduction

Therefore, as economic growth is increasingly constrained by resources and the environment, intensive land use has become one of the effective ways to achieve sustainable urban development. The problem is that changes in land use will inevitably lead to a number of environmental problems.

Land use intensity is characterized by increasing agricultural output per unit of land through management practices, and or increasing the amount of inputs (Lorel et al., 2019). Increased outputs per unit of land occur through improved management practices or increased use of inputs such as fertilizers, pesticides, or energy (Erb et al., 2013). Agroecosystems face increasing demand for agricultural products, feed, and bioenergy. Thus, increasing land use intensity is a dominant strategy that can lead to reduced competition for land (Haberl, 2015). This is confirmed by many models of future land use, as land use will need to be intensified even more, especially in industrial regions (Lambin et al., 2000). However, intensive agriculture poses major threats to European biodiversity (German et al., 2017), and to the provision of ecosystem services (Allan et al, 2015; Simoncini et al., 2019). Nutrients used to increase agricultural production become pollutants when they run off arable

land, are transported to groundwater and delivered to streams. Rivers in many agricultural areas are experiencing increases in nutrient loads of phosphorus (P) and nitrogen (N), degrading surface and groundwater quality and eutrophying local streams and lakes (Cooke et al., 1993).

Accepted manure management practices fail to adequately protect waters from excess nutrients, microbial pathogens and added pharmaceuticals. Heavier manure and fertilizer applications, especially at times when the soil cannot readily absorb them, combined with an increase in the frequency and intensity of storm events, are now threatening surface and groundwater quality even in areas with deeper soils (Wang, 2017). Increasing nutrient loading in surface and subsurface waters degrades water quality and promotes the formation of "dead zones" (Waller, 2021). Agricultural pollution remains a difficult policy issue. As land-use change affects environmental degradation globally (IPBES, 2019) and in Europe (EEA, 2020), monitoring land-use change is a key area of research and policy. However, the extensification of agricultural production may bring with it challenges within the social role of agriculture. There is a predominant use of technology and the labour force is decreasing. This is also due to the different labour intensity within each type of farming. According to Hlavsa and Štolbová (2007), in general, extensive farms with a high proportion of grassland employ fewer people.

Agricultural labour is increasingly affected by changing climatic conditions. According to Cortignani et al. (2021), arable farms (horticulture, fruit and greenhouses), e.g. located in southern Italy, adapt to changes in agricultural conditions mainly by abandoning crops with lower labour productivity. This will reduce family work and worker employment, a serious outcome in areas where unemployment is already high. The production of crops that are implemented in months with higher water availability is offered. However, the low production of these crops does not allow for increased wages for family labour.

The differences in labour productivity between developing and developed countries are much larger in agriculture than in non-agricultural areas (Blanco and Raurich, 2022). The authors divide agricultural products into two sectors for comparison purposes: capital-intensive agriculture and labour-intensive agriculture. As the economy develops and capital accumulation increases, the price of labour-intensive agricultural products rises relative to capital-intensive agricultural products. This price change drives a process of structural change that shifts land and farmers to the capital-intensive sector, thereby increasing labour productivity in agriculture. Giannakis and Bruggeman (2018) addressed agricultural productivity in different farming systems and regions of Europe. They analysed the impact of environmental (soil erosion, rainfall yield potential), structural (farmer education, age, plurality, diversification, rented farmland), technical (yield ratio) and contextual (gross domestic product per capita, population density) factors on labour productivity. Reidsma et al. (2010) remains the most important study of the link between adaptation pathways and profitability, using an econometric approach to assess the impact of structural characteristics and climatic and socioeconomic conditions on farm performance between 1990 and 2003. His results show that adaptation to climate change is largely influenced by crop rotation and input management, as well as farm size and land use intensity.

2. Materials and Methods

Data base: Production is valued at the basic price (i.e. the price the producer receives from the buyer plus the subsidies received for the product from the government minus excluding indirect taxes). Agricultural production in the concept of the methodology of the Aggregate Agricultural Account (AAA) is not derived from the sales of the enterprise, but from the quantity of production in kind (including unfinished production) and the realisation prices of agricultural primary producers (EUR-Lex, 2004). The data are drawn from the Czech Statistical Office (CZSO), which publishes information in the AAA. The final data are known for 2020. The data included in the research are from 2002 -2020. Until 2001, the CZSO collected data by exhaustive survey. The basis for determining the respondent population of the agricultural surveys since 2002 are the results recorded by the nationwide structural agricultural census - Agrocensus 2000. This procedure is fully in line with Eurostat legislation, which defines the statistical reporting unit on the basis of specified "thresholds". Since 2002, the harvested area is not collected separately; hectare yields are calculated per hectare of production area. The production area, excluding grain maize, green and silage maize and permanent grassland, is equal to the area reported in the sowings. The sown area is the sum of all arable crops grown on arable land. The agricultural sector includes agricultural primary production enterprises whose activity is crop and livestock production and services for agriculture.

A partial data base for the research is the commodity and outlook reports of the MoA, which are based on the research of the MoA and the outputs of the Institute of Agricultural Economics and Information (IAEI)

Using the formula

$$\text{Cost – effectiveness (\%)} = \frac{\text{Intermediate consumption (IC)}}{\text{Output of the agricultural industry (OAI)}} * 100 \quad (1)$$

$$\text{Labour productivity (\%)} = \frac{\text{NVA or GVA}}{\text{AWUs}} * 100 \quad (2)$$

$$\text{Productivity of inanimate labour} = \frac{\text{NVA or GVA}}{\text{Gross fixed capital formation (GFCF)}} \quad (3)$$

$$\text{Efficiency of the sector (\%)} = \frac{\text{NVA or GVA}}{\text{Output of the agricultural industry (OAI)}} * 100 \quad (4a)$$

$$\text{Efficiency of the sector (\%)} = \frac{\text{Production subsidies}}{\text{Factor income}} * 100 \quad (4b)$$

$$\text{Wage disparity (\%)} = \frac{\text{Everage gross earnings by sector}}{\text{National economy wage}} * 100 \quad (5)$$

$$\text{Base index (C}_B\text{)} = \frac{\text{Value of the autumnal period}}{\text{Basic baseline period}} \quad (6)$$

$$\text{Cost – effectiveness of the crop (\%)} = \frac{\text{Realisation price minus production costs}}{\text{Production costs}} * 100 \quad (7)$$

Note:

AWU = Annual Work Unit (AWU). One AWU corresponds to the number of hours actually worked in a full-time agricultural job. 1 AWU = 1800 hours, 225 working days of eight hours (Eurostat, 2019).

GVA = Gross value added at basic prices (Output of the agricultural sector less intermediate consumption).

NVA = Net value added at basic prices (Gross value added - depreciation. New value created by industries from the use of their productive capacity..

GFCF = Gross fixed capital formation (The AAA distinguishes five types of components of gross fixed capital formation, namely: planting of crops with recurring yields, livestock, tangible and intangible fixed assets, machinery and equipment, transport equipment, agricultural buildings (non-residential).

OAI = Output of the agricultural industry. Includes the output of agricultural services and non-agricultural secondary activities (non-separable).

IC = Intermediate consumption consists of the value of goods and services consumed as inputs into the production process, excluding fixed assets, the consumption of which is recorded as consumption of fixed capital.

Factor income = remuneration of all factors of production and represents the total value created by units through their productive activities.

The sector is classified according to the CZ NACE section.

Source: EUR-Lex (2004).

Further methodological description of the indicators used in the Aggregate Agricultural Account (AAA):

ENTERPRENEURIAL INCOME = Operating surplus - interest paid+ interest received

OPERATING SURPLUS = Net value added at basic prices - compensation of employees- other taxes on production+ other subsidies on production

CROP OUTPUT (Crop production) = cereals (including seeds) + industrial crops + forage plants+ vegetables + fruits + wine + other crop products

LIVESTOCK SECTOR = animals + animal products

Source: EUR-Lex (2004), CZSO (2020a).

3. Results and Discussion

An important outcome indicator of Czech agriculture is the value of total agricultural production (current prices, constant prices). Equally important is the development of entrepreneurial income of the agricultural sector. The amount expresses not only the profit of agricultural enterprises and the means for their development, but also, in the case of natural persons' enterprises, the source of livelihood of the farmer's family.

In 2020, the entrepreneurial income in Czech agriculture reached CZK 19,093 billion. The agricultural sector's output in 2020 was the highest in five years (CZK 149 billion). Crop production increased year-on-year from CZK 79.9 billion in 2019 to CZK 87.7 billion in 2020. In contrast, the livestock sector saw a slight decline of CZK 0.22 billion to CZK 52.6 billion.

In year-on-year comparison, the cost intensity of production **(1)** was again reduced by 2.5 p.p. in 2020, followed by an increase in the share of gross and net value added in production **(4a)** by 2.6 p.p. and 3.2 p.p. respectively. The share of factor income support **(4b)** fell to 52.8%, decreasing by 7.2 p.p. relative to 2019 (MoA, 2020, CZSO, 2020a).

In 2020, there is a marked increase in the overall efficiency of the agricultural sector, mainly due to a decline in intermediate consumption, and the share of crop production, net and gross value added is also increasing. The declining share of livestock production is not in line with the strategic objectives of the MoA and is a negative development of the sector from this perspective (MoA, 2020). The wage disparity of the agricultural sector **(5)** is at 73 %. According to preliminary data for 2021 and 2022, the disparity is 79.1% and 79.8% respectively (CZSO, 2023). The wage gap is lower for unskilled workers and increases with education level and job position; it is highest for managerial workers (MoA, 2020). Total wage compensation in the agricultural sector increased by 2.03% year-on-year (2019-2020) (CZSO, 2020a). Employment in agriculture has been stable in recent years.

Literature sources may differ on the number of employees. Depending on whether they record agricultural workers or also fishery and hunting workers). The number of workers in 2020 was 92,800 Converted to AWU (AWU = 102,020; MoA, 2020) shows that the workforce is overburdened with a large amount of overtime (i.e. beyond 1800 hours/year).

The share of economically active in agriculture is about 1.9 % and is also stabilizing year-on-year. The age composition of agricultural workers in the country in 2000 was as follows: workers aged 45-59 years (40%) had the highest representation, followed by the category of workers aged 30-44 years (31.8%). The smallest share is in the category of workers aged 15-29 years (15.4%) and workers aged 60 years and over (12.8%) (MoA, 2020).

Labour productivity is a key factor in a country's economic performance. It is defined as the value of output per unit of labour input (animate or inanimate labour). The AWU is used in agriculture. After 2008, the CZSO reassessed the calculation of AWU, so it is not possible to compare the resulting productivity values with previous years (before 2008). Due to the decreasing number of AWU workers in agriculture and the increasing value of total agricultural production, labour productivity is increasing (more Table1).

Table 1. Selected indicators of Czech agriculture (2002-2020) – /price data in current prices/

	OAI	GVA	NVA	IC	GFCF	Agr. land	AWU
Year	Mil. CZK	Mil. CZK	Mil. CZK	Mil. CZK	Mil. CZK	ha	Number
2002	102 290.4	28 736.0	17 288.0	73 554.4	10 437.8	3 652 028	
2 003	93 670.7	27 070.0	16 265.8	66 600.8	9 845.6	3 668 380	
2 004	115 751.5	40 987.0	29 174.3	74 764.1	11 807.0	3 631 423	
2 005	102 893.1	29 789.0	16 796.8	73 104.2	14 171.8	3 605 493	
2 006	102 265.4	28 470.4	14 969.5	73 795.0	14 714.4	3 565 982	
2 007	120 182.5	33 549.7	19 368.8	86 632.8	15 685.3	3 596 716	
2 008	119 776.1	30 868.6	16 258.5	88 907.5	17 112.2	3 571 594	120 700
2 009	97 815.5	19 132.0	4 921.0	78 683.6	11 701.2	3 545 840	114 100
2 010	102 605.8	24 435.8	10 181.2	78 170.0	11 349.8	3 523 857	108 800
2 011	118 879.5	35 435.4	20 610.5	83 444.1	16 264.7	3 504 032	106 200
2 012	122 238.7	33 991.4	18 968.1	88 247.4	18 071.1	3 525 889	105 800
2 013	128 231.9	37 061.8	21 478.2	91 170.1	17 591.2	3 521 000	105 100
2 014	137 021.9	40 909.3	24 501.2	96 112.6	17 261.7	3 515 555	104 900
2 015	128 515.5	38 829.0	21 928.7	89 686.5	17 137.2	3 493 717	104 800
2 016	132 970.3	45 695.2	28 007.6	87 275.1	20 897.7	3 488 788	104 480
2 017	133 868.5	44 098.6	25 373.9	89 769.9	22 474.9	3 521 329	104 600
2 018	136 040.1	43 607.4	23 686.5	92 432.6	22 729.9	3 523 216	104 340
2 019	141 126.5	44 977.6	24 344.8	96 088.0	24 715.0	3 523 659	102 020
2 020	149 013.4	51 193.5	30 395.9	97 777.5	21 447.1	3 523 871	102 020
C _B 2002/20	1.46	1.78	1.76	1.33	2.05	0.96	0.85

Note: Abbreviations - see methodology.

Source: Own processing according to the data: CZSO (2020a, 2023), MoA (2004, 2010, 2014), MoA (2020) and CZSO (2020b).

Labour productivity (2) has more than doubled from 2008 to 2020. The calculation of labour productivity is interesting when converting agricultural outputs (production) into inanimate labour (labour of machinery, equipment, real estate - i.e. investment). Over the period 2002-2020, this productivity has a stable development with minor negative deviations. Calculation (3) shows that with every crown invested in new investment inputs in agriculture (2020), it generates 1.4 crown of NVA. This calculation is not commonly referred to as productivity but rather as intensity, as it is not "typical" labour. Productivity growth is not only influenced by the declining number of people employed in the sector, but also by the increasing output of the agricultural industry (OAI). In current prices, this is an increase of 46 % from 2002 to 2020, while in kind it is an increase of 11 %. The decisive factor in the increase in total output is crop production. Base index 2020/2002 (6) production at current prices = 1.72). The increase in total agricultural production also reflects increased production consumption (IC).

Similarly, the productivity (intensity) of the soil increases. Total agricultural production per hectare of agricultural land (constant prices) increased by 15 % (43 % at current prices). This is due to an increase in total sector production (11 %, constant prices) and also to a decrease in the area of agricultural land (-4 %).

The main intensification factor is therefore: reducing the area of agricultural land while increasing total production. The growth in agricultural production at constant prices per hectare (+15 %) with a simultaneous increase in production consumption per hectare of agricultural land represented a real increase in GVA per hectare of 32 %.

Total production consumption at constant prices (2002-2020) increased by only 3 %. while the increase in consumption in kind per hectare of agricultural land at constant prices was +6 %. Fertilisers and soil improvers¹ per hectare increased by 63 %. On the positive side, investment in agriculture is increasing. The value of gross fixed capital has more than doubled since 2002 These intensification factors have been increasing over the period under review (Table 2).

Table 2. Baseline indices of selected agricultural inputs (2002-2020)

	IC	GFCF	IC	Fertilisers*	GFCF	IC	Fertilisers*	GFCF
	Current prices		Fixed prices			Fixed prices per hectar of agr. land		
C _B 2002/20	1,33	2,05	1,03	1,47	1,64	1,06	1,63	1,7

Note: *) Fertilisers and soil improvers

Source: authors' calculations according to CZSO (2020a), Formula No 6

Business income (profit before tax and investment subsidies, Table 3) increased from 2002 to 2020 from CZK -2.6 billion to CZK 19 billion (Index = 8.19). This is not only due to the performance of Czech agriculture, but also to the support of the EU and the state budget of the Czech Republic. The payment of subsidies increased from CZK 6.8 billion (2002) to CZK 19 billion in 2005 (the year after EU accession) and to CZK 32.7 billion in 2020.

¹ Soil improvers include lime, peat, sludge, sand and synthetic foams

If Czech agriculture did not receive subsidies for production, the value of its profit (entrepreneurial income) would be CZK -14 billion (2020) (CZSOa).

Table 3. Profit of the sector

	Business income (Profit)	Business income per unit of land	Business income per unit of work	Received subsidies for production (EU, CR)
	Mil. CZK	CZK/ha	CZK/AWU	Mil. CZK
2002	-2 643.1	-723.73	84 032.2*)	6 786.6
2020	19 022.2	4 885.225	186 455.3	32 784.5
C _B 2002/20	8.19	8.46	2.22	5.11

Note: *) year 2008

Source: authors' calculations according to CZSO (2020a), MoA (2004) and MoA (2020).

A more detailed look is also focused on the production of the basic crop mix of crop production. This includes basic field crops and is produced on average on 93 % of the Czech Republic's sown area. In 2020, mix production was worth CZK 70 billion. The value of production (current prices) has increased by 67 % since 2002. The development of production over time is still monitored in real terms (production in CZK at basic prices). Mix production at constant prices (due to the increase in per hectare yields) increased by 14 %. The growth of the in-kind result of the mix production is moderate and gradual and is influenced by the decrease in the mix crop area. The decrease in the area sown in the production mix was -7 %. This is a reduction of more than 185 thousand hectares over 19 years. The area under sowing (total arable crops) fell by more than 224 thousand ha. The decrease in the area under arable crops is due to the removal of land from the agricultural stock (construction of infrastructure, planting of forests) or the conversion of arable land to permanent crops (increase in permanent crops by 153 000 ha). The loss of arable land in Czech agriculture (arable land plus fallow land) was also reflected in a decline in the area of sunflowers, mustard and vegetables (parsley, carrots, tomatoes, onions, peas, cucumbers, cabbage, cauliflower, cabbage) (CZSO, 2020a).

Crop mix production intensity (production/ha of sown area) increased by 33 %. Czech agriculture has a limited amount of agricultural land in the Czech Republic (0.4 ha/capita). The intensification process will therefore continue to be a way to ensure the production of crop products for the population and feed for livestock. Organic land management is increasing in the Czech Republic (15 % of agricultural land), mainly on permanent grassland.

Another indicator (production per capita) also documents the increased ability to produce crop commodities in the Czech Republic. The production of Mix crops in constant prices per capita increased by 17 % in the period 2002-20120 (from CZK 4 025/capita to CZK 4 692/capita, standard deviation = CZK 432/capita).

It is also interesting to see how the share of income of individual mix crops changes and thus their relevance also in terms of profitability. The data are given in current prices of specific years (Table 4).

Table 4. Share of mix crop income in total mix income (%) at current prices

Year	wheat	Barley	Rye	oats	maize for grain	rape seed	pulses	sugar beet	Potatoes	Arable fodder crops	MIX Production	Production without fodder crops
2002	28.97	15.23	0.98	1.26	4.74	11.15	0.72	8.83	10.62	17.52	100	82.48
2020	30.36	13.86	1.11	1.05	4.57	16.64	0.83	6.38	6.53	18.67	100	81.33

Source: authors' calculations according to CZSO (2020a).

The cost-effectiveness of wheat (2002-2020), even without subsidies (direct support), is in positive figures. The declining profitability in the last 4 years is due to the price slump in 2016 and the slow recovery. Barley has good growing conditions in the Czech Republic and its overall cost-effectiveness is among the best crops (40 % on average).

The reduced profitability in recent years is again due, as for other cereals, to the increase in costs between 2016/17. The importance of maize cultivation has increased over the last decade in the country in relation to the production of bioethanol. In 2019/2020, of the total amount of bioethanol produced in the country, 54.4 % was produced from maize, i.e. from 26.1 % of the maize planted area. Increased sowings are also associated with the growing use of maize as feed. The use of maize as seed, including seed for maize silage, is significant. Maize is also frequently exported. Profitability is still positive with exceptions (MoA, 2020). Rape is a soil-improving crop. The only criticism is that it is grown in large monoculture fields. The low diversity of crops grown is not suitable in terms of promoting biodiversity and may subsequently cause erosion. Rapeseed is also grown on soils that may not be very suitable for its cultivation (Gebeltova et al., 2020). The simple cost-effectiveness of rapeseed is uneven (-33 % to 26 %) (reason: rising wage and ancillary costs, volatility of input prices). The development of the last five years suggests that rapeseed cultivation is no longer economically viable for agricultural holdings, excluding aid and subsidies. Although demand for rapeseed is increasing, the realisation price cannot cover the total cost of production. For oilseed rape producers, the uneven profit trend is amply compensated by subsidies (SAPS: basic payment + greening; Transitional national aid; ANC-aid; green diesel, insurance). Rapeseed receives the highest subsidies of any crop in the Czech Republic. For example, for cereals, subsidies of 800-1300 CZK/t per tonne were paid (2014/2015-2019/2020). For rapeseed, the subsidy was CZK 1,800-2,200/t. In no year was the cost-effectiveness of rapeseed less than 0 after the subsidy was added to the price (Table 5).

Table 5. Cost- effectiveness (simple and total) of the selected crop mix

	Food wheat		Barley Spring		Corn for grain		Oilseed rape		Potatoes for consumption	
	Simple and total		Simple and total		Simple and total		Simple and total		Simple and total	
Period	%		%		%		%		%	
2002/03	23.78	107.46	46.39	46.39	30.28	30.28	-19.06	-19.06	96.39	96.39
2003/04	16.23	16.23	64.92	64.92	11.59	11.59	-33.48	-33.48	123.74	123.74
2004/05	70.74	96.85	82.66	114.91	13.45	30.25	32.32	49.40	-10.94	-6.26
2005/06	5.68	39.36	29.50	71.51	18.08	44.62	-17.81	4.63	17.49	20.39
2006/07	6.06	41.74	9.36	53.69	9.28	35.48	2.30	26.59	94.44	97.90
2007/08	50.59	81.38	43.74	80.09	38.01	60.08	14.39	37.30	29.84	35.06
2008/09	87.31	115.37	111.62	145.02	106.78	132.89	32.32	52.62	5.52	10.79
2009/10	-4.81	25.96	19.69	54.28	17.06	41.26	-3.24	17.72	4.57	10.37
2010/11	13.75	44.50	11.59	48.40	23.62	49.30	-1.04	19.65	80.99	86.06
2011/12	68.87	96.48	63.20	95.77	87.75	109.01	19.80	37.69	-11.23	-6.20
2012/13	22.96	56.10	31.74	67.32	72.38	100.00	17.85	39.05	-26.61	-20.93
2013/14	53.14	85.40	56.10	94.74	33.60	57.51	26.92	48.14	-8.73	-3.08
2014/15	41.51	71.50	62.44	97.11	40.83	65.10	19.12	38.29	-18.25	-12.81
2015/16	17.21	45.14	39.81	73.72	-27.37	-4.60	0.36	19.33	-18.25	-12.33
2016/17	4.72	32.25	26.60	59.45	11.40	33.03	2.61	21.48	-35.48	-24.27
2017/18	0.89	30.11	13.11	54.10	-4.36	23.44	-5.98	14.21	-5.24	5.77
2018/19	0.2	28.96	18.21	54.06	-17.73	16.15	-3.86	15.69	-14.26	-1.30
2019/20	2.9	30.8	21.5	46.39	18.00	26.60	-15.80	3.1	26.40	36.1
average	26.76	58.09	41.79	73.44	26.81	47.89	3.76	21.80	18.36	24.19

Note: simple profitability is profitability of costs excluding subsidies, total profitability of costs including subsidies (Formula No.7)

Source: own elaboration according to: MoA (2004, 2010, 2014) and MoA (2020).

Crop yields are affected by frequent weather extremes. For example (2009 - hailstorm in May), tropical summers (2003, 2006, 2007, 2013, 2015 and 2018). An early winter came in October 2009, and in 2012 there was hailstorm in August. Tropical summer temperatures (35°C) were replaced by high rainfall in 2009 and 2010 with brief torrential rains. This caused waterlogging to flooding of low-lying land. Waterlogging leads to a decrease in yields, the development of fungal diseases or has an impact on poorer shelf life. The dry winter and the lack of rainfall in the spring of 2007 already caused considerable problems in land preparation. The mild winters (2007, 2019) with few days of snow cover allowed all pests to overwinter (e.g. overpopulation of voles in 2019). Climatic conditions in recent years show that irrigation is an important stabilizing factor in agriculture. However, the droughts in (2012, 2015, 2018) showed that the irrigation systems built were only sufficient to supplement the moisture deficit, not to cover it. In 2015, the summer was virtually devoid of any rainfall. In some localities, the water supply in ponds and rivers was low and there was a risk of limiting water extraction for irrigation. In some areas, irrigation water sources were depleted in the summer (2018), and in many places a ban on surface water abstraction was declared. As a result of the lack of water, plants stopped growing, which had a very negative impact on their yields. Cold water irrigation, on the other hand, caused necrosis to form

on plant leaves due to temperature shock (MoA (2004, 2010, 2014) and MoA (2020)). The impact of the changes is reflected in the cost-effectiveness values (Table 5).

Achieving efficient food production while ensuring sustainable use of inputs is already a huge challenge in the context of increasing urbanisation and industrialisation. However, climate change will exacerbate the situation. It will undoubtedly affect crop productivity, reduce water availability and change its seasonal distribution.

For example, the Research Institute of Agricultural Technology in Prague (RIAT) has carried out research on the energy and food security of the Czech population in a crisis situation². From the data used on agricultural land and information from the field of agrotechnics and zootechnics from 2010-2013, it is clear that: Approximately 1,908,800 hectares of agricultural land are needed to ensure the food security of the Czech population. This implies that 0.18 hectares of agricultural land is needed per capita. This is about half the current value (RIAT, 2014). Previous research by Gebeltova et al (2020) shows that production on agricultural land in the Czech Republic is negatively affected by relatively higher agricultural land grabbing on fertile soils than land grabbing in marginal areas. In practice, farmers pursue different objectives that do not correspond to good land management practices. The authors' results also statistically confirmed the trend of decreasing crop diversity in selected regions of the Czech Republic. Agricultural food production in the world needs to increase by 50 % by 2050 to meet the growing demand for food. The agricultural sector is already responsible for 70 % of global water demand and water availability is expected to decrease by 40 % by 2030 due to increasing pressure (Foley et al., 2011). Water is considered the most critical resource for sustainable agricultural development worldwide (Santos Pereira et al, 2009), particularly in the context of climate change due to the expected impact of changes in precipitation on crop reliability and production efficiency. In addition, water used in agriculture generally has lower yields compared to other uses (Zhang et al., 2018).

Irrigation in agriculture in Italy in 2013 covered approximately 19 % of usable agricultural land and used 2/3 of the available water resources (Massarutto, 1999). Irrigation is a critical issue in southern Italy due to: the high value of fresh fruit and vegetable production (Guzmán et al., 2009). To increase the efficiency of raw material and food production, recycling is effective. According to empirical results (Lu et al. 2022), Germany and Malta have the best overall circular economy efficiency. According to the Pearson correlation coefficient test, agricultural production, food waste, food waste recycling, CO₂ and methane are highly correlated.

The production efficiency in the USA and Europe through the channel of knowledge spillovers from technological innovation in the agricultural sector. In particular, the empirical results evidenced a negative effect of land use spillovers on efficiency indicator for American firms and a positive effect for European ones. Increased investment in research and development is expected, which may further increase productivity and reduce

² Crisis situation: a situation in which the supply of energy, especially diesel fuel, is restricted. In this case, energy must be provided to ensure the basic functions of agriculture, i.e. to provide essential food for the population, products needed for energy production and to ensure the maintenance of unused productive agricultural land.

the reliability of knowledge spillovers (Aldieri et al. 2021). Dumortier et al. (2021) also point out that global GHG emissions are lower due to an overall reduction in arable land area.

4. Conclusion

Labour productivity has more than doubled from 2008 to 2020. The productivity of „inanimate (immortalised)“ labour has a stable trend with minor negative variations. Both the declining number of AWUs and the increasing output of the sector have an impact on productivity growth. In current prices, output increased by 46 %, while in kind it increased by 11%. The growth in total output is driven by crop production. Land productivity is also increasing. Total agricultural output per hectare of agricultural land (constant prices) increased by 9 %. Wheat, barley, rapeseed and forage account for the largest percentage of income in the crop mix. Rapeseed has increased its share of the income mix by about 5 p.p. by 2020.

Farmers have increased the cultivation of rapeseed because it is subsidized and in demand (production of a bio-component for diesel). Furthermore, the production (in tonnes) of all mixed crops except barley, sugar beet and potatoes increased.

However, the dry summers have had an impact on both the sown area and the yields per hectare. In the future, the Czech agriculture industry will not be able to do without major investments in irrigation or covered areas. In this sense, however, investments on rented land may be a problem. It is positive that the situation is improving in this respect. While in 2000 the operators were almost exclusively farming on rented land and the share of their own cultivated agricultural land was 8.5 %, in 2020 they already owned 26.5 % of the total agricultural area (MoA, 2020).

Acknowledgements

This paper was created within the framework of the project NAZV QK1910299 - Sustainable management of natural resources with emphasis on non-productive and productive capabilities of soil.

References

Aldieri, L., Brahmi, M., Chen, X. and Vinci, C. P. (2021). “Knowledge spillovers and technical efficiency for cleaner production: An economic analysis from agriculture innovation“, *Journal of Cleaner Production*, 320, p. 128830, DOI 10.1016/j.jclepro.2021.128830

Allan, E. et al. (2015). “Land use intensification alters ecosystem multifunctionality via loss of biodiversity and changes to functional composition“, *Ecology Letters*. Edited by J. Knops, 18(8), pp. 834–843, DOI 10.1111/ele.12469

Blanco, C. and Raurich, X. (2022), “Agricultural composition and labor productivity“, *Journal of Development Economics*, 158, p. 102934, DOI 1016/j.jdeveco.2022.102934

Cooke, G. D., Wlech, E. B., Peterson, S. A. and Newroth, P. R. (2005). “*Restoration and management of lakes and reservoirs*“. 3rd ed. Boca Raton, FL: CRC Press, <https://doi.org/10.1201/9781420032109>

Cortignani, R., Dell’Unto, D. and Dono, G. (2021). “Paths of adaptation to climate change

in major Italian agricultural areas: Effectiveness and limits in supporting the profitability of farms“, *Agricultural Water Management*, 244, p. 106433, DOI 10.1016/j.agwat.2020.106433

CZSO, Czech Statistical Office (2022), Osevní plochy zemědělských plodin - Česká republika (1920-2022), [online], Available: https://www.czso.cz/csu/czso/zem_cr, [Accessed: 15 Apr. 2023] (In Czech)

CZSO, Czech Statistical Office (2020a), Aggregate agricultural account, [online], Available: https://www.czso.cz/csu/czso/zem_cr, [Accessed: 01 Apr. 2023]

CZSO, Czech Statistical Office (2020b), Veřejná databáze, osevní plochy, [online], Available: <https://vdb.czso.cz/vdbvo2/faces/index.jsf?page=statistiky&katalog=30840>, [Accessed: 10 Jan. 2022] (In Czech)

CZSO, Czech Statistical Office (2023), Průměrná hrubá měsíční mzda podle odvětví - sekce CZ-NACE, 2023, [online], Available: https://www.czso.cz/csu/czso/pmz_cr, [Accessed: 12 Apr. 2023] (In Czech)

Dumortier, J., Carriquiry, M. and Elobeid, A. (2021). “Where does all the biofuel go? Fuel efficiency gains and its effects on global agricultural production“, *Energy Policy*, 148, p. 111909, DOI 10.1016/j.enpol.2020.111909

EEA (2020). “The European environment: state and outlook 2020: knowledge for transition to a sustainable Europe“. LU: Publications Office. Available at: <https://data.europa.eu/doi/10.2800/96749> (Accessed: 26 April 2023)

Erb, K.-H. Haberl, H., Jepsen, M.R., Kuemmerle, T., Lindner, M., Müller, D., Verburg, P. H., Reenberg, A. (2013). “A conceptual framework for analysing and measuring land-use intensity“, *Current Opinion in Environmental Sustainability*, vol. 5, no.5, pp. 464–470, DOI 10.1016/j.cosust.2013.07.010

EUR-Lex (2004). “Regulation (EC) of the European Parliament and of the Council of 5 December 2003 on the economic accounts for agriculture in the Community“, [Online], Available: <https://publications.europa.eu/en/publication-detail/-/publication/c4ae3f49-a467-472a-9217-2e641674340c/language-en>, [Accessed: 25 Sep. 2020]

EUROSTAT (2019), “Statistics Explained“, Annual work unit (AWU), EU, 2019, [Online], Available: [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Annual_work_unit_\(AWU\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Annual_work_unit_(AWU)), [Accessed: 12 Apr. 2023].

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M. and Balzer, C. (2011). “Solutions for a cultivated planet“, *Nature*, vol. 478, no. 7369, pp. 337–342, DOI 10.1038/nature10452

Gebeltová, Z., Malec, K., Maitah, M., Smutka, L., Appiah-Kubi, S. N. K., Maitah, K., Sahatqija, J. and Sirohi, J. (2020). “The Impact of Crop Mix on Decreasing Soil Price and Soil Degradation: A Case Study of Selected Regions in Czechia (2002–2019)“, *Sustainability*, vol. 12, no. 2, p. 444, DOI 10.3390/su12020444

German, R. N., Thompson, C. E. and Benton, T. G. (2017). “Relationships among multiple aspects of agriculture’s environmental impact and productivity: a meta-analysis to guide

sustainable agriculture: Multiple measures of agricultural sustainability“, *Biological Reviews*, vol. 92, no. 2, pp. 716–738, DOI 10.1111/brv.12251

Giannakis, E. and Bruggeman, A. (2018). “Exploring the labour productivity of agricultural systems across European regions: A multilevel approach“, *Land Use Policy*, no. 77, pp. 94–106, DOI /10.1016/j.landusepol.2018.05.037

Guzmán, I., Lario, N. A., Ghelfi, R. and Rivaroli, S. (2009). “Technical efficiency in the fresh fruit and vegetable sector: a comparison study of Italian and Spanish firms“, *Fruits*, vol. 64, no. 4, pp. 243–252, DOI 10.1051/fruits/2009018

Haberl, H. (2015). “Competition for land: A sociometabolic perspective“, *Ecological Economics*, no. 119, pp. 424–431, DOI 10.1016/j.ecolecon.2014.10.002

Hlavsa, T. and Štolbova, M. (2007). “*Mene priznive oblasti pro zemedelstvi a venkov: In: Sbornik prispevku z mezinarodni konference [7. - 10. Nov. 2007, Jihlava]: Collection of papers of international conference = Less favoured areas for agriculture and rural areas*, Research Institute of Agricultural Economics, Prague, pp. 171-190, ISSN 80-86671-46-1 (In Czech)

IPBES (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Zenodo, DOI 10.5281/ZENODO.3831673

Lambin, E. F., Rounsevell, M. D. A. and Geist, H. J. (2000). “Are agricultural land-use models able to predict changes in land-use intensity?“, *Agriculture, Ecosystems & Environment*, vol. 82, no. 1–3, pp. 321–331, DOI 10.1016/S0167-8809(00)00235-8

Lorel, C., Plutzar, Ch., Erb, K.-H. and Mouchet, M (2019). “Linking the human appropriation of net primary productivity-based indicators, input cost and high nature value to the dimensions of land-use intensity across French agricultural landscapes“, *Agriculture, Ecosystems & Environment*, 283, p. 106565, DOI 10.1016/j.agee.2019.06.004

Lu, L. C., Chiu, S-Y., Chiu, Y-h., Chang, T-H. (2022). “Three-stage circular efficiency evaluation of agricultural food production, food consumption, and food waste recycling in EU countries“, *Journal of Cleaner Production*, 343, p. 130870, DOI 10.1016/j.jclepro.2022.130870

Massarutto, A. (2000), “Agriculture, Water Resources and Water Policies in Italy“, *SSRN Electronic Journal* [Preprint], DOI 10.2139/ssrn.200151

MoA, Ministry of Agriculture (2004, 2010, 2014), “Report on the state of agriculture“, (in Czech), 2004, 2010, 2014, Ministry of Agriculture, Prague, ISBN 978-80-7434-005-5

MoA, Ministry of Agriculture (2020), “Report on the state of agriculture“, (in Czech), 2020, Ministry of Agriculture, Prague, ISBN 978-80-7434-005-5

Reidsma, P., Ewert, F. Lansink, A. O. and Leemans R. (2010). “Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses“, *European Journal of Agronomy*, vol. 32, no. 1, pp. 91–102., DOI 10.1016/j.eja.2009.06.003

RIAT, Research Institute of Agricultural Technology (2014), “Yearbook RIAT“ (in Czech), 2014, RIAT, v.v.vi., 2015, pp. 33-36, ISBN 978-80-86884-88-2

Santos Pereira, L., Cordery, I. and Iacovides, I. (2009). “*Coping with Water Scarcity*“. Dordrecht: Springer Netherlands, DOI /10.1007/978-1-4020-9579-5

Simoncini, R., Ring, I., Sandström, C., Albert, C., Kasymov, U. and Arlettaz, R. (2019). „Constraints and opportunities for mainstreaming biodiversity and ecosystem services in the EU’s Common Agricultural Policy: Insights from the IPBES assessment for Europe and Central Asia“, *Land Use Policy*, no. 88, p. 104099, DOI 10.1016/j.landusepol.2019.104099

Waller, D. M., Meyer A. G., Raff, Z., Apfelbaumd, S. I. (2021). “Shifts in precipitation and agricultural intensity increase phosphorus concentrations and loads in an agricultural watershed“, *Journal of Environmental Management*, 284, p. 112019, DOI 10.1016/j.jenvman.2021.112019

Wang, J., Tyau, N. Rae Ybanez, C. (2017). “Farming activity contaminates water despite best practices“, Center for Public Integrity, Investigating inequality, Washington, 2015, [Online]. Available: <https://publicintegrity.org/environment/farming-activity-contaminates-water-despite-best-practices/>, [Accessed: 05 Mar. 2023]

Zhang, S., Zhang, J., Jing, X., Wang, Y., Wang, Y., Yue T. (2018). “Water saving efficiency and reliability of rainwater harvesting systems in the context of climate change“, *Journal of Cleaner Production*, no. 196, pp. 1341–1355, DOI 1016/j.jclepro.2018.06.133

INFLUENCE OF EDUCATION AND HUMAN CAPITAL DEVELOPMENT ON PERFORMANCE OF SELECTED AGRICULTURAL SECTOR

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Annotation: The more general objective of this paper is to examine the relationship between human capital and education in agriculture. Specifically, it focuses on what factors influence education and human capital development in agriculture and how these factors subsequently influence the performance and competitiveness of the agricultural sector. Quantitative and qualitative methods were used for data analysis. Quantitative analysis included statistical methods such as full factorial designs, regression analysis, and correlation analysis. The qualitative research included thematic analysis and content analysis of questionnaire surveys. The study proved the positive influence of the share of agricultural university graduates on the efficiency (productivity) in the use of agricultural land. Furthermore, the positive influence of GDP per Capital in the field of agriculture and the entire society and protection designation (for origin, geographical and traditions) was proven.

Key words: development and the need for human capital, educational programs, agricultural research and development activity, competitiveness, technological development, factor effect, interaction effect.

JEL classification: M11

1. Introduction

Education policy, human capital and modern technology are key factors that can contribute to the development and efficiency of agriculture production (Ma Guoqun, et al., 2023). Various empirical studies and authors currently examine the factors of sustainable agriculture, the effects of advanced technologies, the effects and risks of genetic modification of crops and livestock feed, and the correlation between GDP per capita and the efficiency of agricultural production. Another phenomenon is the influence of a given company's general knowledge and technological sophistication on the quality and productivity of agricultural output. General knowledge is often associated with educational policy. According to some studies, educational policies can help improve the level of farmers' expertise and technical skills in agriculture (Wouterse, 2016; Mahsa et al., 2023). This is a typical situation where government support is crucial to success. Governments can support educational programs and courses that aim to improve farmers' skills in cultivation, processing, efficiency in using new technologies (e.g. precision agriculture) and marketing agricultural products (Jean et al., 2023). Better education can lead to an increase in labour productivity and the profitability of agricultural production. So, in general, modern technologies such as GPS and its satellite mapping, sensors and robotics in sowing, harvesting and maintenance of livestock production help farmers increase their activities' efficiency and profitability. The use of modern technology can help farmers improve planning and process optimization, leading to increased labour productivity and reduced costs (Bull et al., 2022). Modern technology can also help improve the quality of agricultural products and the outputs of production processes.

Other studies place agricultural research and innovation more in the context of divergent thinking and the adaptive capabilities of human capital. In this regard, human capital is key to developing the agricultural sector (Braun et al., 2022). Investments in human capital, such as training, educational programs and health care, can help farmers improve their skills and performance. Human capital also significantly helps create a quality workforce that is key to developing and maintaining the agricultural sector's competitiveness (Ren et al., 2022). A measure of education is used for the level of human capital development in agriculture. An interesting factor in the development and sustainability of agriculture is the connection between the share of workers who have obtained higher education (university education) and the quality and productivity of production. The author dealt with this phenomenon, e.g. (Braun, 2021) and concluded that a higher level of education could contribute to more outstanding expertise, better planning, and management of agricultural production.

Education policy, human capital and modern technology have been repeatedly proven in empirical studies to be critical factors that can help increase the efficiency and competitiveness of the agricultural sector and its long-term sustainability in terms of negative environmental impact. These factors can help farmers improve their skills, optimize processes and use modern technology, which leads to increased labour productivity and profitability of agricultural production.

The objective of the paper's contribution follows from the previous text. It can be briefly characterized as what other factors (introduced education and human capital development in agriculture) affect the performance and competitiveness of the agricultural sector? And how do these factors interfere with agricultural higher education regarding Agricultural land productivity?

2. Materials and Methods

We used secondary data from the EUROSTAT database (in the time frame 2018-2021), data on the proportion of agricultural students in tertiary education (PDoOGT) - marked as factor A; data on the protected designation of original, geographical indications and traditional specifics (PASTE) - marked as factor B; GDP per Capital in the countries of the European Union (GDPpC) - designated as factor C.

We determined the normality in the distribution of controlled variables using the Normal Probability Plot and the Anderson-Darling test to verify a linear regression model of the dependence of the productivity of the agricultural (cultivated or abandoned) area depending on the factors A, B, and C of the first order of their interactions.

The progress includes the development of a full-factorial model that covers the relationship between the empirical mean of productivity of agricultural land (formula (1) from the set of factors A, B, and C.

$$y = \frac{(cp+ap)\%}{aa \%} \quad (1)$$

Where *cp* is crop production, *ap* is animal production and *aa* is agricultural area.

The estimated ratio of the mean productivity of agricultural (cultivated or defamed) area *y* is given by the sequential formula of a regression model for three factors.

$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \cdots + \varepsilon, \quad (2)$$

where β_1 and β_2 are the regression coefficients (calculated as half the effect of a given factor) and β_0 is the distance of the origin of the response surface at the beginning of the Cartesian system (calculated as the average response in the factorial experiment). The term ε is the normally distributed random error. The regression coefficients β_{12} and β_{13} correspond to the interaction between the process parameters x_1 and x_2 and x_1 and x_3 , respectively.

Suppose we symbolically mark the three factors of the two-level, full-factorial design as A, B and C. In that case, the effect of each factor and interactions between the factors can be formally calculated according to the following formulas (Macak et al. 2021).

Estimation of the effect of factor A:

$$A = \bar{y}_{A^+} - \bar{y}_{A^-} = \frac{1}{4n} [a + ab + ac + abc - b - c - bc - (1)] \quad (3)$$

Estimation of the effect of factor B:

$$B = \bar{y}_{B^+} - \bar{y}_{B^-} = \frac{1}{4n} [b + ab + bc + abc - a - c - ac - (1)] \quad (4)$$

Estimation of the effect of factor C:

$$C = \bar{y}_{C^+} - \bar{y}_{C^-} = \frac{1}{4n} [c + ac + bc + abc - a - b - ab - (1)] \quad (5)$$

Estimation of the effect of interaction between factors A and B:

$$AB = \bar{y}_{AB^+} - \bar{y}_{AB^-} = \frac{1}{4n} [ab + (1) + abc + c - b - a - bc - ac] \quad (6)$$

Estimation of the effect of the interaction between factors A and C:

$$AC = \bar{y}_{AC^+} - \bar{y}_{AC^-} = \frac{1}{4n} [ac + (1) + abc + b - a - c - ab - bc] \quad (7)$$

Estimation of the effect of the interaction between factors B and C:

$$BC = \bar{y}_{BC^+} - \bar{y}_{BC^-} = \frac{1}{4n} [bc + (1) + abc + a - b - c - ab - ac] \quad (8)$$

\bar{y}_{A^+} = the mean response factor for the upper-level A, the average response for the lower level of factor A; \bar{y}_{A^-} = the mean response factor for the lower-level A, the average response

for the lower level of factor A; (1), a, b and c = all the eight combinations of the responses for two setting levels of the three factors, and n = the number of replications of this design.

As the last step, we have created a critical discussion of the results and the possibility of generalizing the conclusions and transferring them to other industrial areas, especially the factor of education and economic productivity on agricultural prosperity.

3. Results and Discussion

We analysed data from 20 EU countries located in four geographical groups (Southern Europe: Greece, Portugal, Spain, Italy, Western Europe: Luxembourg, Netherlands, Austria, Germany, France, Eastern Europe: Czechia, Slovenia, Slovakia, Poland, Hungary, Bulgaria, Romania, Northern Europe: Estonia, Latvia, Denmark, Sweden, Finland, Lithuania).

Based on the data analysis of the 20 EU countries divided into four geographical groups (Southern Europe, Western Europe, Eastern Europe, and Northern Europe), we can make some observations and describe the results. Southern Europe (Greece, Portugal, Spain, Italy). These countries are in southern Europe and are known for their Mediterranean climate. They have a rich historical and cultural heritage and are popular tourist destinations. Western Europe (Luxembourg, Netherlands, Austria, Germany, France). These countries are located in the western part of Europe and are generally considered more economically developed. They have strong economies, high standards of living, and well-developed infrastructure. The analysis results for this group may indicate trends or patterns related to their economies, trade, or other relevant factors. Eastern Europe (Czechia, Slovenia, Slovakia, Poland, Hungary, Bulgaria, Romania). These countries are located in Eastern Europe and have diverse histories and cultural backgrounds. Some countries have transitioned from centrally planned economies to market-based systems in recent decades. Northern Europe (Estonia, Latvia, Denmark, Sweden, Finland, Lithuania). These countries are located in northern Europe and often have a colder climate. They have well-developed social welfare systems, high-quality education, and advanced technology sectors.

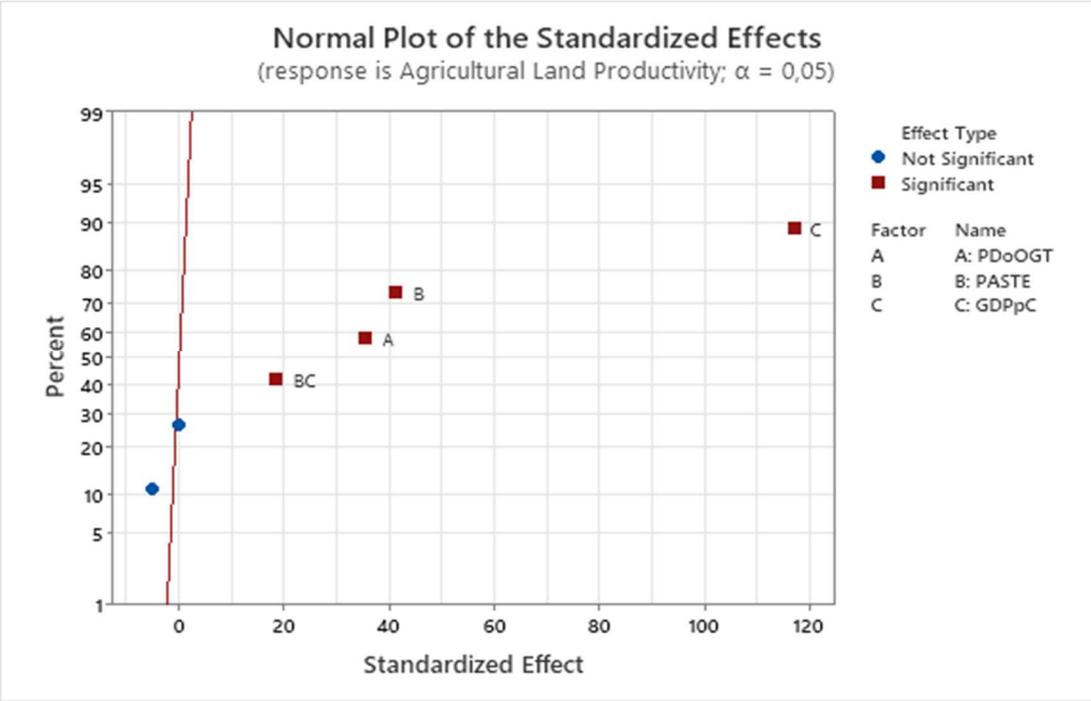
Here it is necessary to mention that the geographical division does not affect the research question of learning the strength of the factors and possible interactions of interactions on the response (agricultural Land productivity). This geographic segmentation is important for further research, for example, for using a higher model level (if it will be necessary to exclude the influence of a third variable or if the interactions will have a greater effect on the response than the factors themselves).

The normal plot from the design is shown in Figure 1. The terms with the highest positive effect are on the right. According to Figure 1, the separate factors (GDP per capital C, data on protected designation B, proportion of agricultural students A) are also crucial for the productivity of the agricultural area. The two- and three-way interaction terms are only important for the BC interaction. Therefore, it is appropriate to use multiple linear models to estimate the mean productivity of the agricultural area. The interaction causes a 'curvature' of the response space, which means using a higher degree model (e.g., polynomial regression) would be appropriate.

The Pareto chart in Figure 2 shows that factor C (GDP per Capital) has the greatest (and positive) influence. This is followed by the influence of factor B (protected designation of origin), and there is a positive influence of factor A (proportion of agricultural students

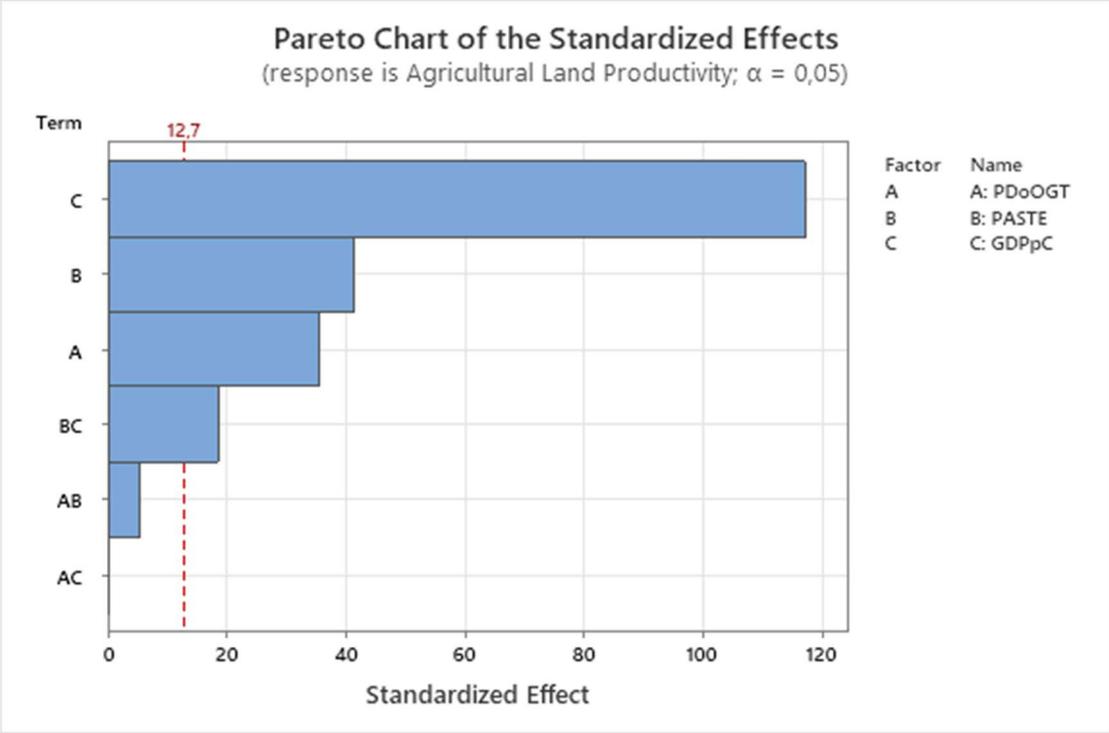
in tertiary education). Interestingly, there is a synergistic effect between GDP per Capital and protected designation of origin. Other synergies are statistically insignificant.

Figure 1. N-P plot of the standardised effect for the productivity of the agricultural (cultivated or abandoned) area.



Source: own calculation (2023)

Figure 2. The pareto plot of standardized effects shows the same selection of significant factors as the N-P plot



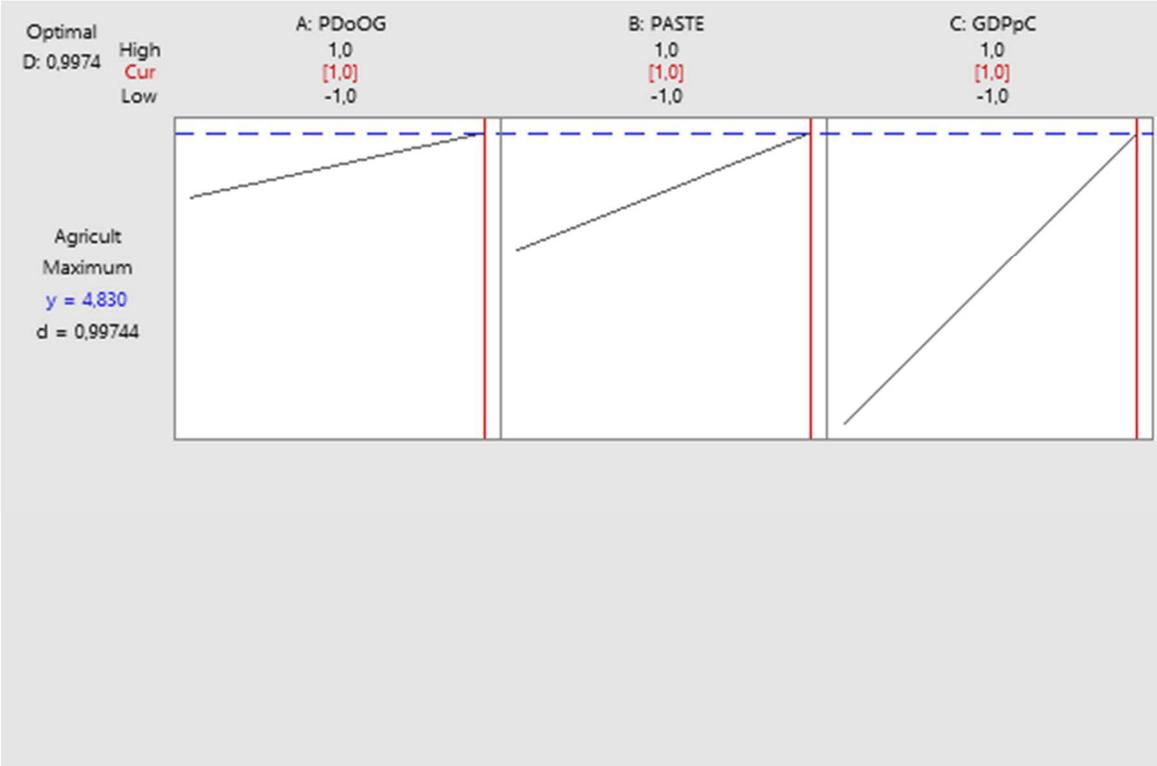
Source: own calculation (2023)

The Pareto chart in Figure 2 shows that factor C (GDP per Capital) has the greatest (and positive) influence. This is followed by the influence of factor B (protected designation of origin), and there is a positive influence of factor A (proportion of agricultural students in tertiary education). Interestingly, there is a synergistic effect between GDP per Capital and protected designation of origin. Other synergies are statistically insignificant.

The two-way and three-way interaction terms are not important for further responses. Therefore, it is appropriate to use multiple linear models to estimate the mean profit and reliability responses. The interaction causes a ‘curvature’ of the response space, and this means it would be appropriate to use a higher degree model (e.g., polynomial regression).

Figure 3 shows the optimization sensitivity of the response of agricultural area productivity depending on the setting of three factors.

Figure 3. Optimization response sensitivity.



Source: own design, (2023)

According to the following response sensitivity formula, all factors have a statistically significant effect on the response, so setting them to the maximum notes in the filling interval is advisable. The factor GDP per Capital in the countries of the European Union (GDPpC) has a strong influence, the factor geographical indications and traditional specifics (PASTE) has a medium effect, and the factor proportion of agricultural students in tertiary education (PDoOGT) has a weak effect. The factor (PDoOGT) is the only one that does not interfere with another factor.

The corresponding equation to predict the response depending on the setting of factors (GDPpC), (PASTE), and (PDoOGT) is given below.

Regression Equation in Uncoded Units.

$$\text{Agricultural Land Productivity} = 2,7600 + 0,3550 (\text{PDoOGT}) + 0,4125 (\text{PASTE}) + 1,1725 (\text{GDPpC}) + 0,1850 ((\text{PASTE}) \times (\text{GDPpC}))$$

Where: (PDoOGT) is proportion of agricultural students in tertiary education - marked as factor A; data on the protected designation of original, geographical indications and traditional specifics (PASTE) - marked as factor B; GDP per Capital in the countries of the European Union (GDPpC) - designated as factor C.

4. Conclusion

The research findings indicate that education and human capital development play a crucial role in the agricultural sector's competitiveness. Specifically, the presence of agricultural university graduates positively impacts the efficiency and productivity of agricultural land use. This suggests that individuals with agricultural education bring about innovation, adopt improved technologies, and contribute to increased productivity in the sector. Additionally, the study highlights the significance of GDP per capita in influencing agricultural sector competitiveness. Higher GDP per capita indicates a stronger economy and greater financial resources, which can support the agricultural sector through investments in infrastructure, technology, and overall growth. A positive relationship between GDP per capita and the competitiveness of both the agricultural sector and the wider society was observed.

The research also emphasizes the positive influence of protection designation on agricultural sector competitiveness. Protection designation, which encompasses factors like origin, geographical importance, and traditions, enhances agricultural products' marketability, reputation, and perceived value. This recognition contributes to increased competitiveness in the sector. Furthermore, the study indicates a positive relationship between GDP per capita and protection designation. Higher GDP per capita can support recognizing and preserving unique characteristics associated with agricultural products, further enhancing their competitiveness.

On the other hand, the proportion of agricultural students in tertiary education was found to have a weak statistically significant effect on agricultural competitiveness. And further, the proportion of agricultural students in tertiary education does not interfere with other factors (i.e. it does not affect GDP per person or the original designation of the agricultural sector or the protection designation). This finding suggests that increasing agricultural students in higher education may translate into something other than improved competitiveness. It highlights the need for other factors and strategies to complement educational efforts in enhancing the sector's competitiveness.

The research findings provide valuable insights into the relationship between education, human capital development, and the agricultural sector's competitiveness. However, it is important to acknowledge the limitations of this study and identify areas for potential follow-up research.

The full factorial design and analysis focused on specific factors such as agricultural university graduates, GDP per capita, and protection designation. Future research could

explore additional variables that may influence agrarian sector competitiveness, such as access to financial resources, technological advancements, infrastructure development, or government policies and support. Furthermore, the research findings establish correlations between different factors, but causality and the direction of the relationships cannot be determined conclusively. Next, the research could employ more rigorous methodologies, such as higher-order model experimental designs, excluding the influence of the third variable (confounding variables) to explore causal relationships between education, human capital development, and agricultural sector competitiveness. Because the research findings are specific to the database and countries included in the analysis, it would be valuable to replicate the study with a larger sample size and a more diverse set of countries or regions to assess the generalizability of the results across different contexts.

And it is also necessary to consider that the accuracy and reliability of the database used for analysis are crucial factors. Therefore, future research could focus on ensuring high-quality data collection and employ robust data validation techniques to enhance the reliability of the findings. A comparative analysis between countries or regions with different levels of education and human capital development can be used for that purpose, providing valuable insights into the relative impact of these factors on agricultural sector competitiveness.

Acknowledgements

The authors also gratefully acknowledge the anonymous reviewers for carefully reading the manuscript and providing useful suggestions.

References

- Bicak, B. E., Borchert, C. E. and Höner, K. (2021). “Measuring and Fostering Preservice Chemistry Teachers’ Scientific Reasoning Competency”. *Education Science*, 11, no. 496. DOI 10.3390/educsci11090496
- Braun, C. L., Bitsch, V. and Häring, A. M. (2021). “Behind the Scenes of a Learning Agri-Food Value Chain: Lessons from Action Research”. *Agriculture and Human Values*, 1–16. DOI /10.1007/s10460-021-10229-7
- Braun, C. L., Bitsch, V. and Häring, A. M. (2021). „Developing agri-food value chains: learning networks between exploration and exploitation”, *The Journal of Agricultural Education and Extension*, DOI 10.1080/1389224X.2022.2082499
- Bull, E. M, L. van der Cruyssen, Vágó, S., Király, G., Arbour T. and L. van Dijk. (2022). Designing for agricultural digital knowledge exchange: applying a user-centred design approach to understand the needs of users, *The Journal of Agricultural Education and Extension*, DOI 10.3390/educsci11090496
- Hadjichambis A. C. (2022). “European Green Deal and Environmental Citizenship: Two Interrelated Concepts”, *Environmental Sciences Proceedings*, vol. 14, no. 1, DOI 10.3390/environsciproc2022014003
- Ma, Guoqun, Minjuan Li, Yuxi Luo and Tuanbiao Jiang. (2023). “Agri-Ecological Policy, Human Capital and Agricultural Green Technology Progress”, *Agriculture* 13, no. 5, p. 941. DOI 10.3390/agriculture13050941

- Macak, T., Hron, J. and Stusek, J. (2020). "A Causal Model of the Sustainable Use of Resources: A Case Study on a Woodworking Process". *Sustainability*. vol. 12, no. 21, p. 9057. DOI 10.3390/su12219057
- Parrella, J. A., Murphrey, T. P., Leggette, H. R., Bates, A. and Esquivel, C. (2023). "Investigating how secondary agriculture teachers' characteristics influence their perceived ability to teach students decision-making skills", *The Journal of Agricultural Education and Extension*, DOI 10.1080/1389224X.2023.2179087
- Ren, J., Lei, H. and Ren, H. (2022). „Livelihood Capital, Ecological Cognition, and Farmers' Green Production Behavior". *Sustainability*, no. 14, p. 16671. DOI 10.3390/su142416671
- Saadvandi, M., Abbasi, E., Biemans, H., Kiumars, Z. and Farhadian, H. (2023). "Identifying characteristics of a competence-based agricultural higher education system: a literature review", *The Journal of Agricultural Education and Extension*, DOI 10.1080/1389224X.2023.2192706
- Zhang, T., Zhe M. and Yingshi Shang (2023). "Higher Education, Technological Innovation, and Green Development Analysis Based on China's Provincial Panel Data", *Sustainability* vol. 15, no. 5, p. 4311. DOI 10.3390/su15054311

HUMAN FACTOR IN TERRITORIAL COMMUNITY DEVELOPMENT STRATEGY

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Annotation: United territorial communities are entering a new stage of their life. They obtained authorities, their own and external resources. They are responsible to the residents for the comfortable and safe living environment. For that reason, the strategy of predicted and motivated development is necessary. Human factor is considered the key inner recourse, that is, the capability of community members due to their knowledge, skills and interaction, to make a contribution to community development every day, either individually or together. In this article the main conceptual directions are determined, the analytical assessment of techniques and approaches used for elaborating territorial community development strategy is carried out. The dynamics of forming united territorial communities of Ukraine and Lviv region is analyzed. It was ascertained to be mostly conditioned by the fact that the legislation provides for voluntary union, which in the future will slow down the process and will cause certain problems. The situation of considering public opinion concerning elaboration of community development strategy in five united territorial communities of Lviv region has been monitored. The model of elaborating community development strategy is suggested on the principles of human-centered approach, which includes consideration of social community status, priorities of their development, strategic and operational goals. The provision saying that maximum involving civic society institutions is an important way of raising local self-government efficiency and forming territorial community capability is substantiated

Key words: Decentralization, Administrative and Territorial Reform, Territorial Community, Human Factor, Development Strategy.

JEL classification: J01; O15; H70

1. Introduction

A radical change in the system of power and its territorial basis at all levels, making real steps towards country development, meeting modern challenges of the society – all that concern the reform of power decentralization in Ukraine based on the provisions of the European Charter of Local Self-Government. The reform of power decentralization in Ukraine was necessary because the current local self-government system doesn't meet the needs of the society, doesn't ensure creating and maintaining favourable living environment for all-round human development and self-realization, rights protection, providing the population with high-quality and affordable administrative, social and other services on the corresponding territories. It's worth mentioning that territorial community development in any direction or sphere, ensuring the vital activity of the community in accordance with the interests of the population and European principles of state policy concerning local self-government depends directly on human factor development, which is the foundation for social and economic progress of the society on the whole. Creating conditions for human potential realization means strategic success both for individual territorial community and social and economic growth of the country as a whole.

Human factor in our study reflects a set of physiological, intellectual, labour, social, psychological, ethno-cultural possibilities that can be used now or in the nearest future and are realized in the environment ensuring their development (reproduction, accumulation, qualitative usage). Human factor is a set of properties accumulated by human economic

system in the process of its formation and conditions its possibilities concerning functions and development.

The purpose of the study is to elucidate the role of human factor in the processes of forming territorial community development strategy, to analyze the ways of involving people in cooperation to plan the community activity, to identify modern innovative tools and mechanisms for solving problems of local development, as well as the essence of “efficient governing”, for a person to become an active participant of positive changes in community development.

2. Materials and Methods

The methodological concept implies interrelationship and interaction of scientific approaches to determining the role of the human factor in forming territorial community development strategy. They are as follows: abstract and logical method – for substantiating theoretical provisions of local development programme elaboration; systemic and holistic approach was used while determining the role of the human factor in forming territorial community development strategy; graphical method was used for reflecting methodological construction of the concept of the human factor role in territorial community development strategy; SWOT analyses method was used for identifying strengths and weaknesses, opportunities and threats in planning effective social development of the community. The sources of information for conducting the research were publications of scientists and practitioners who studied the influence of the human factor on realization and results of administrative and territorial reform, as well as the data of official informational resources, the results of personal observations included.

3. Results and Discussion

Decentralization process in Ukraine has begun since “The Conception of reforming local self-government and territorial power organization in Ukraine” was adopted on the 1st of April 2014 No.333-p, the main purpose of which is determining directions, mechanisms and terms of forming efficient local self-government and territorial power organization for creating and maintaining full-fledged living environment for citizens, providing high-quality and affordable public services, forming institutions of direct people’s power, meeting citizens’ interests in all spheres of life on the corresponding territory, reconciling the interests of the state with those of territorial communities.

To achieve the goal of the Conception the following tasks should be performed:

- to achieve optimal distribution of powers between local self-government bodies and executive power bodies;
- to ensure provision of affordable and high-quality public services;
- to determine a reasonable territorial basis for activity of local self-government bodies and executive power bodies for providing affordable and appropriate quality public services by basic level bodies (village, town councils and their executive bodies, representative offices (representatives) of individual executive authorities), district level bodies (district council and their executive bodies, district state administrations, territorial bodies of central executive authorities) and regional level bodies (regional councils and their executive bodies, regional state administrations, city councils and their executive bodies, city state administrations, territorial bodies of central executive authorities);
- to create appropriate material, financial and organizational conditions for ensuring the fulfilment of their own and delegated powers by local self-government bodies (Order of the Cabinet of Ministers of Ukraine on the Conception, 2014).

Later the Plan of measures concerning the implementation of the Conception of reforming local self-government and territorial power organization in Ukraine was approved, indicating the need to amend the Constitution of Ukraine and to form a package of new legislation (Order of the Cabinet of Ministers of Ukraine on the Plan, 2014).

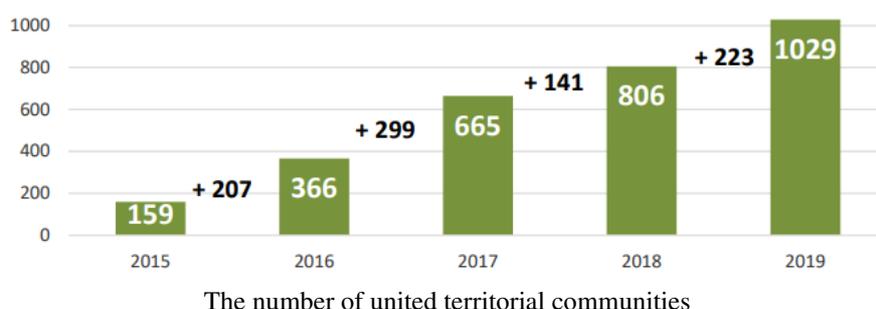
The Law of Ukraine “On voluntary union of territorial communities” adopted on the 5th of February 2015 No.157-19 is one more normative and legal document containing general provisions (principles, subjects, basic conditions of voluntary uniting citizens), the order of voluntary uniting territorial communities (initiation, the order of preparing draft decisions concerning voluntary uniting territorial communities, requirements for them, forming united territorial communities), state support for voluntary uniting territorial communities and the final provisions with adding article 14 about the headman (Law of Ukraine on voluntary union, 2015).

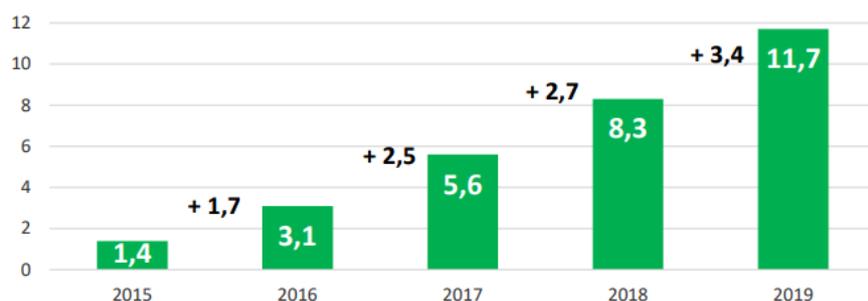
Decentralization reform was initiated mostly in view of the unsatisfactory ability of majority of local self-government bodies out of about 11 thousand local councils existing till 2014 to exercise their own and delegated powers at the appropriate level. Ensuring appropriate ability of territorial communities to provide public services became one of key goals of reforming local self-government and territorial power organization on the principles of decentralization.

According to statistic data, 159 communities were formed in Ukraine in 2015, most of them in Ternopil region -26 communities. In 2016 the number of communities increased by 207 (most of them – in Zhytomyr region -23 new communities), it made up 366 communities. In 2017 299 new communities appeared (25 in Volyn region), together it made up 665 communities. As of November 2018 – 57 new communities were formed, 123 communities are looking forward to elections on December 23rd this year. All in all, during 3 years of power decentralization reform in Ukraine 722 united territorial communities were formed. In Lviv region Zabolotsi village united territorial community became a pioneer of the reform.

During the first stage of decentralization (2015-2019) 1029 united territorial communities were formed (49 out of them are waiting for the decision of the Central Election Committee about appointment of local elections and 44 united territorial communities has administrative centres in the cities of regional significance). In united territorial communities 11,7 million people live (33,3% of the total number of population of Ukraine). The area of united territorial communities makes up 246,8 thousand square km (44,2% of the total area of Ukraine) (Figure 1).

Figure 1. Dynamics of forming united territorial communities in years 2015-2019





The number of population in united territorial communities (mln people)



The area of united territorial communities (thousand square km)

Source: <https://decentralization.gov.ua/>

The second stage of decentralization reform that began in 2020 focused on the need to increase the capability of the united territorial communities first of all to provide public services (Shevchenko O., Romanova V., Zhalilo A., 2020). As a result of administrative reform completion in 2020 1439 territorial communities with total area 576,6 thousand square km were formed in 119 districts of Ukraine. In Lviv region 73 territorial communities were formed in 7 districts (Decentralization, 2023).

The sixth wave of the Ukrainian nationwide sociological research “Decentralization and local self-government reform” was carried out by Kyiv International Institute of Sociology in October-November 2021 commissioned by the Council of Europe Programme “Decentralization and Reform of Public Administration in Ukraine” in cooperation and coordination with the Ministry of Community and Territory Development of Ukraine.

In the course of the research the socio-political attitudes of the adult population (aged 18 and older) were studied through a survey. Main stages of the survey included working out a questionnaire and its supporting tools, selection, interviewing respondents, controlling work quality, inserting and checking data as for logical mistakes, preparing the final amount of the data, tables of one- and two-dimensional distributions and analytical report.

The first wave of the research was conducted in September- October 2015, the second wave – in October-December 2016, the third wave – in October-December 2017, the fourth wave – in November-December 2018, the fifth wave- in August- September 2020.

To conduct the survey a stratified, four-stage selection was elaborated, random at each stage. The selection was represented for adult residents who live permanently on the territory of Ukraine, are not in the military services, in prison or medical institutions (hospitals,

hostels). The territories not temporarily controlled by the government of Ukraine (the Autonomous Republic of the Crimea, some areas of Donetsk and Luhansk regions) were not included into the selection.

At first the population of Ukraine was stratified according to regions (24 regions and the city of Kyiv), then the population of each region additionally was stratified into urban (cities and towns) and rural (with the exception of Kyiv where the population is totally urban). So, on the whole, the population of Ukraine was divided into 49 strata. Due to the number of adult population it was determined how many interviews have to be conducted and how many settlements interviewed should the stratum include. In Donetsk and Luhansk regions only the population of the territories controlled by the government of Ukraine was stratified.

After stratification specific places were selected where interviewers have to work. At the first stage within each stratum settlements were selected. Urban settlements were selected in proportion to the number of adult population in the very settlement. Within rural strata first districts were selected (in proportion to the number of adult population in the district), then within the selected district villages were selected at random. At the second stage polling stations were selected within each settlement. At the third stage the initial address – a street and house number were selected, and in the multi-storied buildings – the number of the flat where the interviewers began the survey. At the fourth stage respondents were selected and surveyed through modified and rout selection.

The survey was conducted by personal interview of the respondents in the households where they lived.

Due to the implementation of random selection at all stages in the final amount of the data women and older people were re-represented a little. To restore the correct proportion a special statistical “weight” was constructed.

The data below are displayed for Ukraine as a whole and separately for 4 macro-regions. Macro-regions consist of: the Western macro-region – Volyn, Rivne, Lviv, Ivano-Frankivsk, Ternopil, Transcarpathien, Khmelnytsk, Chernivtsi regions; the Central macro-region – Vinnytsia, Zhytomyr, Sumy, Chernihiv, Poltava, Kirovohrad, Cherkasy, Kyiv regions, the city of Kyiv; the Southern macro-region – Dnipropetrovsk, Zaporizhzhia, Mykolayiv, Kherson, Odesa regions; the Eastern macro-region – Donetsk, Luhansk and Kharkiv regions.

The field stage of the survey lasted from October 26th till November 17th 2021. In general, within the framework of the research 2000 respondents living in 152 settlements of Ukraine were interviewed.

The statistical error for selecting 2000 respondents (with a probability of 0.95 and for a effect design 1.5) does not exceed:

- 3.3% for indicators close to 50%,
- 2.8% for indicators close to 25% or 75%,
- 2.0% for indicators close to 12% or 88%,
- 1.4% for indicators close to 5% or 95%,
- 0.7% for indicators close to 1% or 99%.

Table 1 gives the number of respondents, error and social-demographic profile of each category in term of which the data are presented in the report.

Table 1. The social-demographic profile of selection respondents on the whole and respondents in terms of settlements depending on their administrative status

	Status			History			Distance to the centre				
100% in column	Ukraine as a whole	Centre	Non-Centre	Centre retained	Centre lost	Non-Centre retained	<5 km	5-9.9 km	10-14.9 km	15-19.9 km	20 km+
Number of respondents	2000	1350	650	1350	450	200	80	200	130	80	160
Error	3.3	4.0	5.8	4.0	6.9	10.4	16.4	10.4	12.9	16.4	11.6
Region											
- West	27.2	21.2	39.7	21.2	41.7	34.9	52.1	40.7	40.0	38.0	33.0
- Centre	34.8	36.5	31.2	36.5	36.1	19.1	13.0	29.0	44.7	47.8	22.8
- South	24.7	27.7	18.2	27.7	15.7	24.2	35.0	16.2	0.0	14.2	29.7
- East	13.4	14.6	10.9	14.6	6.5	21.8	0.0	14.1	15.3	0.0	14.5
Type and size of the settlement											
- village	33.8	6.3	92.0	6.3	88.7	100.0	100.0	84.0	92.0	88.6	100.0
- small town (up to 20 thousand.)	15.4	19.0	8.0	19.0	11.3	0.0	0.0	16.0	8.0	11.4	0.0
- town (20-99 thousand)	13.1	19.3	0.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- big city (100 and more thousand)	37.7	55.5	0.0	55.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Administrative status											
- Community centre	67.9	---	---	---	---	---	---	---	---	---	---
- Not a community centre	32.1	---	---	---	---	---	---	---	---	---	---
History of the administrative status											
- Retained centre status	67.9	---	0.0	---	---	---	0.0	0.0	0.0	0.0	0.0
- Lost centre status	22.7	---	70.7	---	---	---	39.1	82.2	71.4	89.4	61.6
- Retained non-centre status	9.4	---	29.3	---	---	---	60.9	17.8	28.6	10.6	38.4
Gender											
- man	45.3	44.5	47.1	44.5	47.1	47.1	48.8	48.3	46.5	46.5	45.6
- woman	54.7	55.5	52.9	55.5	52.9	52.9	51.2	51.7	53.5	53.5	54.4
Age											
- 18-29 years old	16.1	16.1	16.1	16.1	17.3	13.3	16.3	17.0	15.5	19.3	13.9
- 30-39 years old	20.3	21.3	18.0	21.3	19.0	15.6	15.1	13.2	17.3	25.5	22.2
- 40-49 years old	18.0	18.3	17.4	18.3	17.2	17.8	19.6	17.1	14.4	14.8	20.5
- 50-59 years old	16.6	15.9	18.0	15.9	16.8	20.8	19.2	22.1	17.7	13.0	15.0

- 60-69 years old	15.3	15.4	15.3	15.4	14.2	17.9	17.2	16.2	14.6	12.1	15.4
- 70+ years old	13.7	13.0	15.2	13.0	15.4	14.6	12.7	14.5	20.5	15.2	12.9
Education											
- incomplete secondary and lower	4.4	3.5	6.3	3.5	7.3	4.1	2.9	7.6	6.8	6.7	5.9
- complete secondary	29.6	23.6	42.3	23.6	42.3	42.4	29.0	45.5	44.4	34.1	47.4
- secondary special	33.5	34.5	31.6	34.5	32.3	29.8	40.2	31.4	29.6	31.9	29.0
- higher	32.1	38.1	19.6	38.1	17.9	23.7	27.9	15.5	19.2	27.3	16.9
- hard to say	0.3	0.3	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.7
Main occupation											
- worker (industry, (agriculture)	19.8	20.0	19.3	20.0	18.2	22.0	10.3	22.0	17.5	8.3	27.7
- white-collar workers	8.4	9.0	7.3	9.0	7.1	7.7	19.5	4.2	5.9	8.2	5.8
- specialist	15.3	18.3	9.0	18.3	10.0	6.7	10.7	8.0	8.9	17.0	5.3
-self-employed, entrepreneur, farmer	5.7	6.0	5.0	6.0	5.4	4.1	10.4	5.3	4.6	2.1	3.9
- army, police	0.7	0.7	0.7	0.7	0.8	0.4	0.0	0.0	0.6	0.0	2.3
- householder	8.9	6.6	13.6	6.6	13.5	14.0	10.7	15.4	10.0	13.5	15.9
- retired	30.2	29.3	31.9	29.3	31.6	32.8	26.3	32.8	36.7	32.6	29.2
- pupil, student	2.8	3.2	1.9	3.2	1.4	3.3	4.0	1.5	1.1	0.0	3.2
- unemployed	7.9	6.6	10.7	6.6	11.4	9.0	8.2	9.9	14.7	16.3	6.6
- hard to say	0.3	0.3	0.5	0.3	0.7	0.0	0.0	0.8	0.0	1.8	0.0
The level of family well-being											
- very low	13.1	11.8	15.7	11.8	19.5	6.6	11.0	18.1	21.3	10.0	13.3
- low	36.2	35.6	37.4	35.6	34.2	45.3	33.5	41.2	42.2	32.3	33.4
- average	42.0	43.5	38.7	43.5	38.7	39.0	47.1	31.7	30.2	47.8	45.9
- high	6.1	6.4	5.5	6.4	4.3	8.5	7.6	3.8	5.2	4.6	7.4
- hard to say	2.7	2.7	2.6	2.7	3.4	0.7	0.8	5.1	1.2	5.3	0.0

Source: The sixth wave of the Ukrainian nationwide sociological research “Decentralization and local self-government reform”, Kyiv International Institute of Sociology, October-November 2021 commissioned by the Council of Europe Programme “Decentralization and Reform of Public Administration in Ukraine” in cooperation and coordination with the Ministry of Community and Territory Development of Ukraine. URL: <http://www.slg-coe.org.ua/category/library/>

While interpreting the results among some categories (specific regions, categories, etc.), it should be taken into consideration that since there are fewer respondents in this category than selection in general, the margin of error is accordingly higher. We also took into account the “intersection” of some social-demographic categories. Among poorer respondents, for example, aged and less educated people are represented. For that reason each category in which the data are given, are presented in Table 1 according to the number of respondents, error and also social-demographic profile of this category

Due to decentralization reform the government institution –the closest to a citizen– local self-government was formed. Decentralization reform is based on the provisions of the European Charter of Self-Government. The beginning of the reform caused a contradictory attitude towards it from community residents and the representatives of local self-government bodies.

It was expected that at the beginning of the reform its support among the population was lower than today, but every year the support increased. According to the sixth wave of the national sociological research in 2021 63% of citizens support decentralization (it is by 4% more than last year). The level of awareness in the course of administrative and territorial reform makes up 83%.

The assessment of activity of local self-government body representatives also improved:

- 41% of the respondents positively approve of community head, 15% - negatively;
- respondents assess local council activity rather critically: 33% think its work to be positive, 16% - negative;
- the assessment of headmen activity was also conducted in the settlements that are not community centres: 51% of the respondents assessed positively their headman's activity, 9% - negatively.

In general, the study shows positive perception of the reform among the population and its significance. However, as in 2020, the population expects changes from the reform in some spheres:

- 58% - expect the corruption to decrease due to the reform;
- 42% - expect high quality and affordable services to improve due to the reform;
- 32,5%- expect improving territory organization (Reforms, 2021)

The community itself is the most valuable capital (asset) of a territorial community. The social capital is formed from an active community and is a component of the nation's capital, moreover, it's an integrated indicator of the collective action of individuals and groups, who receive higher social and economic results due to synergetic effect of joint and coordinated actions. Nowadays the question of human factor role in the process of elaborating territorial community development strategy, planning and taking management decisions is the first item in the agenda of local authority renewal.

People – their knowledge, ideas, intellect, desire and ability to cooperate in order to solve current community problems collectively and act towards developing different spheres of the society – are an important factor of competitive advantages under modern development conditions, it is a social community capital. Article 3 of the Constitution of Ukraine says, “Man, his life and health, honour and dignity, inviolability and security are recognized as the highest social value in Ukraine”. That is why any policy in Ukraine at the local and national level must be aimed at people, meeting their interests, creating conditions for full development, safe and comfortable life environment.

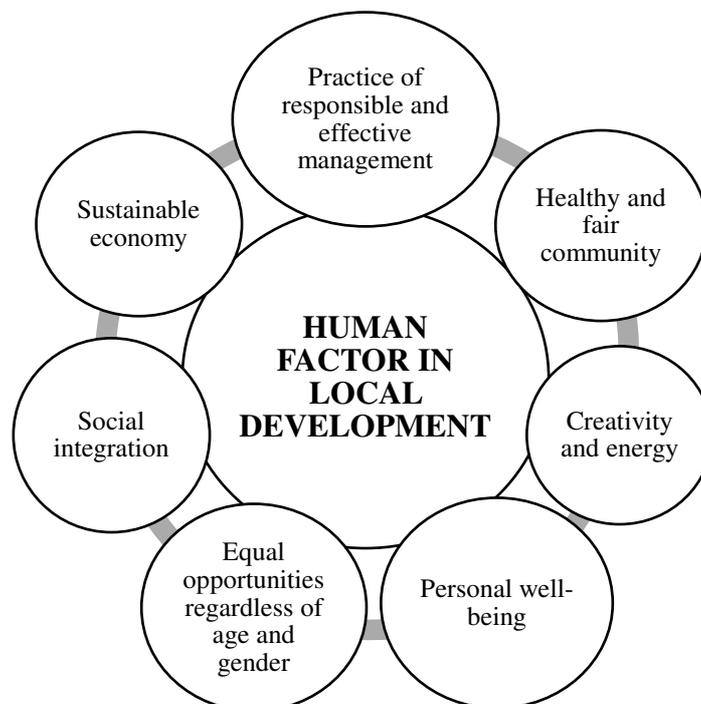
Modern society makes out and improves ways and mechanisms stimulating people to mass self-organization and involving them in development planning processes, thus promoting establishment of interpersonal and intergroup relations based on mutual trust and trust in the authorities. It will harmonize political, social, economic interests, improve the possibilities of their rational expressing at the levels of the community, country and society. In terms of stability, efficiency of action planning and economic development cooperation in the community turns out to be more important development factor that any other (physical, economic) recourses.

Ways of involving citizens in planning and decision-making at all levels can be the subject for discussion and they are actively studied by scientists, politicians and public figures. It is safe to say that increasing the role of the human factor in decision-making processes

becomes an absolute long-term modern tendency. Management classics claim that the key strategy success depends on identifying participants' goals with organization (community) goals.

The human factor activity in modern society is intensified by synergy effect that is inextricably linked to population trust in the authority bodies. The trust should be established between community population and local authorities on order to strengthen communities. Trust itself stimulates rapid economic growth. Francis Fukuyama thinks there is a civil society in Ukraine, which means that people work beyond the government, beyond the state for the sake of common goal (Butsko, 2019). When people are satisfied with state service quality and infra-structure, they become more confident, dissatisfaction among social groups is minimized, new social values are formed. Voluntary decision of a person to take part in community life lies at the heart of social cohesion. At the beginning of management reform process systemic and effective approaches to elaborating state strategies for the long term are rather significant. Human role in the processes of forming local development depends basically on the conditions of territory economic and social development (Figure 2.).

Figure 2. Human factor in local development



Source: developed by the authors

It should be emphasized that not only people, but their effective cooperation, knowledge, skills available, qualification and motivation for mutual searches and activity of developing their own territory, which are synergistically interwoven creating a new value and potential for the development, are a significant and sometimes determining factor of ensuring territory development.

The number of different groups and interested parties taking part in local development, in any society can be very large. Such a large number of participants may cause difficulties involving all interested parties in planning process. Experience shows that the more participants the more expensive, longer and less efficient their activity is. On the other hand, the less

number of participants, the less equal, less transparent and less efficient the activity of strategy formation and implementation will be. That's why it is important to involve interested parties in sufficient number and representativeness for the given community.

In order to determine clearly the role of the human factor and conditions, under which they will agree to take part in the process of local development process, we suggest using "CLEAR" model (Ibrahimova, I., 2020). (Table 2).

The direction of prospective, efficient community development depends on meaningfulness of the development strategy and stages of its implementation. In fact, the strategy is based on the analyses of social and economic development of the territories, settlements included in united territorial communities, a general set of views of local authorities and community residents on the perspective of its development. According to the order "On approval of methodological recommendations concerning formation and implementation of forecast and program documents of social and economic development of united territorial community" No.75 dated 30.03.2016, development strategy of a united territorial community determines goals, indicators, priorities and tasks of sustainable development for the period of 7 years (Order of the Cabinet of Ministry of Ukraine, 2014).

Table 2. CLEAR model of human participation in territorial community planning process

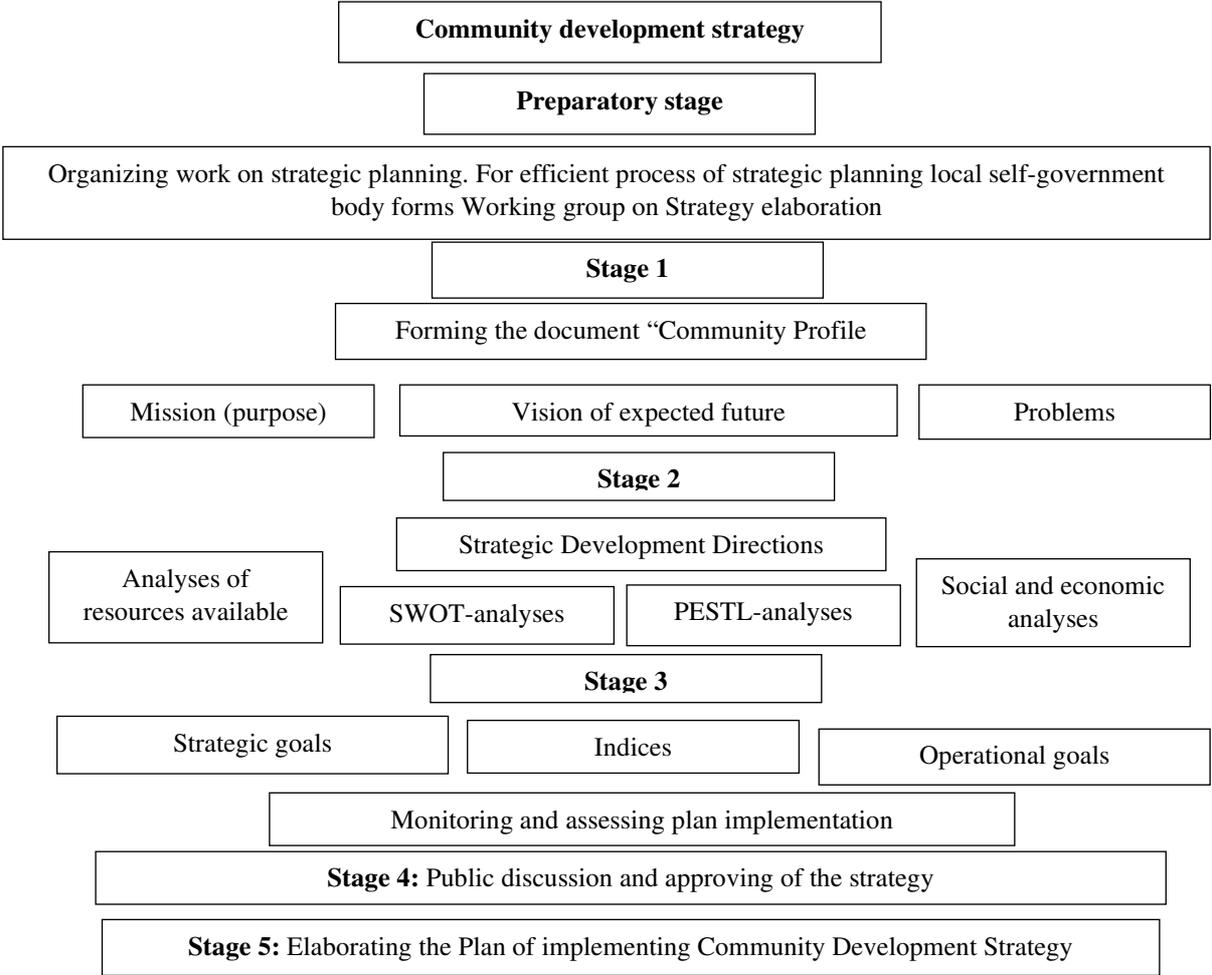
Participation factors	How does it work?	Political action of local authorities
ABILITY TO TAKE PART Can do	Personal resources community representatives have and can suggest (knowledge, information, skills to speak in public, write, organize events, encourage support, etc., as well as confidence of their usage) are essential for ensuring ability to participate	Developing capability: specific support measures and purposeful development of social capital
DESIRE TO TAKE PART Like to	Dedication to participation requires a sense of belonging to the community (communities), a sense of trust and belonging to relations and communities, creates opportunities for people to cooperate and work more efficiently	A sense of community, involving citizens, social capital and citizenship
CREATING POSSIBILITIES FOR PARTICIPATION Enabled to	Public infrastructure, forming voluntary, public advisory groups, organizations and networks – create (or block) opportunities to participate	Developing public infrastructure for forming groups and organizations, able to direct participation and promote it
INVITATION TO PARTICIPATION Asked to	Mobilizing people for participation (decision-making) and expectation of their contribution	Introducing possible ways of public participation and their openness. Using different incentives for development, a sense of duty, continuity of participation, targeted invitations to participate
CONSIDERING POINT OF VIEW, FEEDBACK Responded to	People are ready to participate if they feel to be listened to (not necessarily agree, but it's clear that their opinions are considered)	Ability of public policy system and staff to 'respond' to needs, to weigh different points of view, give feedback- it is important to explain how the decision was adopted and what role of a person or community was

Source: developed by the authors, using (Ibrahimov A., 2020)

Community strategy is a fundamental document determining the vision of territorial community development for the nearest years, the mechanism of community sustainable development, relying on resources and knowing exactly its strengths and weaknesses. The strategy is implemented due to the plan (programme) of social and economic development of the united territorial community, which determines goals and priorities, tasks and mechanisms of their implementation, organizational and administrative measures, etc. for the period of 3-5 years. For the purpose of sustainable development of regions, according to the State strategy of regional development for the years 2021-2027, each united territorial community had to approve by 2022 development strategy based on efficient using state and local resources in the interests of man in the appropriate communities.

In EU countries the strategic document of territory development is a mandatory condition for obtaining external financing, as it indicates that the community is aware of development purpose necessary for its achieving resources, action plan (Strategy, 2018). Nowadays only a third of more than 1.000 communities formed in Ukraine have such a strategy, one more third is still elaborating it, the rest – only plans.

Figure 3. Model of community development strategy elaboration



Source: developed by the authors

Partnership method and managerial or expert approach are applied to elaborating strategic documents. Managerial approach means that only local authorities without involving the public elaborate the strategy. It takes much less time to elaborate documents, however,

if council members change such a document will also greatly change. Expert approach means that experts are involved in elaborating the strategy, the participation of local authorities and the public is minimal, because the experts consult with professional specialists. This approach also has some drawbacks connected with on-line elaborating document without actual assessing community weaknesses and strengths, territory potential, considering local peculiarity, community people's opinions and expectations.

The "LEADER" approach to planning territorial community development deserves attention, it was suggested in 1990 as a respond to traditional policy failure to solve community problems. Its essence ("bottom-up" principle) consists in encouraging people to elaborate and introduce original strategies of territory integrated development within the general context of the European priority tasks – improving life quality, involving high technologies, optimal using natural and cultural resources of local level (Korinets R., 2023). Local population is considered to be the best expert in its territory development.

SWOT-analyses is a kind if a bridge between community diagnosis and its development strategy. SWOT-analyses identifies strengths and weaknesses, external possibilities and threats resulting from existing situation in the community, and at the same time – determines its development prospects. Below SWOT-analyses results are represented, considering human factor in strategic development. (Table 3).

Table 3. Human factor in SWOT territorial community strategy

Strengths	Weaknesses
Developed network of educational and cultural institutions Strong personnel potential available in education Demographic stability in the community Active youth as community driving force Active programmes for population social protection Absence of inter-religious conflicts, religious tolerance Affordable social services	Low social activity of community people Small amount of public organizations Mistrust of the authorities Non-acceptance of reforms Ignorance of rights
Opportunities	Threats
State support (subventions), state and regional social sphere support programmes Active participation in social projects Local budget opportunities: programmes, participation budget Local resources for social sphere development Social cohesion of population in solving community life problems	Changes of state policy priorities concerning decrease in community social sphere support Delegating financial support of state guarantees to local budgets Centralized or manual allocation of financial resources for social services Local population inertia and apathy

Source: made by the authors

Community development strategies are "road maps" of the changes with clearly defined goals, each of them is represented by a set of specific operational measures with detailed tasks, achievable quantitative parameters, fund amount justification, necessary for their implementation. To analyze citizens' participation in territorial community development planning we chose five territorial communities in Lviv region, the so called the Buh area: Radekhiv, Sokal, Zolochiv, Zhovkva and Zabolotsi (the first one in Lviv region stepped on the path of decentralization).

Let's consider the main Strategy structure of the communities studied.

- Part I Methodology

- Part II Diagnostics (Society; Education; Infrastructure; Economic activity and economy structure; Culture, recreation, tourism; Life quality; Community local authority; SWOT-analyses)
- Part III Strategic documents context
- Part IV Vision, mission, strategic and operational goals of citizens
- Part V Action plan
- Part VI Accessible sources of projects financing (foreign sources, national sources)
- Part VII Evaluation and monitoring

The procedure of studying public opinion in the above united territorial communities is aimed at revealing the degree of people's satisfaction from services quality in the community and further taking measures to improve their quality. Studying population opinion is carried out in writing through secret ballot (by hand or via Internet resources, community website, for example). The representatives of working group conduct a survey, determine questionnaires form and content and analyze survey results in order to take them into consideration working further to elaborate the Strategy of the united territorial community development. The form and content of questionnaires for conducting surveys may be different for every other community, though they must include mandatory entries: surname, name, patronymic, position and contact information of the person who conducts the survey; the date and place of the survey; the list of questions asked; general information about the respondent (sex, age, place of residence, etc.). Each questionnaire includes the list of the most important issues (factors) which have the greatest influence on the united territorial community development. Under every question there is a special place for comments or additional information the respondent wants to report. It is important to say that before filling in the questionnaire respondents must be warned about their right not to answer any question he is asked (the Constitution of Ukraine guarantees). Later, according to the results of population opinion study, the representatives of working group write an analytical report, which should include the results of community population opinion study and recommendations to eliminate identified flaws.

RADAR methods, as optimal formula, were chosen in Zabolotsi united territorial community for meeting with inhabitants. They consist in direct expressions of main community problems by residents. Then the indicated problems were prioritized by democratic voting. Working up the instruments for solving the problems became the next step.

The stage of information gathering and the procedure of public opinion study is very important in the process of elaborating the Strategy of united territorial community development that cannot be underestimated. It is the basis of all the further research, the results of which will help the community to identify the priorities of its development and form strategic goals for several years ahead.

Based on the study conducted we suggest our own model of involving people in community development strategy elaboration.

It is precisely this way of forming local government, its actual subordination to the territorial community, control of executive body activity, possibility of direct influencing bodies and officials by electorate through democratic procedures, established according to law, that ensures efficiency and transparency of local government. Of course, if the community itself is ready for such significant participation in forming territorial community development strategy and local government activity.

Figure 3. The model of involving people in community development strategy elaboration



Source: developed by the authors

4. Conclusion

Citizens' initiatives, accountability and controllability of the institutions created by them, the ability to withstand crises, conflicts of interests, etc. are significant factors of community efficiency. The latter is the overarching context of the problems requiring the newest methodological base of studying human factor role in local development in accordance with the principles of territory sustainable development, which is considered to be a promising task for further scientific research.

At present the main task of achieving efficient self-government is transformation of community people thinking and realizing the fact that nobody but they themselves will engage in welfare of the community and solve its development problems with the existing qualitatively updated legislative and financial base.

References

Butsko, D. (2023) "There is not such populist movements in Ukraine, as in the USA or Europe" Fransis Fukuyama [Online], Available: https://lb.ua/news/2019/05/27/427956_v_ukraini_shche_nemaie.html [Accessed: 13 April 2023].

Law of Ukraine "On voluntary union of territory communities": [adopted February 05 2015 No.157-VIII]// *Information of the Verkhovna Rada of Ukraine*. 2015. No.13. P.91; [Online], Available: <http://zakon3.rada.gov.ua/laws/show/157-19/ed20150205> [Accessed: 23 May 2023]

European Charter of Local Self-Government. *Bulletin of legislation and legal practice of Ukraine*. 2002. N. 10: Local self-government in Ukraine. p. 448.

Korinets, R. (2023). “*Rural development*”. Textbook for experts in agrarian and rural development of territorial communities. Kyiv. FOP Lopatina O. p.157.

Order “On approval of Methodical recommendations concerning formation and implementation of programme documents of social and economic development of the united territorial community” from March 30 2016 No.75. [Online], Available: <https://zakon.rada.gov.ua/rada/show/v0075858-16#Text> [Accessed: 10 May 2023].

United communities: list and main data; [Online], Available: <http://decentralization.gov.ua/gromada> [Accessed: 3 May 2023]

Vasylchenko, H., Parasiuk, I. and Yeremenko, N. (2015). „*Planning territorial community development*”. City Association of Ukraine K., “VNA’ ENTERPRISE LTD”. p. 256 ISBN 978-966-9752600-4

Practical manual on forming capable territorial communities [Electronic recourse]. [Online], Available: http://oblrada.dp.ua/user/files/posibnuk_z_ritan_formyvannya_ter_gromad.pdf [Accessed: 20 April 2023]

USAID Project “Increasing work efficiency and accountability of local self-government bodies” (HOVERLA”) [Online], Available: <https://decentralization.gov.ua/donors/hoverla> [Accessed: 3 April 2023]

Community development strategy – not only the document with figures, it is the definition of the future, the community strives for. Decentralization gives opportunities. [Online], Available: <https://decentralization.gov.ua/news/10947> [Accessed: 19 April 2023].

Local self-government reform: what questions are on the agenda and why are they significant? [Online], Available: https://parlament.org.ua/2021/12/22/reforma-mistsevogo-samovryaduvannya-yaki-pitannya-na-poryadku-dennomu-i-chomu-voni-znachimi/#_ftn1 [Accessed: 13 April 2023]

Order of the Cabinet of Ministry of Ukraine “On approval of the Conception of reforming local self-government and territorial power organization in Ukraine”: [Adopted on April 2014 No.333-p]; [Online], Available: <http://zakon2.rada.gov.ua/laws/show/333-2014-p> [Accessed: 23 May 2023]

Order of the Cabinet of Ministry of Ukraine “On adopting measure plan concerning the Conception of reforming local self-government and territorial power organization in Ukraine”: [adopted on June 18 2014 No.591-p]; [Online], Available: <http://zakon2.rada.gov.ua/laws/show/591-2014-p/ed20140618> [Accessed: 20 May 2023]

Ibrahimova, I. (2020). “*Leadership in the community. How to tire people and achieve common goals*”. Uston Publishing House. 106 p. ISBN 978-617-7854-38-7

Decentralization [Online], Available: <https://decentralization.gov.ua/> [Accessed: 23 May 2023]

Shevchenko, O., Romanova, V. and Zhalilo, A. (2020). “*Decentralization and forming regional development policy in Ukraine*”, scientific report; under the scientific editorship of Zhalilo Ya.A., Doctor of Economy. Kyiv; NICD.P.153 ISBN 978-966-554-344-2

Development strategy of Zabolotsi territorial community [Online, Available: <https://zabolotsivska-gromada.gov.ua/strategiya-rozvitku-gromadi-11-17-21-16-03-2018/>] [Accessed: 19 April 2023]

Development strategy of Radekhiv territorial community [Online, Available: <https://miskrada-radekhiv.gov.ua/>] [Accessed: 19 April 2023]

Development strategy of Zhovkva territorial community [Online, Available: <https://zhovkva-rada.gov.ua/golovna.html>] [Accessed: 19 April 2023]

Development strategy of Zolochiv territorial community [Online, Available: <https://zolochivska.gromada.org.ua/>] [Accessed 19 April 2023]

Development strategy of Sokal territorial community [Online, Available: <https://sokal-rada.gov.ua/Pro-gromadu/stor-3>] [Accessed 19 April 2023]

The sixth wave of the Ukrainian nationwide sociological research “Decentralization and local self-government reform”, Kyiv International Institute of Sociology, October-November 2021 commissioned by the Council of Europe Programme “Decentralization and Reform of Public Administration in Ukraine” in cooperation and coordination with the Ministry of Community and Territory Development of Ukraine.URL: <http://www.slg-coe.org.ua/category/library/> [Accessed 29 April 2023]

GENERATION Z STUDENTS' ATTITUDES TOWARDS CIRCULAR ECONOMY FOR THEIR INVOLVEMENT IN ORGANISED COLLECTION OF USED COOKING OIL

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Annotation: Waste management is based on the waste hierarchy, according to which waste prevention is a priority. If it is not possible to prevent waste, then the next step is to prepare it for reuse, recycling, other recovery, including energy recovery. If neither option is possible, disposal is last in the hierarchy. The aim of the research is to map and evaluate the attitudes of Generation Z students towards the circular economy as a sustainable solution for dealing with biodegradable waste based on a questionnaire. Descriptive methods were used for the research. The research method was quantitative survey with output in the form of statistical data. Data collection in this thesis was done in the form of primary quantitative questionnaire survey. This method was chosen because of the quick collection of data from a large number of respondents through Google Forms. The questionnaire was designed to be anonymous and was distributed through the social networking site Facebook and the author's network of personal contacts was also used. The issue of waste management is becoming an increasingly discussed and trendy topic as people realise how important it is to manage waste appropriately. A huge amount of waste is produced every day in the Czech Republic and needs to be disposed of. It is therefore clear that the Czech Republic is concerned with waste management and is trying to reuse waste within the framework of the circular economy. Even so, there is still a long way to go for each of us, and we must start with ourselves and think about our personal waste production.

Key words: circular economy, biofuel, biodiesel, used cooking oil, waste management

JEL classification: O18, O44

1. Introduction

The idea of a circular economy has two long strands, the first of which concerns the flow of materials through the economy, and the second deals with considerations of the economic conditions that might trigger such a flow. These two conceptual strands go back to the origins of the modern environmental movement in the 1960s and 1970s and are in subsequent symbiosis with it. The materials stream evolved from the concept of "industrial ecology," a term that, along with the related term "industrial symbiosis," was used in economic geography in the 1940s to describe the determinants of the location of industrial enterprises in order to use resources efficiently and avoid waste. By 1970, these ideas had acquired a normative element, as a remarkable passage from a speech by the president of the American Association for the Advancement of Science shows: "The goal of the next industrial revolution is to ensure that there is no such thing as waste, on the basis that waste is simply some

substance that we cannot yet use...'. In the next industrial revolution, there must be a feedback loop from the user to the factory that industry must close. (Cohen, 2022; Geissdoerfer et al., 2017; Kirchherr et al., 2017; Zeman et al., 2019)

The aim of circular economy is to preserve the value of products, materials and resources for as long as possible by returning them to the production cycle at the end of their use, while minimising waste. The fewer products we throw away, the fewer materials we use, the better for our environment. The circular economy offers an opportunity to reinvent our economy and make it more sustainable and competitive. Figure 1 shows the circular economy model. (Geisendorf and Pietrulla, 2017; Geng et al., 2009; Global Material Resources Outlook, n.d.; Kirchherr et al., 2017)

Figure 1. Circular economy model



Source: Cohen, 2022

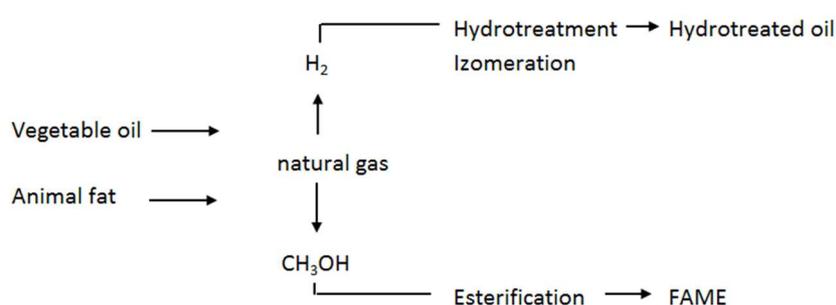
The major social and environmental challenges facing the world require a radical revision of the traditional development model. The circular economy is emerging as a solution, proposing a change from a linear model based on extraction, production, consumption and disposal towards a more sustainable economic model through innovation, competitiveness and care for the environment. It seeks to decouple economic development from the use of natural resources, thus rethinking the design of its processes and products, which in turn contributes to the regeneration of natural ecosystems. All of these schools of thought operate with similar principles. They seek to make materials last as long as possible and to renew materials instead of extracting new non-renewable raw materials. Alongside this, they seek to reduce waste production, maintain a clean environment undisturbed by human activity and find inspiration in natural processes, which they then apply to industrial systems. The circular economy has also adopted these principles. (Cohen, 2022; Global Material Resources Outlook, n.d.; Kirchherr et al., 2017)

The energy needed to power the cycle should be from renewable sources. Solar, hydro, wind, geothermal or biofuels are suitable. (Cohen, 2022; Geissdoerfer et al., 2017; Geisendorf and Pietrulla, 2017)

There is currently a shift from traditional biofuels to second generation biofuels based on the use of waste. Instead of the standard biodiesel from, for example, rapeseed oil,

the possibility of producing biodiesel by hydrotreating is offered. Such biodiesel has much better fuel parameters and is much more suitable for processing used cooking oil. Used cooking oil can thus be processed into a very high quality fuel, which would not be possible by the standard transesterification process to maintain the required quality parameters. The production of hydrogenated vegetable oils is based on the introduction of hydrogen molecules into the fat molecule. This process is associated with the reduction of the carbon compound. When hydrogen is used for the reaction with triglycerides, different types of reactions can occur and different final products are associated with them. (Kirchherr et al., 2017; Zeman et al., 2019)

Figure 2. Simplified diagram for the production of hydrotreated oils and fatty acid methyl esters. FAME: fatty acid methyl esters.



Source: Zeman et al., 2019

Figure 2 shows the difference between the treatment of oils for standard biodiesel by the esterification process and the hydrotreating process.

The aim of the research is to map and evaluate the attitudes of Generation Z students towards circular economy for the possibility of engaging the student community in the organized collection of used cooking oil to reduce the environmental burden of wastewater and for the production of advanced biofuels.

Research question: Can Generation Z potentially be used for organised collection of used cooking oil for industrial use?

2. Materials and Methods

The paper was prepared on the basis of analysis of secondary sources (articles, monographs) and mainly through my own primary research. The data was obtained by means of quantitative research carried out by questionnaire technique. Data collection was carried out among university students across all disciplines within the Czech Republic. The choice of institutions was deliberately chosen to provide a representative cross-section of student attitudes regardless of field of study. The sample consisted of students who were approached according to two basic criteria. The first was studying at a college/university, and the second was age between 18 and 25.

The questionnaire was completed by respondents who studied at a university in Prague. 663 students participated in the survey. Data collection was conducted among university students across all disciplines within Prague universities in the academic year 2022/2023. Students were approached thanks to the willingness of cooperating lecturers.

Data collection in this thesis was done in the form of primary quantitative questionnaire survey. This method was chosen because of the quick collection of data from a large number of respondents through Google Forms. The questionnaire was designed to be anonymous and was distributed through the social networking site Facebook and the author's network of personal contacts was also used.

Multinomial logit model was used for research purpose. This is an extension of the binary logit model when the outcome can have more than two categories. It is used when the dependent variable is categorical and unordered.

Table 1. Summary statistical data

	Respondents (n=663)
Gender	
Male	338 (51%)
Female	325 (49%)
Age	
Average Age	21 years
Age Range	18-35 years
Education Level	
High School or less	203 (31%)
Some College	220 (33%)
Bachelor's Degree or Higher	240 (36%)
Income Level (monthly)	
Under CZK 10,000	200 (30%)
CZK 10,000 - 30,000	263 (40%)
Over CZK 30,000	200 (30%)
Employment Status	
Employed	500 (75%)
Unemployed	80 (12%)
Only Student	60 (9%)

The table 1 provides summary statistics for the gender, age, education level, income level, and employment status of the respondents. Here are a few things to note:

The percentage is calculated by dividing the number of respondents in each category by the total number of respondents and then multiplying by 100.

For the age category, the average age and age range of the respondents are provided.

The education level, income level, and employment status categories provide a breakdown of respondents by these various categories.

3. Results and Discussion

The survey examined knowledge of the concept of circular economy and the management of used cooking oil. The age structure of the respondents is shown in Figure 3.

In the case of used cooking oil management, a questionnaire survey method was used to collect information on the general knowledge of a selected group of people about

the proper disposal of used cooking oil and the possibility to get involved in its collection and the perceived importance of such disposal. Figure 3-16 evaluates the responses of the respondents.

Figure 3. Study by specialisation

The focus of your university studies? (%)

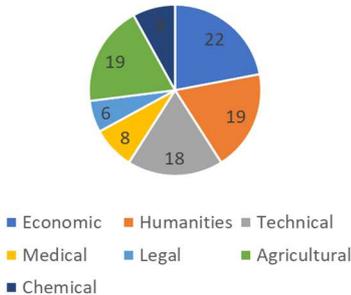
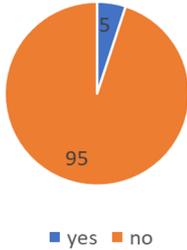


Figure 4. Knowledge of the concept of circular economy

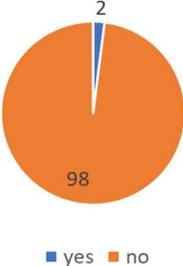
Do you know what the circular economy is? (%)



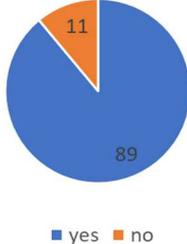
Students from all over the Czech Republic are concentrated at Prague universities. As can be seen in Figure 4 and 5, regardless of the specialisation, the concept and the principles of circular economy as a promising sector is still almost unknown.

Figure 5. Knowledge of the principles of circular economy	Figure 6. Interest in waste management
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Do you know what the principles of the circular economy are? (%)



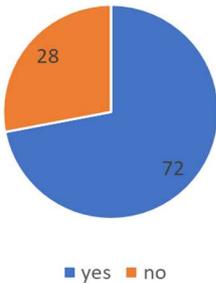
I am interested in the usability of waste (%)



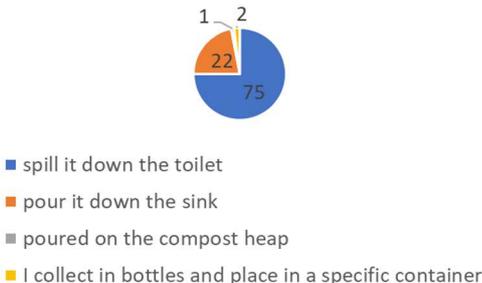
Students are mostly unfamiliar with the circular economy, but on the other hand they are interested in waste treatment mainly for environmental reasons. This interest is illustrated in Figure 6.

Figure 7. Amount of respondents sorting waste	Figure 8. How respondents dispose of used cooking oil
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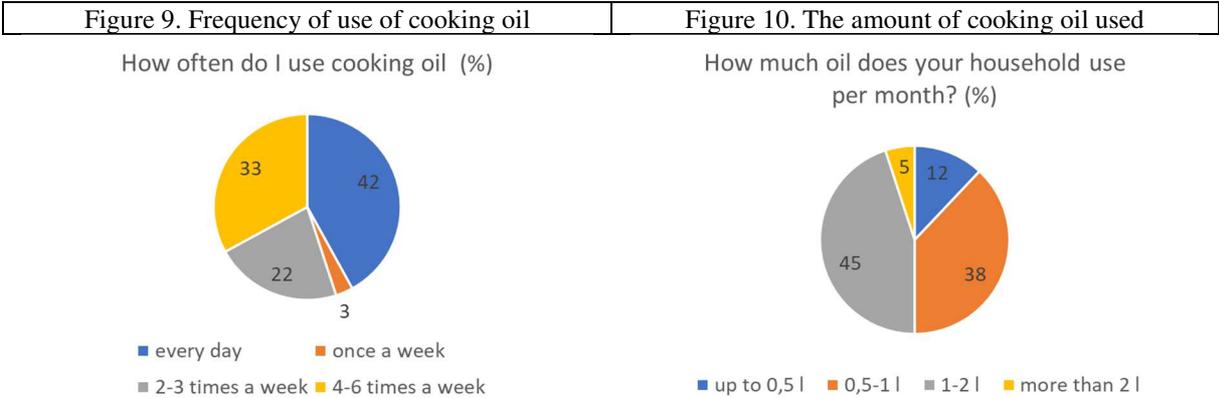
Do you separate waste? (%)



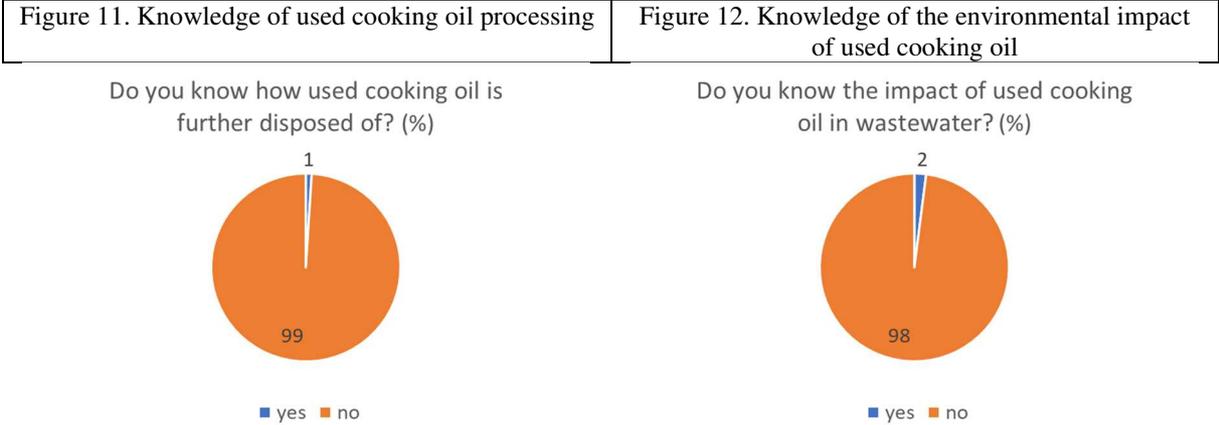
How do you dispose of used cooking oil? (%)



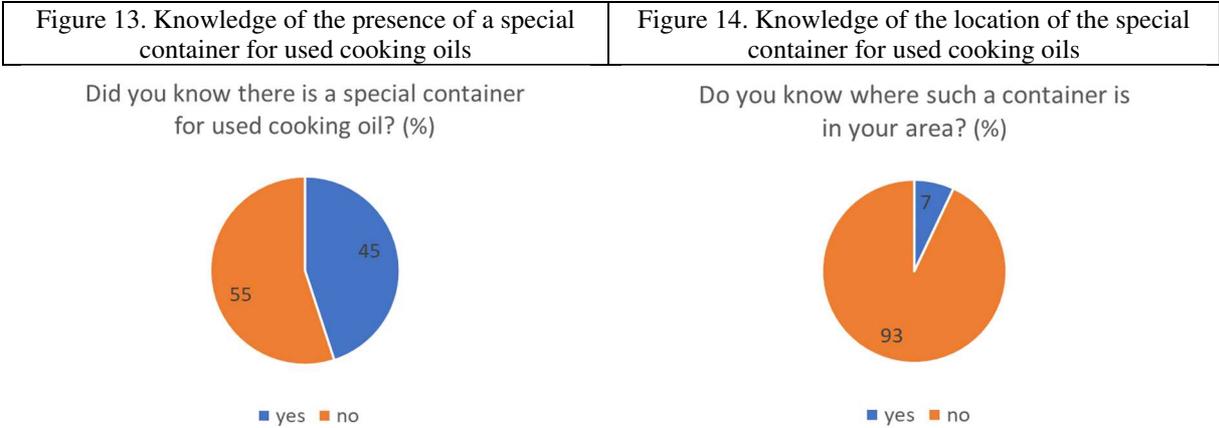
The interest in waste management also corresponds with waste sorting. While waste segregation is becoming relatively standard for this generation, the vast majority of waste cooking oil ends up in the wastewater, as shown in Figure 8.



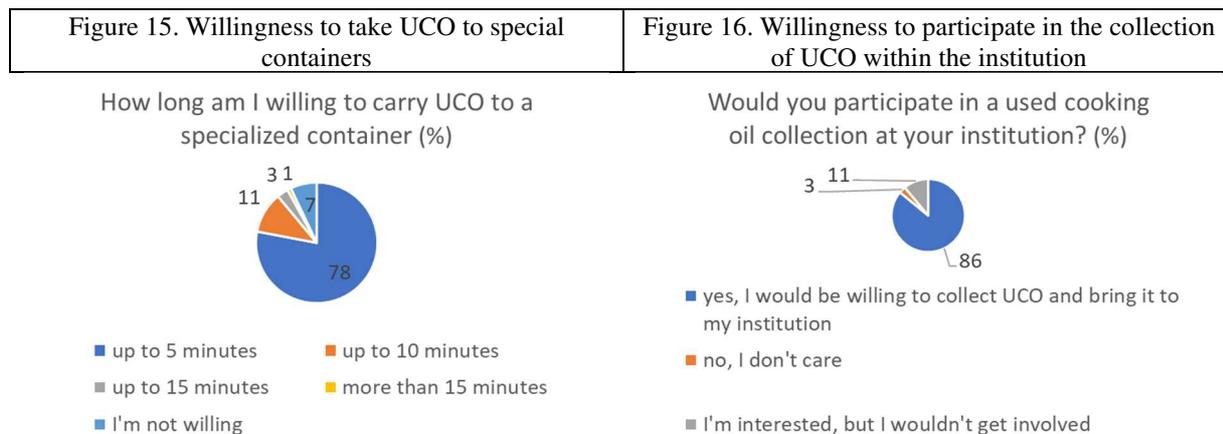
The frequency of use of cooking oil (Figure 9) and the amount of oil used (Figure 10) suggest the potential in ensuring coordinated collection through, for example, universities, faculties and student hostels.



The issue of biofuels is generally a matter of debate. Little known is that it can be used to, produce biodiesel and at the same time reduce the environmental impact in wastewater (Figure 11 and 12). There is already a shortage of this material with respect to demand with the introduction of the European RED II Renewable Energy Directive.



Waste sorting containers are known, but less known among students is that used cooking oil also has its own special container (Figure 13). Almost unknown is its location (Figure 14).



The willingness of students to participate in organised collections is a prerequisite for their involvement. Figure 16 thus presents a positive finding. The fairly unambiguous answers show that there is no relationship between attitudes and field of study or gender.

The questionnaire clearly shows that the concept of circular economy is relatively young and its diffusion is still in its infancy. The principles of the circular economy are thus quite unclear in the sub-state, with 89% of respondents showing an interest in waste management and the majority of respondents, for example, sorting waste. 75% of respondents said they flush used cooking oil down the toilet and a further 22% pour it down the sink. The result is the same and requires more maintenance and cleaning costs for wastewater treatment plants.

Few of the respondents knew that there is a special container for used cooking oil. However, the extension of this container is very limited, At the same time, a problem for further use is that used cooking oil is stored here in different types of containers and industrial use, e.g. for biofuel production in large-scale production, is thus completely impossible. This offers the possibility for universities and other institutions to set up their own collection points for cooking oil, and at the same time to have clearly defined conditions for this collection. The industrial processing of used cooking oil into advanced biofuels has clear limits and these are the limitation of transport costs and single-use collection containers. The paper clearly presents that respondents are aware of the importance of processing waste materials and their involvement in organized collection is thus desirable.

There are research studies looking at young people's recycling behaviour, for example ((Saladié and Santos-Lacueva, 2016). This article provides a new insight into the involvement of university students in the used cooking oil collection scheme. The potential of education for raising awareness and introducing environmental education and the concept of green chemistry is mentioned, for example, by (De Oliveira et al., 2021). The tracking of students' reuse and separate collection behaviour of waste coming from plastic packaging, paper, aluminium, batteries, ferrous packaging waste, electronic equipment, used cooking oil and printer toner is also addressed in (Gherhes et al., 2022). But the industrial ending and infrastructural development of the Czech Republic and the defacto reversal

of the approach, where already existing industry is looking for sources that minimize the environmental impact of oil as an externality, is also important in this article.

4. Conclusion

Sustainable development has always been a contentious concept and has been widely debated over the last 30 years and new classifications have emerged since then. Previously, a radical transformation of the market economy was advocated with the aim of reducing production and consumption, which would increase human well-being and improve environmental conditions. This contradiction has created the need for a new model that challenges and provides an alternative to the linear economy; this new model is called the circular economy. A circular economy that aims to eliminate waste and the constant use of resources. It has gained its relevance in an era of disruptive technological progress and dynamic global value chains. By promoting resource-efficient industrial models, the circular economy preserves and improves natural capital, optimises the value of resources and eliminates negative environmental externalities such as pollution.

A rapid change in the current economic system is necessary because the take-make-produce-sell-produce-consume formula is reaching the limits of the planet's available resources. The rethinking of the circular economy model towards zero waste and zero pollution provides many health, economic and environmental benefits. for the environment in terms of jobs, material and -cost savings and biodiversity.

References

- Cohen, N. (2022). Making the Linear Circular: A short guide to the circular economy: Blog, Green Element. [Online] Available: <https://www.greenelement.co.uk/blog/a-short-guide-to-the-circular-economy/> [Accessed: 29 April. 2015]
- De Oliveira, D. B., Becker, R. W., Sirtori, C. and Passos, C. G. (2021). “Development of environmental education concepts concerning chemical waste management and treatment: the training experience of undergraduate students”, *Chemistry Education Research and Practice*, vol. 22, no. 3, pp. 653-661, ISSN 2578-7365, DOI: 10.1039/D0RP00170H
- Geissdoerfer, M., Savaget, P., Bocken, N. M. and Hultink, E. J. (2017). “The circular economy – a new sustainability paradigm?”, *Journal of Cleaner Production*, vol. 143, 757-768. ISSN 1879-1786 DOI 10.1016/j.jclepro.2016.12.048
- Geisendorf, S. and Pietrulla, F. (2017). “The circular economy and circular economic concepts-a literature analysis and Redefinition”, *Thunderbird International Business Review*, vol. 60, no. 5, 771-782. ISSN 1520-6874, DOI 10.1002/tie.21924
- Geng, Y., Zhu, Q., Doberstein, B. and Fujita, T. (2009). “Implementing China’s circular economy concept at the regional level: A review of progress in Dalian, China”, *Waste Management*, vol. 29, no. 2, 996-1002. ISSN 1879-2456, DOI 10.1016/j.wasman.2008.06.036
- Gherheș, V., Fărcașiu, M. A. and Para, I. (2022). “Environmental Problems: An Analysis of Students’ Perceptions Towards Selective Waste Collection”, *Frontiers in Psychology*, vol. 12, 6346. ISSN 1664-1078, DOI 10.3389/fpsyg.2021.803211

Global Material Resources Outlook to 2060. (n.d.). Retrieved April 30, 2023, from https://www.oecd-ilibrary.org/environment/global-material-resources-outlook-to-2060_9789264307452-en

Kirchherr, J., Reike, D. and Hekkert, M. (2017). “Conceptualizing the circular economy: An analysis of 114 definitions”, *Resources, Conservation and Recycling*, vol. 127, pp. 221-232. ISSN 0921-3449, DOI 10.1016/j.resconrec.2017.09.005

Saladié, Ò. and Santos-Lacueva, R. (2016). “The role of awareness campaigns in the improvement of separate collection rates of municipal waste among university students: A Causal Chain Approach”, *Waste management*, vol. 48, 48-55. ISSN 1879-2456, DOI 10.1016/j.wasman.2015.11.037

Zeman, P. et al. (2019). “Hydrotreated vegetable oil as a fuel from waste materials”, *Catalysts*, vol. 9, no. 1, 337. ISSN 2073-4344, DOI 10.3390/catal9040337

THE ROLE OF RELIGIOUS AUTHORITIES IN AN INNOVATIVE APPROACH IN ORDER TO IMPROVE HUMAN CAPITAL FOR AGRICULTURAL DEVELOPMENT: THE CASE OF THE ARCHDIOCESE OF BUKAVU (EAST OF THE DEMOCRATIC REPUBLIC OF CONGO)

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Annotation: The province of South-Kivu in the Democratic Republic of Congo is a densely populated area with very good pedo-climatic conditions for agriculture. Though the agricultural potential is very high, poverty and hunger are widespread among rural areas, where families generally practice subsistence agriculture on less than 0.5 hectare. This paradoxical situation is mainly due to the lack of infrastructures and public support to agricultural activities and to a weak human capital. Faced to these problems, the religious organizations, like the archdiocese of Bukavu, take in charge more responsibilities in order to initiate the development of local rural communities by improving their human capital, based on good health, education and social relations for the largest majority of the inhabitants, including the poorest. According to secondary data, it appears that the archdiocese of Bukavu runs a large network of structures dealing with health care, and also a large network of schools, from kindergartens to university. Based on a survey of 51 key actors, it is clear that these actions are highly appreciated. However, it is also considered that the involvement of the archdiocese in socioeconomic development is insufficient and should be reinforced. The archdiocese launched a pilot animal raising program since a decade, defined with the participation of the whole local population. This program increases the management capacity of the beneficiaries. Finally, it appears that religious authorities can significantly contribute to the improvement of human capital in rural communities, especially when public authorities are not enough efficient in developing countries.

Key words: Bukavu, religious organizations, human capital, agricultural development, general welfare

JEL classification: Q18, O10

1. Introduction

The contribution of the civil society to public policies has become the topic of many studies. Several authors studied the involvement of the Congolese Catholic Church into the socioeconomic development of the DRC (Musongora, 2014; Muhingisa, 2017; Ngombaniro, 2018). However, the question of the human capital as the real capacity of the actors to take a part in these processes is rarely considered as an original experience in education.

Nevertheless, experiences like the Peasant University in Brazil (Coudel, 2009) or the Peasant University of the Peasant Organizations and Agricultural Producers from Western Africa (ROPPA/www.rpoa-afrique.org) are new. The goals of these Universities are to valorize the peasant knowledge and to promote peasant agriculture. They argue that peasant societies can adopt, innovate and anticipate: all capacities which are more often denied by the actors

of development (Amouan Kassi, 2021). It is under this scheme that the originality of this article consists in the description of the role played by the archdiocese of Bukavu, in the Democratic Republic of Congo, in the improvement of the common human capital for the development of peasant agriculture with an innovative approach.

In the DRC, in general, agriculture is in a disastrous situation, though the country has huge human and natural resources. Its agricultural potential is very high and its total arable area could reach 80 million hectares. However, only less than 10% of this area are effectively managed, with around 3.5 million hectares for vegetal production and 4.5 million hectares for animal raising. In addition, the Congolese rural areas welcome more than 70% of the Congolese population. In contrast, 28% of the 87 million inhabitants (in 2019) are in a situation of food insecurity and 4.2 million children are affected by a chronic malnutrition (RDC/Ministère de l'Agriculture et du Développement rural, 2010; PDL-145T, 2022).

Indeed, the agricultural sector must face several constraints, including the financing of agricultural activities and infrastructures in general. Generally, the share of agriculture in the national budget does not exceed 2%, far behind the 10% recommended by the Maputo Agreements, while private investments are rare because of the lack of a supporting scheme and the difficult access to bank credit and to agricultural inputs in rural areas. Agricultural yields are low due to the quantitative and qualitative weaknesses of basic infrastructures and services: transportation, agricultural ways, electricity provision, access to extension services, capacities of peasant organizations, institutional capacity and management... (RDC/Ministère de l'Agriculture et du Développement rural, 2010; Ngalamulune, 2022; Vwima and Rushigira, 2020).

In South-Kivu, the territory of the archdiocese of Bukavu is particularly densely populated. So, the access to arable land is difficult for different groups of population; more than 80% of farmers manage traditional family-type small farms, of which the area does not exceed 0.5 ha. They focus mainly on food crops. Most of these peasants use techniques which deteriorate the quality and fertility of the soils, leading to low yields. So, poverty is more spread in these less productive rural areas. Poverty reduces the access to food and increases food insecurity, which concerns supply as well as demand in villages where food production is insufficient since many years and where food dependency is extreme and food imports are very large (TECSULT-AECOM, 2009; Bisimwa and Bashi, 2009; Lebailly, Michel and Ntoto M'vubu, 2015; Vwima and Rushigira, 2020). Besides, the role of women in agriculture is particularly important and the labour force is rather aged, with 60% of workers being over 40, with less than 4 years of education at school (Vwima, 2014).

So being, the question is: what about an agricultural policy able to boost rural development in South-Kivu in particular and in the DRC in general? This question concerns mainly the human capital, as natural resources are very abundant. Though several institutions are already working in the field of education in agronomy (Institut Supérieur de Développement Rural (ISDR/Bukavu), Faculté d'agronomie/Université Catholique de Bukavu (UCB), International Institute of Tropical Agriculture (IITA-BUKAVU), Institut National pour l'Etude et la Recherche Agronomiques (INERA-Bukavu), Institut Technique Vétérinaire Maka (ITV-MAKA)), how to explain the so precarious situation of rural areas?

Some researchers pointed out the non-participation of rural communities in the decision process and implementation and the lack of valorization of research results which could boost agricultural production (Ngalamulume, 2016; Vwima and Rushigira, 2020). According

to others, and this is the central hypothesis of this paper, it is crucial to improve human capital in three aspects: health, knowledge and social relations. In a previous study dealing with the role of associations in socioeconomic development (Kalumire Bashwira, 2022), survey results show how the archdiocese of Bukavu could play a role in order to improve human capital for agricultural development in South-Kivu thanks to an innovative approach with three dimensions: health, education and social relations. According to the World Bank (Yong, 2018), human capital explains from 10 to 30% of income differences per capita.

2. Materials and Methods

This paper is based on both primary and secondary data. The secondary data come from official documents from the Democratic Republic of Congo or the archdiocese of Bukavu, from reports of different organizations... The primary data are collected through a survey among key actors of agricultural development.

As recommended by Beaud and Weber (2010), field surveys can be used in order to have a deeper understanding of the role that the archdiocese of Bukavu can play in the improvement of human capital.

The approach is a qualitative one, consisting in data collection through a semi-open survey among key actors involved in development activities.

The interviewed persons were selected according to a reasoned choice, taking into account their involvement level in local development activities: managers of diocesan development services, intellectuals and university professors, members of associations devoted to socioeconomic development (Friedberge, 1997). The size of the sample was determined by the so-called "reputation method". According to this method, some key actors are interviewed and then give the names of other key actors whom they know and who are interviewed in their turn, and so on. (Piotet and Sainsaulieu, 1994). For the survey, the first person to be interviewed was the archbishop of Bukavu himself. Finally, the sample size reached 51 persons, when the names of already interviewed key actors came out (Kalumire, 2022).

The main topics are dealt with in order to show how the archdiocese of Bukavu would be involved in the improvement of human capital and of the participation of the population in societal relations in order to develop family agriculture. These topics constitute the base for the guidelines of the survey. They are the following ones:

- (1) Is the agricultural sector, within the territory of the archdiocese of Bukavu, a vector of growth for the local communities?
- (2) How do the interviewees appreciate the role of the religious authorities in the field of investments in the market economy, especially in the case of the agricultural sector?
- (3) What about extension and accompanying services to peasant communities in the agricultural sector provided by the archdiocese of Bukavu?

3. Results and Discussion

The archdiocese of Bukavu is mainly rural. It includes the town of Bukavu, the territories of Kabare, Walungu and Idjwi, the communities of Luhwinja and Burhinyi in the Eastern part of the territory of Mwenga and the South-Western part of the territory of Kalehe. More than 80% of the inhabitants live in rural areas, mainly practicing subsistence agriculture (Ngombanero, 2018).

a. Access to health care and education

Under the scheme of the partnership convention N°1250/CAB/MW/S/020/CAJ/OWE/2018 of August 2nd, 2018 concerning cooperation in the field of health care signed by the government of the DRC and the national episcopal Conference of Congo (CENCO), the archdiocese of Bukavu, in order to increase the possibility for peasants who live within its boundaries to live longer and in good health, is committed to deal with local health care structures and to improve the access to basic good quality health care for the poorest. So, the archdiocese has to take care of one third of the population of the province of South-Kivu. It has to manage a large network of 11 health zones with 11 reference general hospitals (HGR), 5 hospital centers (CH), 68 health centers (CS), including 32 with a maternity, 2 specialised centers, education centers to life, including the diocesan center to fight AIDS (Codilusi) and the health insurance network of the communities of Bukavu (REMUSACO) which is a federation of 22 health insurances with several hundreds of thousands of beneficiaries, etc. The REMUSCO is connected to 140 medical trainings spread throughout the province of South-Kivu. This network helps the poorest to have access to the basic health care (BDOM/Bukavu, 2020).

A convention signed with the government in 1977 concerning the National Schools gave to the Catholic Church the management of several schools. Nowadays, the Coordination of the Convention Catholic Schools of Bukavu (CECC/Bukavu) manages 547 schools, among which 13 kindergartens, 356 primary schools and 178 secondary schools for 237,210 pupils, 119,064 boys and 118,146 girls (CECC/Bukavu, 2020).

Based on the decree n° 06/106 signed by the President of the Republic on June 12th, 2006, the Catholic University of Bukavu (UCB) organizes 7 faculties, 4 institutes and schools and 5 research centers. The faculties deal with the following topics: architecture and urbanism, law, agronomy, economics and management, medicine, computer and environmental sciences, social sciences. The faculty of agronomy was founded in order to make available local and regional expertise. One of the goals of the university is to lead young students to understand the problems of their society and to contribute to solve them (UCB, 2018; UCB, 2019).

b. Role of the archdiocese of Bukavu in agricultural development

For a semi-directed interview, questions are open. However, though each interviewee has his/her own way to express his/her ideas, precise information linked to the research topics constitute the answers to the three main questions of the survey guidelines. Several answers to questions (1) and (2) represent very similar ideas. This fact proves the objectivity of the expertise of the interviewed resource persons. Based on these results, question (3) was elaborated and led to the interview of the archbishop of Bukavu about his vision of agricultural development for the wealth of the peasant community, contained in the agropastoral pilot projects initiated by the religious authorities of the archdiocese of Bukavu.

The main lessons drawn from the survey are:

- (1) In relation to the agricultural sector in the territory of the archdiocese of Bukavu as a vector of growth for the local communities

The interviewees think that the potentialities that the archdiocese of Bukavu benefits from in the agricultural sector constitute a great opportunity to create jobs and wealth.

They also observe at the same time that these potentialities are under-exploited or even sometimes not exploited at all. As the other large landowners in South-Kivu, the archdiocese of Bukavu develops a traditional type of agriculture on reduced areas and rents out its agricultural land to landless peasants who practice a subsistence type of agriculture. Considering its human and natural resources, its reputation and its influence within the local communities, the archdiocese of Bukavu should, according to the interviewees, invest more in the modernization of agriculture, as it is done in the fields of health and education in South-Kivu and promote an agricultural development model to local communities in order to alleviate poverty and undernutrition.

(2) In relation to the role played by the archdiocese of Bukavu in the investment in marketed production in the agricultural sector

The survey respondents identified the existence of different problems which prevent the religious authorities of the archdiocese of Bukavu from playing a crucial role in the investments in favour of market agriculture thanks to a modernized and more efficient way of production which can make agriculture become a true growth factor.

The problems which are cited by the interviewed persons are notably: insecurity in rural areas where armed conflicts often happen, the general lack of financial and technical means and, as consequences, insufficient infrastructures, equipment and technical tools, the culture and religious challenges against the spirit of entrepreneurship, risk aversion and finally the lack of a local agricultural development plan built according to a global vision and where the individual and community participation is free and active.

In brief, there is a paradoxical situation, apparently an insurmountable blockage. According to the surveyed people, there are, on one side, the opportunities to invest in the agricultural sector as a vector of growth for the archdiocese of Bukavu and, on the other side, there are several problems which hinder the initiatives which are built up in order to develop agricultural activities in the socioeconomic and natural context of the archdiocese of Bukavu.

(3) In relation to extension and accompanying services provided to peasant communities in the agricultural sector by the archdiocese of Bukavu

Two pilot programs are implemented by the archdiocese of Bukavu, confirming its option to support small scale agriculture.

The agropastoral program at school

This program consists in giving a group of pupils and teachers two rabbits or a pig for each member of the group in order to raise them at home. The first young rabbits and piglets are then distributed to a second group of teachers and pupils and so on till everybody has been concerned and the process can begin again. The beneficiaries must also cultivate a plot which is fertilized with the rabbits and pigs manure, mixed with domestic waste, leaves from trees etc. These activities are supervised by the direction of the school in order to ensure the continuation of the process. This program began in catholic primary schools of the parishes of Burahale and Mulamba of the territory of Walungu (Paroisse Burhale, 2017; meeting with the archbishop Mgr Maroy, February 10th, 2023)

The agropastoral program in the villages

This program is similar to the program for schools. Here, the beneficiaries are households which receive a cow. In addition, some households receive a bull to be used by all

the households of the group for reproduction purposes. For the Bashi, the local population, a cow has a cultural signification. The first calves which are born are distributed to another group and so on. While receiving a cow, a household has the obligation to cultivate a field which will be fertilized with the manure of the animal.

So, the particularity of this program is not only to give work (animal husbandry) to the farmers, but also to improve the quality of soils which have been deteriorated by overexploitation, and so to increase food staple production in order to reach household's self-sufficiency and to sell the exceeding quantities. This program began in the village of Mwegerera in the parish of Burahale under the name: "Cow raisers association of Mwegerera" (ASSEVAM) with the goal to spread over other parishes (Paroisse Burhale, 2017; meeting with the archbishop of Bukavu, February 10th, 2023).

Both abovementioned agropastoral programs have been implemented since a little bit more than one decade, under the guidance of the archbishop of Bukavu, Mgr François-Xavier Maroy, in consultation with all the beneficiaries themselves, who are all conceptors, owners and actors of the programs. It is a model of community project, with the will and active participation of all the members of the community.

The archdiocese of Bukavu and its partners support these agropastoral programs by financing the initial investments. Later, specific extension services are built up, including local agronomists and veterinary doctors. They have to inform the small scale farmers about new techniques and tools (seeds, fertilizers, fodder crops, vaccines, irrigation, seasonality...) and to draw their attention on risk management, the promotion of a favourable environment and sane and local food (Amitiés Belgique – Bukavu, 2018).

4. Conclusion

This paper showed how the archdiocese of Bukavu contributes to build the human capital of rural communities. This contribution is not limited to the health and knowledge dimensions of human capital. The archdiocese also promotes small scale agriculture by improving the rural capacity to solve the problems of local rural communities in order to begin the development process.

In South-Kivu, the rural world is faced to the problem of valorization of its natural resources in agriculture, the peasants being left alone without any efficient public policy. So, the archdiocese of Bukavu rents out its land to landless peasants and, since one decade, engaged in extension services and accompanying actions in order to reinforce the social status of the peasants, as well as their qualities as entrepreneurs and managers, through two agropastoral pilot programs in schools and in villages.

Indeed, the vertical integration which was imposed to the farmers for the modernization of agriculture was, according to Fortin (1971) "the unique selection and education mechanism of farmers", because "left to themselves, they go to a failure; guided, they could become efficient entrepreneurs". However, Fortin himself acknowledges that vertical integration is dangerous for farmers, though he is in favour of it because it represents an efficient constraint for modernization. On the contrary "Peasant Universities" today want to valorize the traditional peasant knowledge and to promote small scale agriculture. Actors involved in development can not deny the peasant communities their innovation and anticipation capacities (Coudel, 2009; Amouan Kassi, 2021).

Finally, in addition to good health and knowledge, the question of human capital is also linked to social participation. Development mainly depends on people's will. Social aptitudes like personal and collective willingness can lead to good economic results. Local communities agropastoral programs introduced by the archdiocese of Bukavu in schools and villages must be supported for the promotion of local and community entrepreneurship and management. When social cohesion is reinforced around a project, people recover confidence and the willingness to take care of themselves in order to fight against poverty and hunger. So doing, agricultural development can be possible by a step-by-step transition from traditional and small scale agriculture towards sustainable agriculture in which the peasant remains at the centre.

References

- Amouan Kassi, P. (2021). Université paysanne du ROPPA (UPR), Séminaire International-Formation continue des producteurs et productrices, Novembre 2021, Sénégal. (www.reseau-far.com)
- Beaud, S. and Weber. F. (1997). "*Guide de l'enquête de terrain. Produire et analyser des données ethnologiques*", Paris, La Découverte, ISBN 9782707160089
- BDOM/Bukavu (2020), Rapport annuel 2020
- Bisimwa, G. and Bashi, M. (2009). "*Souveraineté alimentaire: le paradoxe du Sud-Kivu*". Eco Congo
- Coudel, E. (2009). "Formation et apprentissages pour le développement territorial : regards croisés entre économie de la connaissance et sciences de gestion. Réflexion à partir d'une expérience d'Université Paysanne au Brésil". *Economie et finances*. Ecole nationale supérieure agronomique de Montpellier – AGRO M, Français. NNT: . tel-00371589v2
- ECC/Bukavu (2018), Rapport annuel 2018
- Fortin, G. (1971). "*La fin d'un règne*", Montréal, Hurtibise HML
- Friedberge, E. (1997). "*Le pouvoir et la règle. Dynamique de l'action organisé*", Paris, Seuil
- Kalumire Bashwira, J. (2022). "Le rôle des associations dans le développement socioéconomique en appui aux secteurs public et privé en RD Congo. Cas de l'archidiocèse de Bukavu, de 2016 à 2020", *Mémoire de Master*, Kinshasa, Université Catholique du Congo (UCC)
- Lebailly, P. (2010). "Cinquante années de dépendance alimentaire en RDC: situation et perspectives". *Colloque sur Contribution de la formation et de la recherche agronomiques au développement durable du Congo*, Gembloux Agro-Bio Tech, Gembloux, 19 octobre 2010. <http://orbi.ulg.ac.be/handle/2268/74168>
- Lebailly, P., Michel, B. and Ntoto M'VUBU, A. R. (2015). "Quel développement agricole pour la RDC?". *Conjonctures congolaises 2014*, pp. 45-63, ISBN 978-2343059815
- Muhingisa Musoda, J-P. (2017). *Le partenariat Eglise-Etat dans l'archidiocèse de Bukavu au Sud-Kivu (1990-2012)*, Paris, l'Harmattan.
- Mushagalusa Mudinga, E. (2021). "Insécurité foncière en RDC. L'accaparement des terres dans la province du Sud-Kivu: expériences paysannes", Angaza, Institute

- Musongora Syasaka, E. (2014). *Associations confessionnelles et dynamique de développement local. Analyse des pratiques marchandes et financières des associations confessionnelles à l'Est de la République Démocratique du Congo*, PhD thesis, Louvain-la-Neuve
- Ngalamulume Tshiebue, G. (2016). “Le développement rural en RD Congo. Quelles réalités possibles?” *Louvain-la-Neuve: Academia/L’Harmattan*
- Ngalamulume Tshiebue, G. (2022). « Le paysan d’abord, promouvoir l’agriculture et l’agriculteur pour combattre la faim et la pauvreté, réflexion à l’occasion du 60^e anniversaire de l’indépendance de la R.D. Congo”, *Le Scientifique au service d’un Congo en quête de son émergence*, Mélanges en l’honneur du Professeur Justin OKANA N’SIAMI LEBUN, Université Catholique du Congo, Kinshasa, pp. 321-352
- Ngombaniri Rutashigwa, F.-N. (2018). “*L’implantation missionnaire au Congo-RDC. De l’assistance à l’autonomie financière*”, Paris, l’Harmattan
- Paroisse Burahle (2017). Rapport annuel 2017
- Pesche, D., Losch B. and Lemberon, J. (dir.). (2016). “Une nouvelle ruralité émergente. Regards croisés sur les transformations rurales africaines”. *Atlas pour le Programme Rural Futures du NEPAD*. deuxième édition revue et augmentée. Montpellier. Cirad. NEPAD
- Piotet, F. and Sainsaulieu, R. (1994). “Méthodes pour une sociologie de l’entreprise”, *Presses de la fondation nationale des sciences politiques*
- RDC/ Ministère de l’agriculture et du développement rural (2010). “*Stratégie Sectorielle de l’Agriculture et du Développement Rural*” (SSADR)
- TECSULT-AECOM (2009). “Etude du secteur agricole. Rapport préliminaire”. *Bilan-Diagnostic et Note d’orientation*. République Démocratique du Congo, Ministère de l’Agriculture et du Développement rural
- Université Catholique de Bukavu/UCB. (2019). “*Etudier à l’UCB 2019-2020*”
- Université Catholique de Bukavu/UCB. (2018). “*Prospectus*”. 2018
- Vwima, S. (2014). Rôle du commerce frontalier des produits alimentaires avec le Rwanda dans l’approvisionnement des ménages de la ville de Bukavu (province du Sud-Kivu). Gembloux Agro-bio tech/Ulg, PhD thesis
- Vwima, S. and Rushigira, C. (2020). “Problématique de l’intégration de l’agriculture du Sud-Kivu à la République Démocratique de Congo dans la Communauté Economique des Pays des Grands Lacs”, *Repères et Perspectives Economiques*. Vol. 4, Numéro spécial/novembre 2020, mis en ligne le 26 novembre 2020.
<https://revues.imist.ma/index.php/rpe/article/view/23798>
- Yong, J., (2018). “*Le déficit de capital humain : inciter les gouvernements à investir dans les ressources humaines*”, Tribune 18 juin 2018. Banque Mondiale

HOW WIGGLY IS THE PRICE TRANSMISSION BETWEEN PIG MEAT MARKETS IN VISEGRAD COUNTRIES?

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Annotation: In the twenty first century horizontal price transmission has become the topic of a great interest in applied microeconomics research in terms of the perspective of understanding on how geographically separated markets function. The paper provides detailed review of applied research in the field of the spatial price transmission modelling. Most popular econometric models are discussed in the light of the main advantages and disadvantages with a special focus on nonlinear techniques. Being in line with the last studies on non-linear time series models of spatial agri-food price transmission and market integration, we introduce non-parametric technique of generalized additive modelling in order to provide evidence of agri-food market integration efficiency and non-linear patterns in price linkages. The results of our empirical approach contribute to the knowledge about market efficiency and competitiveness as well as provide information to policymakers.

Key words: Horizontal price transmission, market integration, nonlinear time series, generalized additive model

JEL classification: Q110, C510

1. Introduction

The spatial separation has led to vast increase in number of studies that are evaluating the price linkages between goods at the same stage of the supply chain with different origin in terms of changes in speed, magnitude and nature. Spatial price transmission and market integration has become the topic of a great interest in applied microeconomics research from the perspective of understanding on how geographically separated markets interact.

The applied analysis of market integration has mostly used models of horizontal price linkages in selected agro-commodities markets. In recent research a wide variety of empirical techniques are used to study spatial price transmission. From conceptual point of view, the literature on the spatial price transmission and market integration in agri-food markets has been categorized into three empirical approaches, namely "pre-co-integration", "co-integration" and "other" ("post co-integration") (von Cramon-Taubadel, 2017; von Cramon-Taubadel and Goodwin, 2021).

The first strand of studies characterize the use of spatial correlation coefficients and simple linear regression models for estimating the relationships between agri-food prices in various regions (Ravallion, 1986; Stigler and Sherwin, 1985). However, the correlation analysis does not illustrate the extent to which markets are integrated. Criticism of correlation technique resulted in introduction of linear regression-based approaches.

Second stream of literature on spatial price transmission relies on co-integration technique and error correction modeling. This strand of research is based on assumption that price series tend to move identically over time and have common stochastic trend, i.e. series are

co-integrated. In such case, one can obtain super-consistent ordinary least squares estimates for the model parameters. Granger (1981) pointed out, that a vector of non-stationary time series could have linear combinations which are stationary in levels. The co-integration approach introduced by Nobel laureates Engle and Granger in 1987 after British economists Granger and Newbold (1974) published the spurious regression concept. However, there exist some limitations of the Engle-Granger framework which have been addressed in co-integration tests by Johansen (1988), Phillips and Ouliaris (1990), Gregory and Hansen (1996) and Maki (2012). Many latest studies use linear vector error correction model (VECM) of spatial price transmission between agri-food markets in Europe (Penone et al., 2022; Svanidze et al., 2022), in the Asian region (Dong et al., 2018; Thong et al., 2020), in the Southern and Northern American continent (Villanueva, 2022) and in Africa (Martey et al., 2020; Nzuma and Kirui, 2021). Several researchers have previously explored agri-food market integration among Visegrad Group (also known as "V4") countries by using VECM approach. For instance, Vargova and Rajcaniova (2018) examined the linkages among the prices of raw cow milk in V4 countries. They found some patterns in price transmission, namely the fastest adjustment speed in Hungarian market as a response to the price shocks of the other countries, Slovak market fast reaction to the price shocks from Poland, the most sensitive reaction in Slovak and Czech markets to the price shocks from Hungary. In like manner, Roman and Kroupová (2022) evaluated spatial processes between Polish and Czech markets based on trade flows and prices for raw milk, butter, skimmed milk powder and Edam cheese. Researchers concluded that the Czech Republic and Poland characterize a long range of linkages that are strong indication of the market integration for the all analyzed products. Apart from VECMs, these authors and other researchers (e.g. Gao et al., 2022) built vector autoregressive models (VAR). In fact, VECM is a restricted VAR model designed to be used with nonstationary price series that are known to be co-integrated. If co-integration exists, then VECM, which combines price variables in levels and differences, should be estimated instead of a VAR in levels. By way of contrast, in academic literature there is an issue of whether the variables in a VAR need to be stationary. Indeed, some studies argued that non-stationary variables can be directly involved in VAR model without prior transformation into stationary ones (Kilian and Lütkepohl, 2017). Given the limitation of VAR-VECMs in the aspect of linearity, further development in spatial agri-food price transmission analysis has been carried out within the framework of regime-dependent models.

Trade arbitrage requires that the prices of related goods move together, but the presence of transaction costs can produce a band-threshold effect, where only deviations above a threshold will have an effect on price movements (Hansen, 2011). A threshold brings nonlinearities into the functional relationships between prices (Tong, 1990). In order to incorporate transaction costs effect, threshold autoregressive (TAR) models in different modifications became widely used, where transaction costs from one agri-food market to another one could be estimated by a threshold parameter (Durborow et al., 2020; Yovo and Adabe, 2022). These models relate to piecewise linear regressions. Closely related to the TAR models are the smooth transition autoregressive (STAR) models, where the patterns of price adjustment are smooth rather than discrete and allow for a continuous transition between regimes (Goodwin et al., 2011).

Balke and Fomby (1997) introduced the threshold co-integration approach, more precisely, a combination of Tong's TAR model and Engle-Granger's VECM. Extensions to a threshold VECM have been made by several researchers (e.g. Enders and Siklos, 2001; Hansen and Seo, 2002). The threshold vector error correction model (TVECM) has been substantially influential in agricultural economics research, specifically, spatial price transmission studies

(Kharin, 2019). In the context of modelling regime-dependent price volatility transmissions between agri-food markets, it is worth mentioning about a large number of empirical studies related to asymmetric price transmission that are highly heterogeneous in the sense of type of asymmetries and applied approaches. Analysis of asymmetry in price linkages is important because it provides valuable information on market structure and performance.

Surveys of Frey and Manera (2007) and von Cramon-Taubadel and Goodwin (2021) present a review of the empirical techniques on asymmetric price transmission in agri-food markets. Asymmetric error correction models (AECM) has been reliable enough to be widely used as a tool to estimate spatial price asymmetries and adequately represents price series behavior in the presence of non-stationary and co-integration. In those models the correction of deviations from the long-run equilibrium relationship between price variables switches between regimes depending on whether the deviation from equilibrium is positive or negative.

Indeed, recent literature has progressed to display threshold-type nonlinearity in the error correction of the prices (Alam et al., 2022) instead of linear relationships (Wiranthi, 2021). On the other hand, the AECM hypothesizes that the long-run price relationship is characterized by a symmetric linear combination of nonstationary price variables. According to research from Rezitis (2019), the assumption of a linear long-run equilibrium price relationship may lead to misleading empirical findings in cases where transaction costs (or policy interventions) are significant factors. To identify both long- and short-run asymmetric price transmission between prices, the nonlinear autoregressive distributed lag (NARDL) model introduced by Shin et al. (2014) is widely used. The NARDL model has several advantages over the aforementioned empirical techniques. First, the model is estimable by ordinary least squares and reliable long-run inference can be achieved by bounds-testing, regardless of the integration orders of the variables. In contrast to ECMs, which impose the assumption that all regressors should be integrated of the same order. Second, it allows the joint modeling of asymmetries and co-integration dynamics. Currently, there are a few studies on spatial (Kamaruddin et al., 2021) and vertical (Rezitis, 2019) price transmission by means of NARDL modeling in the agri-food markets.

The third strand of literature on agri-food market integration relies on non-parametric approaches as well as parity bounds models (PBM). The PBM describes spatial price equilibrium in switching regime framework, first introduced by Spiller and Wood (1988), and extended further by Baulch (1997), Barrett and Li (2002). Trade costs are included directly in the PBM unlike VECM-based approach, which only uses data on prices. However, despite the advantages, the PBM has been criticized for some reasons (von Cramon-Taubadel, 2017). In recent years, PBM analysis has received far less attention in the literature unlike co-integration methods, nonetheless there are studies of agri-food market integration based on PBM technique (e.g. Durborow et al., 2020).

In fact, aforementioned parametric modelling approaches have been criticized for the choice of functional form and pattern of the transition process between regimes. In contrast, non-parametric methods offer to analyze price transmission in a more flexible way, having diminished, first of all, the assumption of linearity. Several non-parametric techniques are documented in the literature on spatial price transmission between agro-commodities markets. Only a few works in literature on agri-food market integration demonstrate such methods as copula-based models (Capitanio et al., 2020), local polynomial regressions (Fousekis, 2015), penalized smoothing spline regressions within the framework of generalized additive models (GAM) (Guney et al., 2019) and semi-parametric single index threshold models (Choe

and Goodwin, 2022). To our best knowledge, no prior studies have examined spatial agri-food price transmission analysis in Visegrad group countries within non-parametric approach.

2. Data and Methods

Spatial price transmission analysis in this paper is based on weekly observations related to average nominal prices for pigmeat in slaughter weight of the class E at the wholesale stage from May 2004 to February 2023 in the Visegrad group countries. The number of observations equals to 981 that is sufficient and desirable sample to obtain robust results. The source of the price data is the European Commission’s agricultural and rural development department.

We begin our study with the preliminary tests for the purpose of identifying time series properties followed by the appropriate model specification. Firstly, we perform unit root tests for each of the time series of logarithmic prices, namely the sieve bootstrap ADF test1 (Smeeke, 2013). Classical unit root tests, such as ADF test (Dickey and Fuller, 1981), rely on asymptotic inference and suffer from potentially size distortions. For this reason, bootstrap unit root tests have become a commonly used alternative to asymptotic inference (Smeeke and Wilms, 2020). The bootstrap approximates the exact distribution of the test statistic by repeatedly drawing new samples from the original sample, thus capturing the features of price series. The bootstrap unit root tests have accurate size properties under very general conditions.

In order to select maximum lag, we apply ad-hoc rule, suggested by Schwert (1989). The optimal lag order is determined in accordance with the modified version of Bayesian Information Criterion (mBIC) (Ng and Perron, 2001).

As a next step, to check the price series and determine the co-integrating rank we use the Johansen procedure (Johansen, 1988) based on maximum likelihood estimation.

As previously mentioned in the section 1, a linear pattern may not be appropriate in most cases of price development, whereas the assumption of linearity may hold only over short periods. Some non-linear effects can be accommodated in linear models by using polynomials of different order, dependent variable transformation or regime-switching dummies. However, there exist some issues related to specifying functional form of more complex price relationships and interpreting the results of modelling. Generalized Additive Model (GAM) has been proposed as an alternative without necessity to pre-specify the functional form of complex non-linear relationships. The GAM is an extension of the linear model in such a way that allows to maintain the interpretability and to model the non-linear effects. The GAMs are particularly useful for exploratory data analysis to allow the data to “speak for themselves” (Yee, 2015). GAMs have resulted from additive models and have been introduced by Hastie and Tibshirani (1990) and was extended further by Reiss and Todd Ogden (2009), and Wood (2004, 2008, 2011, 2013).

GAMs are non-parametric extensions of the generalized linear model (GLM) and can be formally written as:

$$g(E(y_i)) = \alpha + \sum_{i=1}^k (\beta_i x_i) + \sum_{j=1}^m f_j(x_{k+j}) + \varepsilon_i \quad (1)$$

$$\varepsilon_i \sim N(0, \sigma^2 I)$$

where $g(\cdot)$ is a monotonic function that links the expected value $E(y)$ to the predictors x_1, x_2, \dots, x_{i+j} (identical in our study), α is an intercept, the terms $f_j(\cdot)$ denote smoothing, non-parametric functions of the covariates. Smoothing function f is composed by sum of base functions b and their corresponding regression coefficients, i.e. formally $f(x) = \sum_i b_i(x)\beta_i$. The model may include smoothing functions alone or jointly with linear terms ($\sum_i \beta_i x_i$).

The standard coefficients in linear regression are replaced by non-parametric relationships, modelled by smoothing functions in GAM. GAMs are semi-parametric because the probability distribution of the dependent variable is specified (e.g. economic variables follow mostly normal distribution), whereas smoothing functions $\sum_j f_j(x_j)$ are non-parametric (e.g. thin plate regression splines). The main advantage of GAMs is that they can deal with highly non-linear relationships between the dependent variables and the predictors without the necessity to transform variables or use polynomial terms.

In fact, the smoothing functions are based on *splines*, special mathematical functions defined piecewise low-degree polynomials (called basis functions), joined at points called knots. Smoothing spline is a sum of weighted basis functions, evaluated at the values of the data. Splines have variable stiffness. In our study, we use penalized regression splines based on eigen approximation to a thin plate splines (TPS). Unlike others, thin plate regression splines do not suffer from the problem of choosing knot positions or selecting basis functions. Moreover, they can deal with any number of predictors (Wood, 2006).

The GAM can be estimated with penalized likelihood maximization (corresponds to penalized least squares in our study) by minimizing loss function as follows:

$$\sum_{i=1}^N (y_i - f(x_i))^2 + \lambda J(f)$$

$$J(f) = \int_{\mathbb{R}} f''(x)^2 dx \quad (2)$$

where $\lambda J(f)$ is the penalty term, containing λ - penalization smoothing parameter is used to regularize the spline smoothness (trade-off between the smoothness and wiggleness of the estimated smoothing function) and $J(f)$ - penalty function equals to the integral of the squared second derivative over the interval (one-dimensional thin plate spline in our study). Accordingly, the more curves the higher the penalty.

As a next step, we choose optimal smoothing parameter by using cross validation technique. Parameter λ is determined based on the minimum generalized cross-validation score (see Eq.3).

$$v_\lambda = \frac{n \sum_{i=1}^n (y_i - \hat{f}(x_i))^2}{[tr(\mathbf{I} - \mathbf{A})]^2} \quad (3)$$

where $\hat{f}(x)$ is the estimate from fitting to all the data, tr is the trace of matrix, \mathbf{I} is the identity matrix and \mathbf{A} is the projection matrix, i.e. influence matrix $X(X^T X + S)^{-1} X^T$ with penalty matrix $S = \sum_j \lambda_j S_j$ (Wood, 2004).

As mentioned above, the GAM is fitted by penalized least squares, more precisely penalized iteratively re-weighted least squares (P-IRLS). In a linear model, we can estimate the regression parameter using ordinary least squares (OLS) as $\hat{\beta}_{ols} = (X^T X)^{-1} (X^T y)$. In this case, we have errors with means of zero and constant variance, i.e. $\epsilon \sim \mathcal{N}(0, \sigma^2 I)$. However, if the relationship between dependent and independent variables is not linear, OLS errors have an unconstant variance, i.e. $\epsilon \sim \mathcal{N}(0, C)$. The solution could be using weighted least squares (WLS), i.e. $\hat{\beta}_{wls} = (X^T C^{-1} X)^{-1} (X^T C^{-1} y)$. In fact, it is not possible to apply that for GLM type due to using link function (y -variable of a GLM is different from the predicted variable). In order to overcome the aforementioned issue, we can use the IRLS algorithm, when the parameters are estimated by iterating over specific recursive relationships. Given the fact, that GAMs are just semi-parametric GLMs, penalized version of the IRLS method is applicable to them. Therefore, GAM-coefficients can be obtained as $\hat{\beta}_{P-IRLS} = (X^T X + S)^{-1} X^T y$.

The interpretation of GAM results is mainly based on the effective degrees of freedom (EDF). To measure the GAMs flexibility, the effective degrees of freedom are calculated as the trace of the projection matrix, i.e. $tr(\mathbf{A})$. Unlike the degrees of freedom in a linear regression, the EDF of the GAM are estimated and interpreted in different manner. In standard regression fitted by OLS, the model degrees of freedom equal to the number of non-redundant free terms in model. This is not applicable with GAMs due to the penalized estimation. Since the number of free parameters in GAMs is difficult to define, the EDF are instead related to the smoothing parameter λ , such that from *Eq.3* the greater the penalty, the smaller the EDF. Higher values of EDF imply more complex, "wiggly" splines. In other words, a smaller roughness penalty corresponds to a higher EDF and a lower value of smoothing parameter. The EDF with values close to one suggest that price relationships effect is almost equivalent to the one in linear VAR model. Accordingly, a non-linear effect can be revealed if the values of EDF are greater than one. In a theoretical sense, the EDF vary from zero to infinity. After assessing the time series properties of the price data, we fit the GAM in Vector Autoregression (or Vector Error Correction model) representation with lagged values of logarithmic prices as the thin plate regression splines. The specification of the model relates to pair-wise price series of each agri-food market.

3. Results and Discussion

In Figure 1 the price development in Visegrad countries over the period of 2004-2023 is depicted. The observations relate to the weekly prices of pigmeat carcasses at the wholesale stage in Euro per unit. Original prices appear to move synchronously with the common upward trend since the end of 2021. Hence, some pattern of spatial price transmission with potential long-run linkages might be present. Furthermore, some non-linear relationships pattern is also visually apparent.

In order to describe the basic features of the price series, we summarized descriptive statistics in Table 1. Considering the results, it is reasonable to conclude that prices in Czech Republic are less dispersed around the mean value. Compared to other price series, the coefficient of variation is higher for prices in Poland. The standard deviation is rather low, so prices are close to the mean of our samples. The distributions have a right skew and skewness coefficient value is close to zero (as in normal distribution). Additionally, kurtosis is also close to zero (Fisher's definition) but with negative values meaning the flatter peaks and lighter tails than the normal distribution.

Table 1. Descriptive statistics for the weekly price series over the period of May 2004-February 2023

Country	N	Mean	Std.Dev	Min	Max	Median	CV	IQR	Skewness	Kurtosis
CZ	981	154.42	19.24	119.91	216.88	151.43	0.12	27.10	0.62	-0.22
HU	981	156.42	20.34	118.71	225.34	151.96	0.13	26.78	0.72	-0.05
PL	981	150.48	22.64	111.53	227.41	146.81	0.15	34.04	0.58	-0.20
SK	981	158.17	20.42	112.21	218.10	153.39	0.13	28.31	0.63	-0.17

Source: European Commission's agricultural and rural development department

Taking the algorithm described above into account, we start our analysis with checking the log-transformed price series for stationarity. From the Figure 1 time series have a changing mean, therefore intercept worth being incorporated in the regressions for unit root tests. Moreover, visual examination of the price series suggests that the model for unit root test should contain a time trend. (Non)stationarity is detected with the bootstrap version of Dickey-Fuller test. Results are shown in the Table 2. According to the test, the null hypothesis of non-stationarity can be rejected for the price variables. Testing based on time series in levels has revealed significant test statistics at 1 % for Czechia and Poland, 5 % for Hungary, 10 % for Slovakia. Hence, the bootstrap unit root tests show, that log-transformed price variables are stationary in levels, i.e. I(0).

Table 2. Results of the bootstrap Dickey-Fuller unit root test

Price series*	Largest root**	Test statistic	p-value***
CZ	0.9889	-3.375	0.009
HU	0.9864	-3.249	0.014
PL	0.9859	-3.363	0.007
SK	0.9904	-2.505	0.089

Source: Own calculations

Note: * - Logarithmic prices in levels; ** - The largest root of the autoregressive lag polynomial, corresponding to the coefficient of the lagged series in the DF regression; *** - Calculations are made using 1000 bootstrap replications of size $n = 1.75T^{1/3}$, the deterministic specification contains intercept and trend, lag length selection is done with mBIC. Instead of standard augmented DF test, we use DF-GLS test.

In our study we fit time series with GAM approach in VAR representation to capture potential non-linearities in price relationships. Our GAMs in VAR model representation of pairwise price linkages have been estimated with the penalized maximum likelihood algorithm described above. We built the GAMs as the sum of smooth functions s of the input. The idea is that each predictor makes a separate contribution to the response, and these just add up, but these contributions are not strictly proportional to the inputs.

All lagged price variables are allowed to have non-linear effects in price transmission representation. Additionally, parametric intercept is also incorporated in the model. We assumed that the residuals of the GAMs are normally distributed. Lag lengths of 2-3 have been defined in accordance with Schwartz-Bayesian information criteria (BIC). The model diagnostics given the indication that the model assumptions are not violated.

Tables 3 - 6 show the GAM estimated parameters for each price pairs, namely price series for pigmeat markets in Czechia, Slovakia, Hungary and Poland. The effective degrees of freedom (EDF) represent the measure of non-linearity implied by the responses. They can be interpreted as intensity of smoothing of given price variable, consequently higher EDF value implies more complex splines and more "wiggly" price transmission between agri-food

markets pair in V4 countries. According to Hunsicker et al. (2016) the EDF equal to 1 is equivalent to a linear relationship, the EDF value range of 1-2 can be considered a weakly non-linear relationship, and EDF value exceeding 2 represents a highly non-linear price relationships. Moreover, the upper values of EDF correspond to the smaller smoothing parameters. In our analysis, the largest EDF value of 9 for the smoothed individual covariate can be seen in the GAM model of spatial price transmission between Slovak and Polish markets (see Table 4).

Figure 1. Pigmeat price development in Visegrad group countries for the period of May 2004 to February 2023



Source: European Commission’s agricultural and rural development department

Above all, most of the nonlinear effects are highly statistically significant as shown with the F-statistics in the tables. Given that fact, we can conclude that pigmeat markets in V4 countries are well integrated. Weak non-linearity can be observed when pigmeat prices ”transmit” from Hungarian market to Czech, Czech one to Polish, Slovak market to Hungarian and from Hungarian to Polish. We have revealed the most ”wiggly” non-linear pattern in spatial price transmission between Slovak and other V4 countries markets, especially in the pairs between Slovakia-Czechia with total EDF equals to 27.886 as well as Slovakia-Poland, where total EDF is 41.605 and all the splines are significant at the 1 % level of significance (see Table 4).

Table 3. Bivariate penalized GAM model estimates: Czechia (CZ_t)

GAM component	EDF	Smoothing parameter, λ	F-value
Model I ($CZ \sim HU$, 2 lags)			
Intercept	1.000	5.033 ^a	10740 ^{b***}
s(CZ_{t-1})	1.000	1799501	1230.57 ^{***}
s(CZ_{t-2})	3.068	2.68388	30.07 ^{***}
s(HU_{t-1})	1.000	2798774	46.75 ^{***}
s(HU_{t-2})	1.000	3655286	32.80 ^{***}
Total EDF ^c = 8.068; adj.R ² = 0.985; GCV score: GAM=0.000217, VAR=0.000218; AIC (GAM) = -5480.41, AIC(VAR)=-5471.65; LR-test of linear VAR vs. GAM, test statistic=4.5028 ^{***}			
Model II ($CZ \sim SK$, 2 lags)			
Intercept	1.000	5.033 ^a	10874 ^{b***}
s(CZ_{t-1})	1.000	123322	1591.43 ^{***}
s(CZ_{t-2})	5.416	0.159217	23.20 ^{***}
s(SK_{t-1})	5.414	0.098419	10.10 ^{***}
s(SK_{t-2})	4.171	0.181794	10.08 ^{***}
Total EDF ^c = 18.001; adj.R ² = 0.986; GCV score: GAM=0.000213, VAR=0.000219; AIC (GAM) = -5494.82, AIC(VAR)=-4893.35; LR-test of linear VAR vs. GAM, test statistic=3.3548 ^{***}			
Model III ($CZ \sim PL$, 3 lags)			
Intercept	1.000	5.033 ^a	11477 ^{b***}
s(CZ_{t-1})	1.000	2215946	1158.62 ^{***}
s(CZ_{t-2})	1.000	841692	20.04 ^{***}
s(CZ_{t-3})	1.000	1353147	4.73 ^{**}
s(PL_{t-1})	4.593	0.162814	20.92 ^{***}
s(PL_{t-2})	6.212	0.039258	5.76 ^{***}
s(PL_{t-3})	6.730	0.039226	2.90 ^{***}
Total EDF ^c = 22.535; adj.R ² = 0.987; GCV score: GAM=0.000192, VAR=0.000196; AIC (GAM) = -5591.19, AIC(VAR)=-5571.57; LR-test of linear VAR vs. GAM, test statistic=2.7178 ^{***}			

Source: Own calculations

Note: ^a estimate for constant by penalized MLE in place of the smoothing parameter (λ); ^b t-value instead of F-value; ^c – taking parametric dispersion term into account; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4. Bivariate penalized GAM model estimates: Slovakia (SK_t)

GAM component	EDF	Smoothing parameter, λ	F-value
Model I ($SK \sim HU$, 2 lags)			
Intercept	1.000	5.056 ^a	8645 ^{b***}
s(SK_{t-1})	8.965	0.000283	90.54 ^{***}
s(SK_{t-2})	3.837	0.160175	15.39 ^{***}
s(HU_{t-1})	7.215	0.020438	19.17 ^{***}
s(HU_{t-2})	1.717	1.527770	27.93 ^{***}
Total EDF ^c = 23.734; adj.R ² = 0.979; GCV score: GAM=0.000343, VAR=0.000383; AIC (GAM) = -5030.84, AIC(VAR)=-4922.11; LR-test of linear VAR vs. GAM, test statistic=7.3839 ^{***}			
Model II ($SK \sim CZ$, 2 lags)			
Intercept	1.000	5.056 ^a	8598 ^{b***}
s(CZ_{t-1})	6.404	0.033608	18.86 ^{***}
s(CZ_{t-2})	6.697	0.031371	11.06 ^{***}
s(SK_{t-1})	8.540	0.003934	97.66 ^{***}
s(SK_{t-2})	4.245	0.105740	15.37 ^{***}

Total EDF ^c = 27.886; adj.R ² = 0.978; GCV score: GAM=0.000348, VAR=0.000394; AIC (GAM) = -5016.25, AIC(VAR)=-4893.35; LR-test of linear VAR vs. GAM, test statistic=6.8538***			
Model III (SK ~PL, 3 lags)			
Intercept	1.000	5.056 ^a	9591 ^{b***}
s(SK _{t-1})	6.592	0.021549	101.55***
s(SK _{t-2})	8.161	0.003024	7.14***
s(SK _{t-3})	9.000	0.0000002	10.51**
s(PL _{t-1})	3.955	0.237344	39.43***
s(PL _{t-2})	6.135	0.043090	7.77***
s(PL _{t-3})	5.762	0.063100	2.54**
Total EDF ^c = 41.605; adj.R ² = 0.987; GCV score: GAM=0.000284, VAR=0.000342; AIC (GAM) = -5212.54, AIC(VAR)=-5029.15; LR-test of linear VAR vs. GAM, test statistic=7.0103***			

Source: Own calculations

Note: ^a estimate for constant by penalized MLE in place of the smoothing parameter (λ); ^b t-value instead of F-value; ^c - taking parametric dispersion term into account; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5. Bivariate penalized GAM model estimates: Hungary (HU_t)

GAM component	EDF	Smoothing parameter, λ	F-value
Model I (HU ~SK, 2 lags)			
Intercept	1.000	5.045 ^a	8237 ^{b***}
s(SK _{t-1})	4.441	0.245521	9.61***
s(SK _{t-2})	3.933	0.322377	11.02***
s(HU _{t-1})	1.000	4464692	1107***
s(HU _{t-2})	1.000	1812938	50.72***
Total EDF ^c = 12.374; adj.R ² = 0.977; GCV score: GAM=0.000372, VAR=0.000381; AIC (GAM) = -4951.76, AIC(VAR)=-4926.45; LR-test of linear VAR vs. GAM, test statistic=4.5567***			
Model II (HU ~CZ, 2 lags)			
Intercept	1.000	5.045 ^a	8047 ^{b***}
s(CZ _{t-1})	1.000	1686169	5.01**
s(CZ _{t-2})	4.196	0.568944	1.92*
s(HU _{t-1})	4.871	0.195969	161.03***
s(HU _{t-2})	1.991	1.588069	27.68***
Total EDF ^c = 14.058; adj.R ² = 0.976; GCV score: GAM=0.000348, VAR=0.000394; AIC (GAM) = -4904.52, AIC(VAR)=-4895.77; LR-test of linear VAR vs. GAM, test statistic=2.2892***			
Model III (HU ~PL, 3 lags)			
Intercept	1.000	5.045 ^a	8850 ^{b***}
s(HU _{t-1})	6.092	0.050456	80.13***
s(HU _{t-2})	3.582	0.153899	0.72
s(HU _{t-3})	4.611	0.138168	1.23
s(PL _{t-1})	4.850	0.158263	25.35***
s(PL _{t-2})	3.472	0.213861	9.80***
s(PL _{t-3})	5.833	0.082775	1.44
Total EDF ^c = 30.377; adj.R ² = 0.980; GCV score: GAM=0.000328, VAR=0.000334; AIC (GAM) = -5070.36, AIC(VAR)=-5050.31; LR-test of linear VAR vs. GAM, test statistic=2.2238***			

Source: Own calculations

Note: ^a estimate for constant by penalized MLE in place of the smoothing parameter (λ); ^b t-value instead of F-value; ^c - taking parametric dispersion term into account; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Indeed, we have showed that semi-parametric GAM representation of price transmission has improvements over typical linear VAR model. The first evidence of that can be found with a comparison of the Akaike information criterias (AIC) and generalized cross validation (GCV) scores. In order to define the better model, we orient on the lowest AIC and GCV values. The second one is that the likelihood ratio tests are used. They have shown that test statistics are highly significant in every case (see Tables 3 - 6).

Table 6. Bivariate penalized GAM model estimates: Poland (PL_t)

GAM component	EDF	Smoothing parameter, λ	F-value
Model I ($PL \sim SK$, 3 lags)			
Intercept	1.000	5.004 ^a	7877 ^{b***}
$s(SK_{t-1})$	1.000	5353725	4.55 ^{**}
$s(SK_{t-2})$	3.160	2.044594	2.25 [*]
$s(SK_{t-3})$	1.000	161046	0.088
$s(PL_{t-1})$	1.000	4075391	2550.9 ^{***}
$s(PL_{t-2})$	6.496	0.047295	40.49 ^{***}
$s(PL_{t-3})$	6.547	0.046662	11.98 ^{***}
Total EDF ^c = 21.203; adj.R ² = 0.982; GCV score: GAM=0.000403, VAR=0.000416; AIC (GAM) = -4868.49, AIC(VAR)= -4835.90; LR-test of linear VAR vs. GAM, test statistic=3.7464 ^{***}			
Model II ($PL \sim CZ$, 3 lags)			
Intercept	1.000	5.004 ^a	7866 ^{b***}
$s(CZ_{t-1})$	1.000	1644205	4.53 ^{**}
$s(CZ_{t-2})$	2.836	1.620458	2.96 ^{**}
$s(CZ_{t-3})$	1.000	2531997	4.41 ^{**}

Table 6 (continued)

$s(PL_{t-1})$	1.000	33811870	2317.42 ^{***}
$s(PL_{t-2})$	6.987	0.033371	37.38 ^{***}
$s(PL_{t-3})$	6.268	0.053058	10.13 ^{***}
Total EDF ^c = 21.091; adj.R ² = 0.982; GCV score: GAM=0.000404, VAR=0.000416; AIC (GAM) = -4865.16, AIC(VAR)= -4836.77; LR-test of linear VAR vs. GAM, test statistic=3.3936 ^{***}			
Model III ($PL \sim HU$, 3 lags)			
Intercept	1.000	5.004 ^a	7870 ^{b***}
$s(HU_{t-1})$	1.000	10762970	7.33 ^{***}
$s(HU_{t-2})$	1.000	14249270	7.99 ^{***}
$s(HU_{t-3})$	1.817	4.380433	2.54 [*]
$s(PL_{t-1})$	1.000	5368609	1961.52 ^{***}
$s(PL_{t-2})$	6.736	0.039270	34.86 ^{***}
$s(PL_{t-3})$	6.589	0.043820	9.92 ^{***}
Total EDF ^c = 20.142; adj.R ² = 0.982; GCV score: GAM=0.000403, VAR=0.000415; AIC (GAM) = -4867.02, AIC(VAR)= -4838.31; LR-test of linear VAR vs. GAM, test statistic=3.5802 ^{***}			

Source: Own calculations

Note: ^a estimate for constant by penalized MLE in place of the smoothing parameter (λ); ^b t-value instead of F-value; ^c – taking parametric dispersion term into account; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Unlike other non-parametric approaches, the significant advantage of GAMs is that they are relatively interpretable. Typical approach for GAMs is plotting the partial effects and inspect the relationships between response price variables (in our case CZ_t , SK_t , HU_t and PL_t) and predictors visually. Visual GAM model output in the aspect of partial effects shows

the impact of selected lagged price variable on the response, assuming that the rest of model predictors equals to their mean values³. The findings imply that asymmetry exists in terms of the disproportionate response to the appropriate predictor increase. We can observe non-linear asymmetry in price transmission between Polish market and others. In other words, response price variable reacts differently to the changes of the same lagged variables.

4. Conclusion

Being in line with the last studies on non-linear time series models of spatial agri-food price transmission and market integration, we use non-parametric generalized additive model to give evidence of non-linear nature in price relationships. The advantage of the GAM approach is that researcher is not limited to global basis expansions of model covariates. Instead a wide range of penalized spline bases is used which may better adapt to the price data rather than imposing a concrete functional form (for instance, polynomial regressions). Indeed, the polynomial can be significantly inflexible for complex nonlinear interactions. The non-parametric GAMs reveal better description for spatial price transmission in pig-meat markets of V4 countries in comparison with linear VAR modelling, that is in line with the findings of Guney et al. (2019) and B. Goodwin et al. (2021) for USA food markets. Our study fills the gap in the empirical literature on horizontal price transmission in EU agri-food markets based on GAM modeling.

A consideration of horizontal price transmission by means of the advanced econometric techniques is used to address a variety of economic issues. We have detected the assumption about well integrated pig-meat V4 markets in terms of non-linear price relationships. The price transmission "wiggleness" has been estimated and the most "wiggly" non-linear pattern has been revealed between Slovak-Polish and Slovak-Czech pig-meat markets. Asymmetries also exist in the non-linear relationships between V4 markets in terms of the disproportionate response to the appropriate price predictor increase. The findings of our research will provide important information for the decision-making field. Understanding the nature of spatial price transmission can have considerable welfare and policy implications. We suggest the following measures in order to stabilize Slovak pig-meat market and mitigate the price asymmetry. Firstly, it is important to balance the regulatory environment and avoid cutting off state support: the support system for the pig-meat producers must be effective and sustainable. Secondly, there is also scope for improving the transparency in price formation along the supply chain.

This study can be extended with considering multivariate GAM in VAR representation. In order to build more flexible GAM models, another spline alternatives could be used with incorporating interactions between lagged price variables, generalized impulse response function analysis might also be of interest.

Acknowledgements

Sergei Kharin acknowledges the contribution of the EU "Next Generation EU through the Recovery and Resilience Plan for Slovakia" under the project No. 09I03-03-V01-00054 and Ivan Lichner thanks for support from project VEGA 2/0143/21.

³ Plots of GAM partial effects of one particular predictor on response are not presented, but available from the authors upon request.

References

- Alam, M., Gómez, M., Patinoc, M., de Alcântara, M. and Begume, I. (2022). Price transmission between international and domestic prices in the Brazilian citrus sector. *International Food and Agribusiness Management Review*, vol. 25, pp. 393–410. DOI 10.22434/IFAMR2020.0156
- Balke, N. S. and Fomby, T. B. (1997). Threshold cointegration. *International Economic Review*, vol. 38, no. 3, pp. 627–645. DOI 10.2307/2527284
- Barrett, C. B. and Li, J. R. (2002). Distinguishing between equilibrium and integration in spatial price analysis. *American Journal of Agricultural Economics*, vol. 84, no. 2, pp. 292–307. Retrieved January 28, 2023, from <http://www.jstor.org/stable/1244953> [Online]
- Baulch, B. (1997). Transfer costs, spatial arbitrage, and testing for food market integration. *American Journal of Agricultural Economics*, vol. 79, no. 2, pp. 477–487. Retrieved April 23, 2023, from <https://ideas.repec.org/a/oup/ajagec/v79y1997i2p477-487.html> [Online]
- Capitanio, F., Riviuccio, G. and Adinolfi, F. (2020). Food price volatility and asymmetries in rural areas of South Mediterranean countries: A copula-based GARCH model. *International Journal of Environmental Research and Public Health*, vol. 17, no. 16, DOI 10.3390/ijerph17165855
- Choe, K. and Goodwin, B. K. (2022). Nonlinear Aspects of Integration of the US Corn Market (2022 Annual Meeting, July 31-August 2, Anaheim, California No. 322158). Agricultural and Applied Economics Association. DOI 0.22004/ag.econ.322158
- Dickey, D. A. and Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, vol. 49, no. 4, pp. 1057–1072. Retrieved February 3, 2023, from <http://www.jstor.org/stable/1912517> [Online]
- Dong, X., Waldron, S., Brown, C. and Zhang, J. (2018). Price transmission in regional beef markets: Australia, China and Southeast Asia. *Emirates Journal of Food and Agriculture*, vol. 30, pp. 99–106. DOI 10.9755/ejfa.2018.v30.i2.1601
- Durborow, S., Kim, S.-W., Henneberry, S. and Brorsen, B. (2020). Spatial price dynamics in the US vegetable sector. *Agribusiness*, vol. 36, pp. 59–78. DOI 10.1002/agr.21603
- Enders, W. and Siklos, P. L. (2001). Cointegration and threshold adjustment. *Journal of Business and Economic Statistics*, vol. 19, no. 2, pp. 166–176. DOI 10.1198/073500101316970395
- Fousekis, P. (2015). Spatial price transmission in the EU pigmeat markets: An empirical investigation with a non parametric approach. *International Journal of Applied Economics*, pp. 108–122. Retrieved January 29, 2023, from <http://ikee.lib.auth.gr/record/281963?ln=en> [Online]
- Frey, G. and Manera, M. (2007). Econometric models of asymmetric price transmission. *Journal of Economic Surveys*, vol. 21, no. 2, pp. 349–415. DOI 10.1111/j.1467-6419.2007.00507.x
- Gao, S., Bagnarosa, G., Dowling, M., Matkovskyy, R. and Tawil, D. (2022). Price transmission in European fish markets. *Applied Economics*, vol. 54, pp. 2194–2213. DOI 10.1080/00036846.2021.1985075
- Goodwin, B., Holt, M. and Prestemon, J. P. (2011). North American oriented strand board markets, arbitrage activity, and market price dynamics: A smooth transition approach. *American Journal of Agricultural Economics*, vol. 93, no. 4, pp. 993–1014. DOI 10.1093/ajae/aar024

- Granger, C. (1981). Some properties of time series data and their use in econometric model specification. *Journal of Econometrics*, vol. 16, no. 1, pp. 121–130. DOI 10.1016/0304-4076(81)90079-8
- Granger, C. and Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, vol. 2, no. 2, pp. 111–120. DOI 10.1016/0304-4076(74)90034-7
- Gregory, A. W. and Hansen, B. E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics*, vol. 70, no. 1, pp. 99–126. DOI 10.1016/0304-4076(96)01685-7
- Guney, S., Goodwin, B. and Riquelme, A. (2019). Semi-parametric generalized additive vector autoregressive models of spatial basis dynamics. *American Journal of Agricultural Economics*, vol. 101, pp. 541–562. DOI 10.1093/ajae/aay033
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, vol. 12, no.2, pp. 231–254. DOI 10.1016/0165-1889(88)90041-3
- Kamaruddin, Masbar, R., Syahnur, S. and Majid, S. A. (2021). Asymmetric price transmission of Indonesian coffee (M. Shafiullah, Ed.). *Cogent Economics and Finance*, vol. 9, no. 1, 1971354. DOI 10.1080/23322039.2021.1971354
- Kharin, S. (2019). Horizontal price transmission on the Russian dairy market: Nonlinear approach. *Agris On-line Papers in Economics and Informatics*, vol. 11, pp. 45–54. DOI 10.7160/aol.2019.110305
- Kilian, L. and Lütkepohl, H. (2017). Structural vector autoregressive analysis. Cambridge University Press. ISBN: 9781108164818, DOI: <https://doi.org/10.1017/9781108164818>
- Hansen, B. E. (2011). Threshold autoregression in economics. *Statistics and its Interface*, vol. 4, no. 2, pp. 123–127, DOI:10.4310/SII.2011.v4.n2.a4
- Hansen, B. E. and Seo, B. (2002). Testing for two-regime threshold cointegration in vector error-correction models [Long memory and nonlinear time series]. *Journal of Econometrics*, vol. 110, no. 2, 293–318. DOI 10.1016/S0304-4076(02)00097-0
- Hastie, T. and Tibshirani, R. (1990). Generalized additive models. Wiley Online Library. Retrieved February 6, 2023, from <https://www.taylorfrancis.com/books/mono/10.1201/9780203753781/generalizedadditive-models-hastie> [Online]
- Hunsicker, M. E., Kappel, C. V., Selkoe, K. A., Halpern, B. S., Scarborough, C., Mease, L. and Amrhein, A. (2016). Characterizing driver–response relationships in marine pelagic ecosystems for improved ocean management. *Ecological Applications*, vol. 26, no. 3, pp. 651–663. DOI 10.1890/14-2200
- Maki, D. (2012). Tests for cointegration allowing for an unknown number of breaks. *Economic Modelling*, vol. 29, no.5, pp. 2011–2015. DOI 10.1016/j.econmod.2012.04.022
- Martey, E., Gatti, N. and Goldsmith, P. (2020). Assessing the performance of regional soybean prices in Ghana. *International Food and Agribusiness Management Review*, vol. 23, pp. 267–282. DOI 10.22434/IFAMR2019.0138
- Ng, S. and Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, vol. 69, no. 6, pp. 1519–1554. DOI 10.1111/1468-0262.00256
- Nzuma, J. and Kirui, P. (2021). Transmission of global wheat prices to domestic markets in Kenya: A cointegration approach. *African Journal of Agricultural and Resource Economics*, vol. 16, pp. 80–93. DOI 10.53936/afjare.2021.16(2).06

- Penone, C., Giampietri, E. and Trestini, S. (2022). Futures–spot price transmission in EU corn markets. *Agribusiness*, vol. 38, pp. 679–709. DOI 10.1002/agr.21735
- Phillips, P. C. B. and Ouliaris, S. (1990). Asymptotic properties of residual based tests for cointegration. *Econometrica*, vol. 58, no. 1, pp. 165–193. DOI 10.2307/2938339
- Ravallion, M. (1986). Testing market integration. *American Journal of Agricultural Economics*, vol. 68, no. 1, pp.102–109. DOI 10.2307/1241654
- Reiss, P. T. and Todd Ogden, R. (2009). Smoothing parameter selection for a class of semiparametric linear models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, vol. 71, no. 2, pp. 505–523. DOI 10.1111/j.1467-9868.2008.00695.x
- Rezitis, A. N. (2019). Investigating price transmission in the Finnish dairy sector: An asymmetric NARDL approach. *Empirical Economics*, vol. 57, pp. 861–900. DOI 10.1007/s00181-018-1482-z
- Roman, M. and Kroupová, Z. Ž. (2022). Spatial market integration: A case study of the Polish–Czech milk market. *Economies*, vol. 10. DOI 10.3390/economies10010025
- Schwert, G. W. (1989). Tests for unit roots: A Monte Carlo investigation. *Journal of Business and Economic Statistics*, vol. 7, no. 2, pp. 147–159. Retrieved February 4, 2023, from <http://www.jstor.org/stable/1391432> [Online]
- Shin, Y., Yu, B. and Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In R. C. Sickles & W. C. Horrace (Eds.), *Festschrift in honor of peter schmidt: Econometric methods and applications* (pp. 281–314). Springer New York. DOI 10.1007/978-1-4899-8008-3_9
- Smeeke, S. (2013). Detrending bootstrap unit root tests. *Econometric Reviews*, vol. 32, no. 8, pp. 869–891. DOI 10.1080/07474938.2012.690693
- Smeeke, S. and Wilms, I. (2020). *BootUR: An R package for bootstrap unit root tests*. DOI 10.48550/ARXIV.2007.12249
- Spiller, P. T. and Wood, R. O. (1988). The estimation of transaction costs in arbitrage models. *Journal of Econometrics*, vol. 39, no. 3, pp. 309–326. DOI 10.1016/0304-4076(88)90061-9
- Stigler, G. J. and Sherwin, R. A. (1985). The extent of the market. *The Journal of Law and Economics*, vol. 28, no. 3, pp. 555–585. DOI 10.1086/467101
- Svanidze, M., Ólafsdóttir, G., Durić, I. and Thakur, M. (2022). Price relationships along the Norwegian salmon value chains: A comparative study of the leading consumption market in France and the largest processing industry in Poland. *Aquaculture Economics and Management*. DOI 10.1080/13657305.2022.2104403
- Thong, N., Ankamah-Yeboah, I., Bronnmann, J., Nielsen, M., Roth, E. and Schulze-Ehlers, B. (2020). Price transmission in the pangasius value chain from Vietnam to Germany. *Aquaculture Reports*, vol. 16. DOI 10.1016/j.aqrep.2019.100266
- Tong, H. (1990). *Non-linear time series: A dynamical system approach*. Oxford university press, ISBN 9780198523000
- Vargova, L. and Rajcaniova, M. (2018). Spatial price transmission of milk prices among Visegrad countries. *Trendy v podnikání*, vol. 8, no. 4, pp. 19–27. DOI 10.24132/jbt.2018.8.4.19_27

- Villanueva, J. (2022). Vertical and spatial price transmission in the Mexican and international cattle and beef market. *Revista Mexicana De Ciencias Pecuarias*, vol. 13, pp. 894–909. DOI 10.22319/rmcp.v13i4.5839
- Von Cramon-Taubadel, S. (2017). The analysis of market integration and price transmission—results and implications in an African context. *Agrekon*, vol. 56, pp. 83–96. DOI 10.1080/03031853.2017.1295655
- Von Cramon-Taubadel, S. and Goodwin, B. (2021). Price transmission in agricultural markets. *Annual Review of Resource Economics*, vol. 13, pp. 65–84. DOI 10.1146/annurev-resource-100518-093938
- Wiranthi, P. (2021). Asymmetric price transmission of Indonesian, Thailand, and the Philippine canned tuna to the European market. *International Journal of Economic Policy in Emerging Economies*, vol. 14, pp. 377–391. DOI 10.1504/IJEPEE.2021.116451
- Wood, S. N. (2004). Stable and efficient multiple smoothing parameter estimation for generalized additive models. *Journal of the American Statistical Association*, vol. 99, no. 467, pp. 673–686. DOI 10.1198/016214504000000980
- Wood, S. N. (2006). Generalized additive models: An introduction with R. Chapman; Hall/CRC. Retrieved February 7, 2023, from <https://www.taylorfrancis.com/books/mono/10.1201/9781315370279/generalized-additive-models-simon-wood> [Online]
- Wood, S. (2008). Fast stable direct fitting and smoothness selection for generalized additive models. *Journal of the Royal Statistical Society, Series B (Statistical Methodology)*, vol. 70, no. 3, pp. 495–518. DOI 10.1111/j.1467-9868.2007.00646.x
- Wood, S. N. (2011). Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, vol. 73, no. 1, pp. 3–36. DOI 10.1111/j.1467-9868.2010.00749.x
- Wood, S. N. (2013). On p-values for smooth components of an extended generalized additive model. *Biometrika*, vol. 100, no. 1, pp. 221–228. Retrieved February 6, 2023, from <http://www.jstor.org/stable/43304548> [Online]
- Yee, T. W. (2015). Vector generalized linear and additive models: With an implementation in R (Vol. 10). Springer. Retrieved February 6, 2023, from <https://link.springer.com/book/10.1007/978-1-4939-2818-7> [Online]
- Yovo, K. and Adabe, K. (2022). Asymmetry and transmission of international price shocks of cocoa and coffee in Togo. *African Journal of Agricultural and Resource Economics*, vol. 17, pp. 80–91. DOI 10.53936/afjare.2022.17(1).5

CULS – INDOOR OCCUPANCY DETECTION DATASET

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Annotation: A new dataset for occupancy detection in smart buildings such as universities is presented in this paper. The dataset can be used to train neural network models for this task (object recognition of person's head). Detectable space in smart buildings is defined as corridors/common areas as well as, for example, classrooms and auditoriums. New dataset is specific and unique because it contains annotations of indoor occupants from three views: front, side and back. This is different from other datasets that normally focus on only one type of annotation. The dataset also considers the varied conditions that occur during detection – for example, the positioning of cameras in overhead, from the side, or other conditions, such as lighting. In the cooperation with Security Department of Czech University of Life Sciences Prague, the video recordings of five lecture rooms were obtained for a duration of ~372 hours, from which still images were created and all persons appearing there were manually annotated with bounding boxes. The number of these annotations amounts to 10 044 persons. Comparison was then made on this data with other publicly available datasets. Then, ResNet-50 model was trained using this dataset to determine if this dataset is applicable in machine learning. It was found that a similar dataset designed primarily to count people from different perspectives in auditoriums did not exist at the time of the research. Compared to other dataset, presented dataset is smaller in size, however by creating an experimental model based on ResNet50, it was found that in transfer learning, the model created is capable of inference and is therefore practically applicable. Hence, the dataset can be used in machine learning.

Key words: dataset, detection, indoor occupancy, neural networks, ResNet50

JEL classification: C80 General

1. Introduction

People spend up to 80% of their time in buildings (Ander and Sedlák, 2019). Health, quality of life and productivity depend on the indoor environment, and approximately 40% of all energy produced is needed to maintain thermal comfort in the indoor environment (Mantovani and Ferrarini, 2015).

Building highly energy-efficient structures require careful attention to their design. This involves having information on how many people are using the building at any given time. This information can help adjust the building's temperature and lighting according to the needs of the occupants. Some studies (Mantovani and Ferrarini, 2015), (Tran and Tan, 2014) reported that systems relying on actual occupancy levels resulted in 17.8% energy savings for heating, ventilation and air conditioning (HVAC). The lighting control system, which was described in more detail in the study (Leephakpreeda, 2005), has seen a 35%-75% reduction in energy consumption for light sources.

It is estimated that in 2017, only 6% to 10% of commercial buildings were equipped with occupancy sensors (Buccitelli et al., 2017; Elliott et al., 2019), an increase of 1% to 5% from the original 5% in 2012 (Ashe et al., 2012). However, this increase was mostly

due to the construction of new warehouses between 2010 and 2015, which saw a 33% increase from the original 1% (Ashe et al., 2012). However, storage areas are rarely occupied by people and so these sensors are not always fully utilised. In contrast, the education sectors have seen a decline in the adoption of occupancy sensors from 9% to 8% and for office space there has been a decline from 14% to 8% (Feagin Jr. et al., 2020).

However, since these sensors can lead to significant savings in energy, money and therefore overall environmental savings, it is advisable to implement these sensors.

The level of detail that different sensors can offer varies depending on their type and function. Therefore, the sensors can be categorized on how much information they can capture and deliver. The categories of sensors according to their information granularity are as follows:

Presence detection

By occupancy detection it is meant those approaches that are able to detect that someone is in the room (i.e. that the room is occupied or not).

The presence of people in a room can be detected, for example, using environmental sensors (CO₂ level) in an enclosed space used to estimate the number of students as demonstrated in the study (Ramli et al., 2020) or radar sensing (Papatsimpa & Linnartz, 2018).

Census of people

Census methods include approaches that make it possible to determine (even approximately) how many people are currently in a given room. These include, for example, counting people using optical or capacitive counting barriers, or by detecting users smart devices, where all devices that are in the room and have some wireless technology enabled - either the Wi-Fi or Bluetooth and that can be detected (Li et al., 2015).

Approaches to locating people

Person location approaches are those that have the highest granularity of data - these approaches are not only able to determine how many people are in smart buildings, but also where those people are specifically located (people sitting in seats or moving around the room).

Locating people can be done in several ways, for example by using machine vision from surveillance cameras or by attaching an IoT sensor to a seat that detects the presence of a person - for example by using a strain gauge, as demonstrated in the study (Sifuentes et al., 2018).

A cost-effective way to gather as much information as possible about the occupancy of a room is to leverage the existing infrastructure that is already in place. Therefore, machine vision is a suitable technique that can identify the locations of the occupants' heads from the footage of the cameras that are usually installed in buildings. However, to build a reliable detection model, a dataset of images with annotated heads is required. This dataset will be used to train a neural network that can recognize the presence and position of the persons inside the room.

A new dataset for detecting and localizing people (primarily) in auditoriums is presented in this study, which can be used to train neural network models for object detection.

2. Materials and Methods

The data for dataset was obtained from already installed surveillance cameras located in a total of five lecture halls at the Czech University of Life Sciences Prague (CULS). The cameras were installed near the ceiling in the lecture halls, in 3 lecture halls the view was from the "front" - the occupants had their faces visible, and in two lecture halls the cameras were installed from the back (the occupants had their backs to the camera). In collaboration with the Security Department, the camera footage was collected over a period of time for a total of 14 days in 2022, selecting the time periods when the rooms were most used (according to the schedule available in the University's electronic information system).

Because a proprietary camera system is installed at the university, the resulting video recordings were in a proprietary format, with a "projector" attached to each video file that was able to read this proprietary format. The projector was then used to obtain images of occupied auditoriums. Images showing the occupants were selected in such a way that there was a variety of data (the beginning or end of the class when the students were settling in, or two or three images from the course of the class when the occupants of the lecture hall were facing the camera at different angles).

The installed cameras are of different models and therefore have different parameters, such as output video resolution, output video noise and others. The following table provides details of the acquired video recordings:

Table 1. Details of videofiles

Designation of the auditorium	Video length	Resolution	Camera view	Total seating capacity
EI	58:20:00 (2 days, 10 hours and 10 minutes)	1600x1200 px (1,92 Mpix)	Frontal	140
EII	89:30:00 (3 days, 17 hours and 30 minutes)	1600x1200 px (1, 92 Mpix)	Frontal	140
EIV	86:40:00 (3 days, 14 hours and 40 minutes)	2688x1520 px (4,08 Mpix)	Rear	60
EV	84:40:00 (3 days, 12 hours and 40 minutes)	2688x1520 px (4,08 Mpix)	Rear	60
TI	53:00:00 (2 days, 5 minutes)	1600x1200 px (1,92 Mpix)	Frontal	280

Source: Authors

The total size of the video recordings was 416 GB, cumulative length of all videos was 372 hours and 10 minutes (15 days, 12 hours, 10 minutes).

From the obtained recordings, it is necessary to extract the images and then annotate the heads of the persons appearing in these images.

Since there is an assumption that after annotation, the dataset will not be of such a size that it is possible to train the neural network model purely on it, it is advisable to use transfer learning and build the neural network model using the already pre-trained model on a larger dataset, therefore, older architecture ResNet-50 with 25.6 million parameter pre-trained on COCO dataset was chosen as the test model.

ResNet is a family of deep neural networks for image recognition. The original ResNet paper was published in 2015 by Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun (He et al., 2016). The paper introduced a residual learning framework to ease the training of networks that are substantially deeper than those used previously. The layers were explicitly reformulated as learning residual functions with reference to the layer inputs, instead of learning unreferenced functions (He et al., 2016).

COCO dataset is a comprehensive collection of images that have annotations for various computer vision tasks, such as detecting objects, segmenting regions, captioning scenes, identifying key points, integrating segments, and estimating poses. It was developed by Microsoft and other collaborators in 2014 (Lin et al., 2014) and has been widely utilized as a criterion for evaluating models. COCO dataset has 80 categories of objects and over 1.5 million instances, as well as 91 categories and 250 000 person instances with key points. It also has around 500 000 captions that describe over 330 000 images. COCO dataset is stored in a JSON format that includes information about the images, licenses, categories, and annotations. COCO dataset is a valuable resource for computer vision researchers and practitioners who want to train, test, and assess their models on a diverse and challenging set of images.

In addition to the classical evaluation metrics commonly used in object detection (precision, recall), it is important to consider alternative metrics that can measure the performance of object counting methods (such as simple counting the number of visitors in a scene without localisation). One option is to use MAE and RMSE, which are commonly applied in regression-based approaches for people counting.

MAE stands for mean absolute error and RMSE stands for root mean squared error. They are both regression metrics that measure the difference between the predicted and actual values of a target variable.

MAE is calculated as the average of the absolute values of the errors between the predicted and actual values. RMSE is calculated as the square root of the average of the squared errors between the predicted and actual values.

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i| \quad (2)$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2} \quad (3)$$

Where:

n is the sample size

y_i is the observed value for the i -th observation

\hat{y}_i is the predicted value for the i -th observation

3. Results and Discussion

Still images were extracted from video recordings and annotated manually by drawing bounding boxes around the person's heads in each image. All the bounding boxes had a square shape and were labelled with one of three classes - front, back, or side. The class “front” was given to the boxes where the person’s face was fully visible and facing the camera. The class “side” was given to the boxes where the person’s face was partially visible (cheeks or nose were visible) and turned to either side of the camera. The class “back” was given to the images where the person’s back was facing the camera and their face was not visible at all.

Several situations occurred during still image acquisition and annotation: the recordings from the higher resolution cameras contained more compression artifacts (sometimes so extensive that it was impossible to recognize what was actually in the recording). This problem was relatively easily solved by selecting the closest image to the one that contained these compression artifacts. Furthermore, these higher resolution cameras contained both time markers and camera identification. If the annotated person's head was largely behind the marker, then that person was not annotated.

The annotation details can be found in the following table:

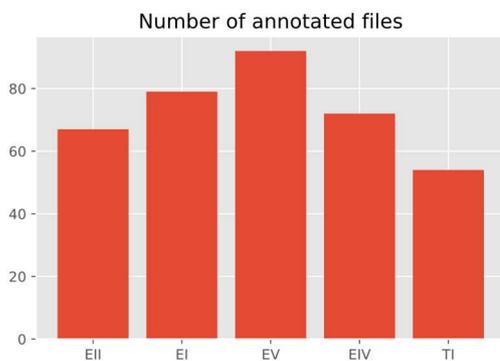
Table 2. Dataset annotation details

Auditorium	Annotations			Files total
	Front	Side	Back	
EI	1 392	1 013	70	79
EII	1 064	908	50	67
EIV	118	675	806	72
EV	139	946	934	92
TI	1 175	725	29	54
Total	3 888	4 267	1 889	364
	10 044			

Source: Authors

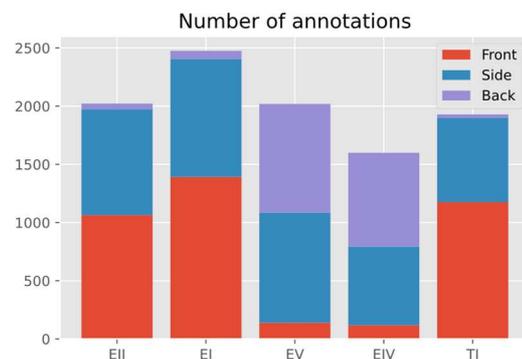
The data from the table can also be seen in the following graphs:

Figure 1. Graph of annotated files for every auditorium



Source: Authors

Figure 2. Graph of number of annotations per every auditorium



Source: Authors

Comparison with other datasets

In the table below (Table 3), a comparison with other datasets dealing with person detection/counting can be observed. In addition to datasets that contain bound boxes, like the dataset presented here, there are also datasets that use only one point for annotation and thus are primarily used for person counting methods (regression methods). Datasets annotated with only one point (the center of a person's head) are included because the dataset presented in this study can be very easily converted from a bounding box to annotation of only one point (using a centroid). Conversely, datasets annotated with only one point can be converted to pseudo-ground truth using, for example, the method presented in (Liu et al., 2019).

Table 3. Comparison with existing dataset used for person counting/localization

Dataset	Type	Frames	Annotations				Bounding box
			Min	Avg	Max	Total	
UCSD (Chan et al., 2008)	Surveillance	2 000	11	24.9	46	49 885	
Caltech Pedestrian dataset (Dollar et al., 2009)	Vehicle camera	250 000	-	1.4	-	350 000	Y (whole)
UCF_CC_50 (Idrees et al., 2013)	Surveillance	50	94	1 279.5	4 543	63 974	
Mall (Loy et al., 2013)	Surveillance	2 000	13	31.2	53	62 316	
WorldExpo (Cong Zhang et al., 2015)	Surveillance	3 980	1	50.2	253	199 923	
Shanghaitech A (Y. Zhang et al., 2016)	Surveillance	482	33	501.4	3 139	241 677	
Shanghaitech B (Y. Zhang et al., 2016)	Surveillance	716	9	123.6	578	88 488	
AHU-Crowd (Hu et al., 2016)	Surveillance	107	58	420.6	2 201	45 000	
Smart-City (L. Zhang et al., 2017)	Surveillance	50	1	7.4	14	369	
CityPersons (S. Zhang et al., 2017)	Vehicle camera	2 975	-	7	-	-	Y (whole)
CrowdHuman (Shao et al., 2018)	Crawl	15 000	-	22.64	-	339 565	Y (head)
UCF-QNRF (Idrees et al., 2018)	Surveillance	1 535	49	815.4	12 865	1 251 642	
FDST (Fang et al., 2019)	Surveillance	15 000	9	26,7	57	394 081	

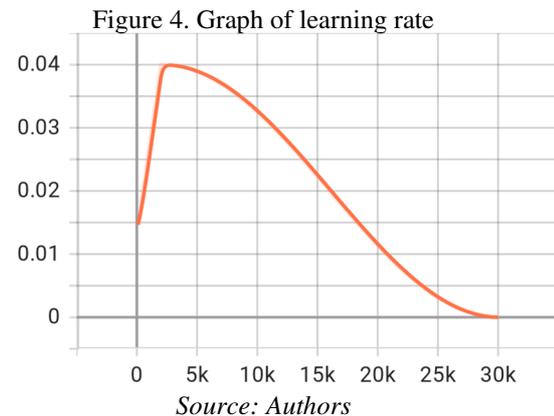
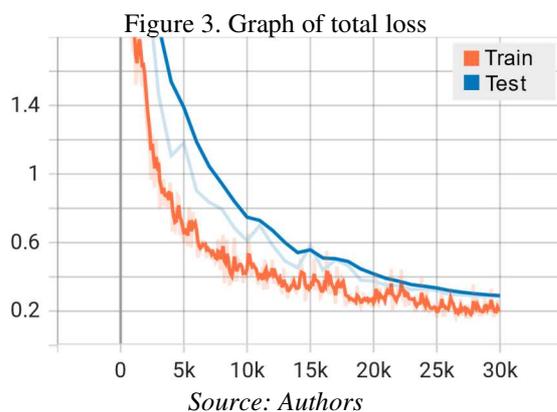
GCC (Wang et al., 2019)	Synthetic	15 212	0	3995	501	7 625 843	
Crowd Surveillance (Yan et al., 2019)	Surveillance	13 945	-	35	-	386 513	
Vis-Drone- CC2020 (Du et al., 2020)	Aerial	3 360	25	144.7	421	486 155	
Metro platform (J. Zhang et al., 2021)	Surveillance	627	-	15	43	9 243	
CULS Indoor Occupancy dataset	Surveillance	364	2	27.6	90	10 044	Y

Source: Every source is cited by dataset name

Training a neural network for object recognition

The performance of the dataset for interior person detection was evaluated by applying it to train and test a neural network model that can recognize people in different images. The dataset after annotation was split randomly into two subsets: 90% for training and 10% for testing. The task was also simplified by merging all the original classes in the dataset (“front”, “side”, “back”) into one class - “head”. The presence of a person rather than their orientation was focused on by this way.

The test model was trained with micro-batch (on 2 samples) using mixed-precision, also dataset augmentation was used as follows: random horizontal flip, random brightness change (max Δ : 0.2), random contrast change (min Δ : 0.7, max Δ : 1.1), random cropping of input image (minimum aspect ratio 0.75, maximum aspect ratio 3.0, minimum area 0.75, maximum area 1.0). Training was done with momentum optimizer, with cosine decay learning rate for 30 000 steps. Figure 3 shows loss curves for both training and testing. It can be observed that the model converged and that there was no evident overfitting. On Figure 4 one can see the cosine decay learning rate with linear warmup that was used for training.



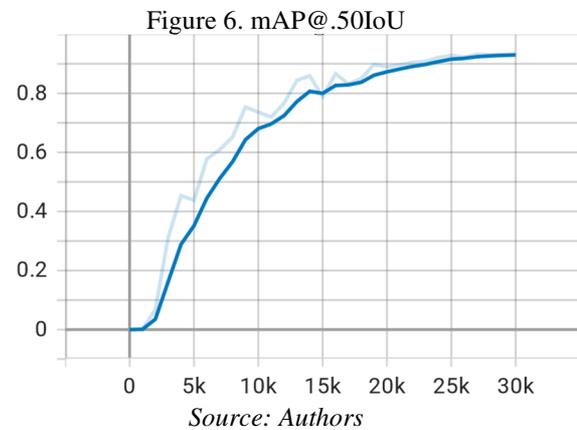
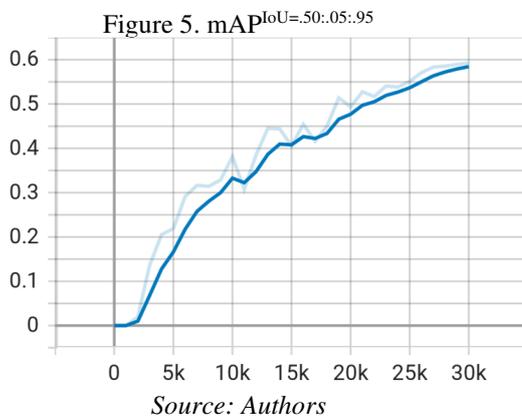
Model evaluation

During model building, checkpoints were saved, and the model was tested on them: There were 30 checkpoints in total (one for every 1000 steps of learning).

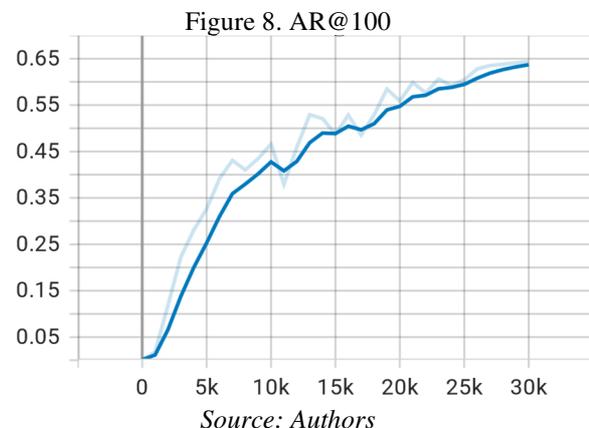
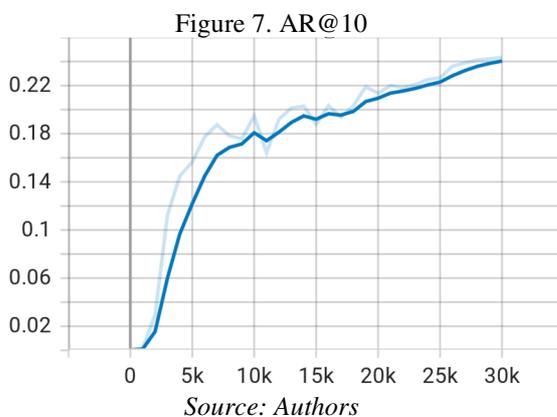
Since the ResNet-50 model pre-trained on the COCO dataset was used, the COCO metrics were primarily used for the evaluations, and the evaluation was further extended to include an evaluation of object counting for the last checkpoint.

In Figure 5 it is possible to see a graph of mAP, that is averaged over multiple Intersection of Union (IoU) values. Specifically, $mAP^{IoU=.50:.05:.95}$ means, that there are 10 IoU thresholds (starting with 0.50 to 0.95 in 0.05 increments). For clarity, mAP is shown in Figure 6 if the IoU is 0.5, which corresponds to the common Pascal VOC metric. The IoU, sometimes referred to as the Jaccard index, is defined as follows (Rezatofighi et al., 2019):

$$IoU = \frac{A \cap B}{A \cup B} \quad (1)$$



In the following figures it is possible to see graphs of average recall limited to 10 and 100 images respectively. The computation is calculated through 10 IoU thresholds, similar to the mAP case.

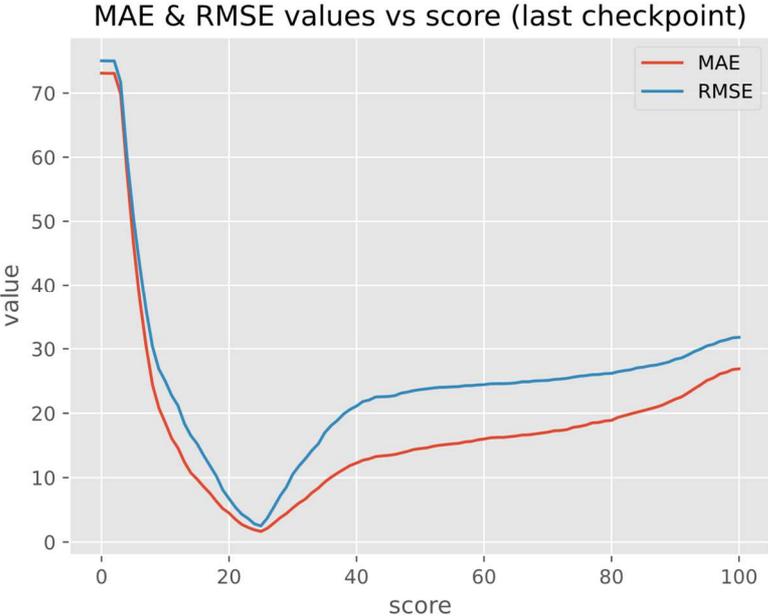


The graphs above show the progress of the model's performance during the training process. The model gradually improved its accuracy, recall and reduced its loss as it learned

from the data. By the time the training was completed (that is, after 30,000 steps), the model achieved the following results: $mAP^{IoU=.50:.05:.95} = 0.5925$, $mAP @ 0.5IoU = 0.932$, $AR@10 = 0.2434$, $AR@100 = 0.637$.

Since the output of the model are bounding boxes with a certain confidence score that determines how likely it is that the desired object is inside the bounding box, it is possible to calculate the MAE and RMSE values from the last checkpoint of the model to see how the MAE and RMSE change when the detector's confidence score tightens, as can be seen in Figure 9. From the figure, it can be seen that in the case of just counting people, the model showed the lowest MAE (1.65) and RMSE (2.51) when the bounding box confidentiality score was $\geq 25\%$. However, setting such a low score is not very appropriate in a production deployment (for robustness reasons - the model may detect false positives). It is more appropriate to choose a higher confidence score (at least $\geq 60\%$), where the tested model had MAE (16) and RMSE (24.44) on the test dataset.

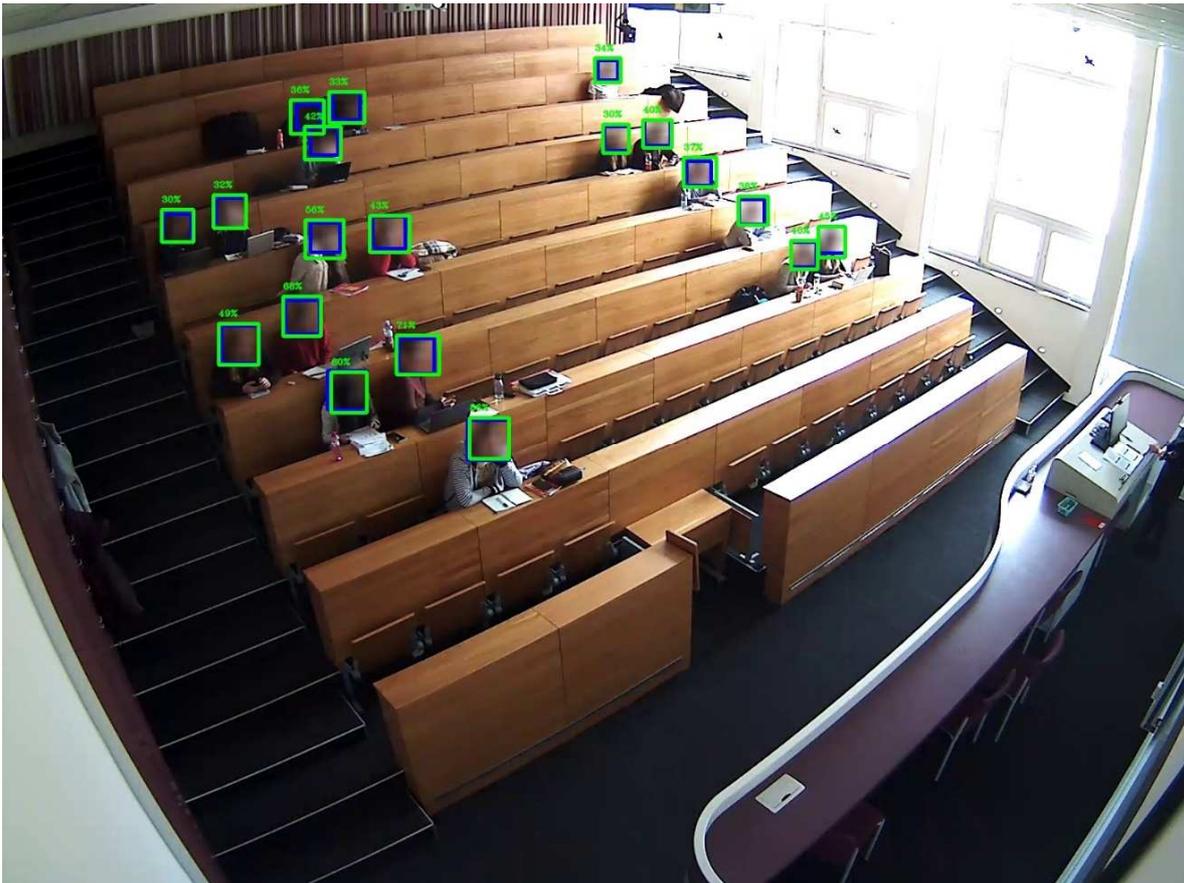
Figure 9. MAE & RMSE values vs classification confidence score



Source: Authors

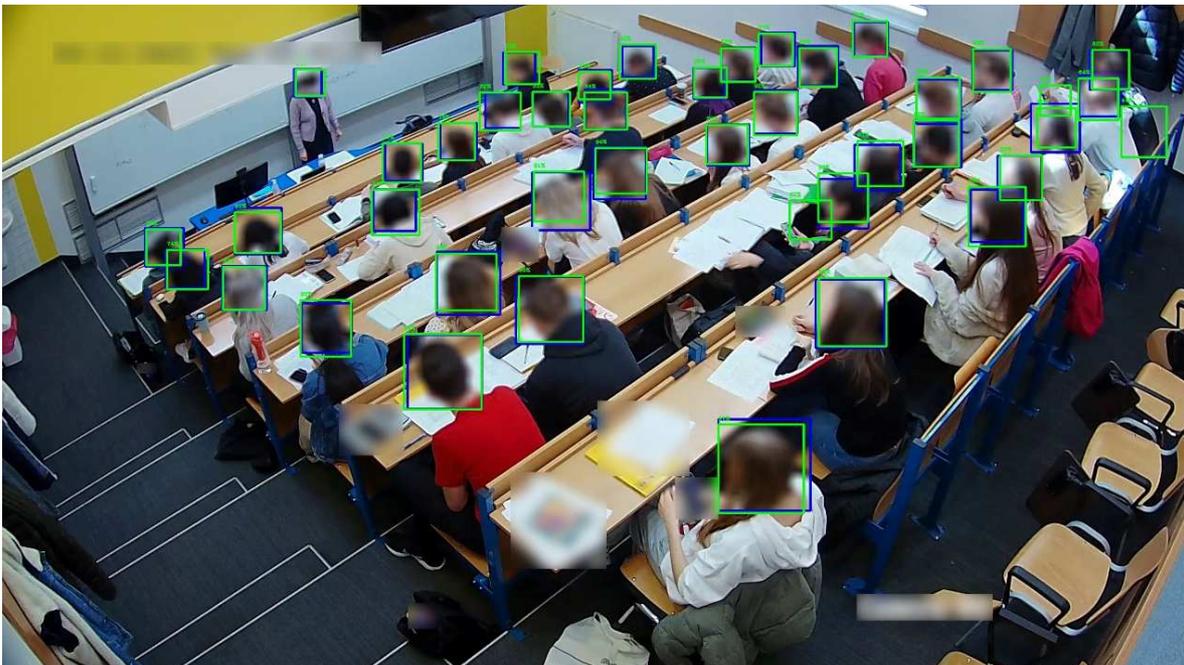
In the following pictures it is possible to see pictures of the auditoriums. The blue bounding boxes indicate ground truth as annotated by authors. The model output is marked in green (all bounding boxes where the confidence score $\geq 25\%$ are plotted), with the confidence score above each marked bounding box. All ground truth bounding boxes are blurred by gaussian blur to make it impossible to identify any person. Other parts of the image that could lead to disclosure of identities have also been manually blurred.

Figure 10. Ground truth + model output (frontal view)



Source: Authors

Figure 11. Ground truth + model output (back view)



Source: Authors

4. Conclusion

In this paper, a new dataset was presented to train neural network models for indoor person detection. A similar dataset that would contain annotations of the heads of persons using bounding box, would be collected indoors (auditoriums) and would have three classes of annotations was not found. Statistical comparison with the other datasets shows that this presented dataset is smaller in size, but the results of the ResNet-50 model developed show that even from such a small dataset, it is possible to create a detection model that can be used to detect and locate people in smart buildings using existing infrastructure. Since the resulting model can be used to locate people, it is possible to annotate seats if necessary, and if the detected bounding box is located in the seat annotation, it is possible to determine if the seat is occupied. This approach is useful if the lighting/heating of a given auditorium needs to be changed. The resulting model can be used in practice at the Czech University of Life Sciences to take a count of people and then create more detailed statistics on how many people are interested in attending a lecture or exercise, and it is possible to plan and estimate which agricultural subjects are most in demand.

Acknowledgements

This work was supported by the Internal Grant Agency of Faculty of Economics and Management, CZU Prague (IGA FEM) with the project title “The use of autonomous IoT network and the issue of anonymization of personal data in terms of GDPR in the context of regional development” with grant identification number 2023A0017 and by the EC’s Horizon Europe funding in the project CODECS, grant no. 101060179.

References

- Ander, M. and Sedlák, M. (2019). Chytré budovy - domy nabité energií. Available: https://www.modernienergetika.cz/wp-content/uploads/2019/10/chytre-domy-zlom_2019_10_23-final-web.pdf (In Czech)
- Ashe, M., Chwastyk, D., de Monasterio, C., Gupta, M. and Pegors, M. (2012). 2010 U.S. Lighting Market Characterization. <https://doi.org/10.2172/1219460>
- Buccitelli, N., Elliot, C., Schober, S. and Yamada, M. (2017). 2015 U.S. Lighting Market Characterization. <https://doi.org/10.2172/1413883>
- Chan, A. B., Zhang-Sheng John Liang and Vasconcelos, N. (2008). “Privacy preserving crowd monitoring: Counting people without people models or tracking”. *IEEE Conference on Computer Vision and Pattern Recognition*, 1–7. <https://doi.org/10.1109/CVPR.2008.4587569>
- Cong Zhang, Hongsheng Li, Wang, X. and Xiaokang Yang. (2015). “Cross-scene crowd counting via deep convolutional neural networks”. *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 833–841. <https://doi.org/10.1109/CVPR.2015.7298684>
- Dollar, P., Wojek, C., Schiele, B. and Perona, P. (2009). “Pedestrian detection: A benchmark”. *IEEE Conference on Computer Vision and Pattern Recognition*, 304–311. <https://doi.org/10.1109/CVPR.2009.5206631>
- Du, D. et al. (2020). VisDrone-CC2020: “The Vision Meets Drone Crowd Counting Challenge Results” (pp. 675–691). https://doi.org/10.1007/978-3-030-66823-5_41
- Elliott, C., Yamada, M., Penning, J., Schober, S. and Lee, K. (2019). Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. <https://doi.org/10.2172/1607661>

- Fang, Y., Zhan, B., Cai, W., Gao, S. and Hu, B. (2019). Locality-constrained Spatial Transformer Network for Video Crowd Counting, <https://doi.org/10.48550/arXiv.1907.07911>
- Feagin Jr., B., Poplawski, M. and Day, J. (2020). A Review of Existing Test Methods for Occupancy Sensors. <https://doi.org/10.2172/1668746>
- He, K., Zhang, X., Ren, S. and Sun, J. (2016). “Deep residual learning for image recognition”. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 2016-December. <https://doi.org/10.1109/CVPR.2016.90>
- Hu, Y., Chang, H., Nian, F., Wang, Y. and Li, T. (2016). „Dense crowd counting from still images with convolutional neural networks”. *Journal of Visual Communication and Image Representation*, vol. 38, pp. 530–539. <https://doi.org/10.1016/j.jvcir.2016.03.021>
- Idrees, H., Saleemi, I., Seibert, C. and Shah, M. (2013). “Multi-source Multi-scale Counting in Extremely Dense Crowd Images”. *IEEE Conference on Computer Vision and Pattern Recognition*, pp. 2547–2554. <https://doi.org/10.1109/CVPR.2013.329>
- Idrees, H., Tayyab, M., Athrey, K., Zhang, D., Al-Maadeed, S., Rajpoot, N. and Shah, M. (2018). Composition Loss for Counting, Density Map Estimation and Localization in Dense Crowds, pp. 544–559. https://doi.org/10.1007/978-3-030-01216-8_33
- Leephakpreeda, T. (2005). “Adaptive occupancy-based lighting control via Grey Prediction”. *Building and Environment*, vol. 40, no. 7, pp. 881–886. <https://doi.org/10.1016/j.buildenv.2004.08.026>
- Li, H., Chan, E. C. L., Guo, X., Xiao, J., Wu, K. and Ni, L. M. (2015). Wi-Counter: Smartphone-Based People Counter Using Crowdsourced Wi-Fi Signal Data. *IEEE Transactions on Human-Machine Systems*, vol. 45, no. 4, pp. 442–452. <https://doi.org/10.1109/thms.2015.2401391>
- Lin, T. Y., Maire, M., Belongie, S., Hays, J., Perona, P., Ramanan, D., Dollár, P. and Zitnick, C. L. (2014). Microsoft COCO: Common objects in context. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 8693 LNCS(PART 5). https://doi.org/10.1007/978-3-319-10602-1_48
- Liu, Y., Shi, M., Zhao, Q. and Wang, X. (2019). Point in, Box out: Beyond Counting Persons in Crowds. <https://doi.org/10.48550/arXiv.1904.01333>
- Loy, C. C., Gong, S. and Xiang, T. (2013). “From Semi-supervised to Transfer Counting of Crowds”. *IEEE International Conference on Computer Vision*, pp. 2256–2263. <https://doi.org/10.1109/ICCV.2013.270>
- Mantovani, G. and Ferrarini, L. (2015). “Temperature Control of a Commercial Building With Model Predictive Control Techniques”. *IEEE Transactions on Industrial Electronics*, vol. 62, no. 4, pp. 2651–2660. <https://doi.org/10.1109/tie.2014.2387095>
- Papatsimpa, C. and Linnartz, J. P. M. G. (2018). “Propagating sensor uncertainty to better infer office occupancy in Smart Building Control”. *Energy and Buildings*, no. 179, pp. 73–82. <https://doi.org/10.1016/j.enbuild.2018.08.039>
- Ramli, M. F., Muniandy, K., Adam, A., Nasir, A. F. Ab. and Shapiai, M. I. (2020). “Indoor occupancy estimation using carbon dioxide concentration and neural network with random

- weights”. *IOP Conference Series: Materials Science and Engineering*, 769(1), 12011. <https://doi.org/10.1088/1757-899x/769/1/012011>
- Rezatofghi, H., Tsoi, N., Gwak, J., Sadeghian, A., Reid, I. and Savarese, S. (2019). “Generalized Intersection Over Union: A Metric and a Loss for Bounding Box Regression”. *IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, 658–666. <https://doi.org/10.1109/CVPR.2019.00075>
- Shao, S., Zhao, Z., Li, B., Xiao, T., Yu, G., Zhang, X. and Sun, J. (2018). CrowdHuman: A Benchmark for Detecting Human in a Crowd. <https://doi.org/10.48550/arXiv.1805.00123>
- Sifuentes, E., González-Landaeta, R., Cota-Ruiz, J. and Reverter, F. (2018). “Microcontroller-Based Seat Occupancy Detection and Classification”. *Proceedings*, vol. 2, no. 13, 1040. <https://doi.org/10.3390/proceedings2131040>
- Tran, D. and Tan, Y. K. (2014). “Sensorless illumination control of a networked LED-lighting system using Feedforward Neural Network”. *IEEE Transactions on Industrial Electronics*, vol. 61, no. 4, pp. 2113–2121. <https://doi.org/10.1109/tie.2013.2266084>
- Wang, Q., Gao, J., Lin, W. and Yuan, Y. (2019). Learning from Synthetic Data for Crowd Counting in the Wild. <https://doi.org/10.48550/arXiv.1903.03303>
- Yan, Z., Yuan, Y., Zuo, W., Tan, X., Wang, Y., Wen, S. and Ding, E. (2019). Perspective-Guided Convolution Networks for Crowd Counting. <https://doi.org/10.48550/arXiv.1909.06966>
- Zhang, J., Liu, J. and Wang, Z. (2021). „Convolutional Neural Network for Crowd Counting on Metro Platforms”. *Symmetry*, 13(4), 703. <https://doi.org/10.3390/sym13040703>
- Zhang, L., Shi, M. and Chen, Q. (2017). Crowd counting via scale-adaptive convolutional neural network. <https://doi.org/10.48550/arXiv.1711.04433>
- Zhang, S., Benenson, R. and Schiele, B. (2017). CityPersons: A Diverse Dataset for Pedestrian Detection. <https://doi.org/10.48550/arXiv.1702.05693>
- Zhang, Y., Zhou, D., Chen, S., Gao, S. and Ma, Y. (2016). „Single-Image Crowd Counting via Multi-Column Convolutional Neural Network”. *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 589–597. <https://doi.org/10.1109/CVPR.2016.70>

LABOR PRODUCTIVITY IN AGRARIAN SECTOR OF THE CZECH REPUBLIC

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Annotation: The paper is focused on the examination of the labor market in the agrarian sector of the Czech Republic. The analysis mainly deals with the examination of the short-term dynamics as well as the long-term tendency in the labor market and quantified labor productivity compared to overall labor productivity in the Czech Republic. Finally, the prediction of further development is provided. The analysis of the employment in the agrarian sector of the Czech Republic is based on the time series provided by Luiss - Lab of European Economics containing the annual observations in the period from 1995 to 2020. The methods of the regression analysis, statistical testing as well as the forecasting are employed to fulfill the objective. A regression growth model together with the Chow test are employed to detect possible structural breaks in analyzed time series. The dynamics of analyzed time series is examined using the growth rate. The trend function is employed to detect and describe the long-term tendency of analyzed indicators. The basic results point to differences in labor productivity in the agrarian sector and the national economy. In general, it can be stated that the labor productivity is increasing, but significant shocks are visible in the agrarian sector, due to which productivity is very fluctuating. In the national economy, the development of productivity is less affected by potential shocks, but the results show an alarming decrease in productivity gains (changes) in the monitored time period.

Key words: Labor market, labor productivity, agriculture, national economy, structural breaks, Czech Republic

JEL classification: E24, E27, J43

1. Introduction

Agricultural sector plays an important role in economic, social, regional as well as ecological aspects of every national economy. Even more developed countries emphasize rather the tertiary sphere the role of agriculture is still important. Despite the decreasing agricultural share in employment the agriculture subsidies increase with the growth of the country's economy. Thus, the agricultural labor market should not be excluded when analyzing the economy of all both, developing and developed economies. The importance of the agricultural sector with its output and employment for a regional economy is emphasized by (Loizou et al., 2019). (Nowak and Róžańska-Boczula, 2021) demonstrate that human resources are of utmost importance in the structure of the sources of competitiveness. However, as (Bochtis et al., 2020) or (Sven Smit et al., 2020) add that the labor market as well as the level of the agricultural workforce have been seriously affected by COVID-19 pandemic. On the other hand, (Mamonova and Franquesa, 2020) argue that the European countryside remains largely overlooked in debates on the current political crisis and the ways out of it.

(Kónya et al., 2020) define the following major issues of the specific agricultural labor market: agricultural subsidies, measurement problems with farmers' income and the volatility of agriculture value added. According to (Giannakis and Bruggeman, 2018) technical efficiency, soil erosion, regional economic development and low population density are

important determinants of related agricultural labor productivity. (Bárány and Siegel, 2021) adds that either capital accumulation, nor the occupational employment structure within sectors explain much of the sectoral differences in labor productivity growth. (McErlean and Wu, 2003) emphasize the trend of migration from agriculture to non-agricultural sectors as a fundamental resource adjustment in most developing economies. Thus, the link between the development of the non-agricultural sector and the decline in agricultural labor as a proportion of the total labor force is obvious.

(Kónya et al., 2020) detected that both the level and the dynamics of the labor share vary significantly across the Central and Eastern European Countries (CEEC). Nevertheless, they also detected some common characteristics. The authors found that the labor share is lower on average in CEEC countries than in developed EU countries, both excluding and including agriculture. The same conclusion was provided e. g. by (Kołodziejczak, 2020). Similarly, (Giannakis and Bruggeman, 2018) show that the agricultural labor productivity varies across Europe. The authors detected significant differences between the continental northern-central countries and the continental peripheries (the Mediterranean, Eastern Europe and Scandinavia). The inter-country differences in the labor productivity were also confirmed by (Pawlak et al., 2021) where the difficult competitive situation is observed in the CEEC countries as well as the Mediterranean region, specializing in land- and labor-intensive production. (Martino, 2015) show that some EU regions perform better than others, having higher aggregate productivity growth despite a similar structure of output.

The differences in the agricultural labor productivity exist also in microregional level. (Ženka et al., 2016) discovered that land-use fragmentation affects negatively microregional agricultural labor productivity. The authors show that larger average size of plots is positively related to microregional agricultural labor productivity despite potentially negative effects of land tenure. The influence of the land segmentation on labor productivity is also confirmed by (Zsarnóczai and Zéman, 2019).

Besides the issues mentioned above the specifics of the labor market and labor productivity in agriculture should be considered. As (Kónya et al., 2020) explain the high share of self-employed, semi-subsistence farmers in agricultural employment makes the measurement and interpretation of the labor share and labor productivity complicated. (Obadić et al., 2023) add that the labor markets operate in conditions of market imperfection, so then they require certain actions of institutions and an appropriate mix of different regulations, taxes, or subsidies that affect the relationship between workers and employers.

Moreover, the relationship between the labor market optimization and labor productivity should be examined. The question: “What is the optimal level of employment in agriculture?” is answered e. g. by (Kołodziejczak, 2020). From the technological point of view, it is the level which ensures the best utilization of existing resources and inputs while respecting environmental governance and safety of produced food. From the economic point of view, it is the level which guarantees maximization of surplus produced in enterprises of the agricultural sector, particularly farms. From the social point of view, it is the level which, after division of Gross value added (GVA) generated by agriculture between all the employed in this sector, gives GVA per 1 person employed comparable to those employed in the industry and the services sector.

Finally, the influence of the EU policy on the employment and labor market should not be omitted. (Garrone, Emmers, Lee, et al., 2019) prove that on average, EU's Common Agricultural Policy subsidies increase the agricultural labor productivity growth, but this aggregate effect hides important heterogeneity of effects of different types of subsidies. However, (Garrone, Emmers, Olper, et al., 2019) show that the empirical evidence of the impact of the subsidies on agricultural employment is contradictory. Even one may assume that the subsidies increase agricultural employment, i. e. they lead to more jobs in agriculture than it would be without (or with less) subsidies, some studies confirm while other reject that.

2. Materials and Methods

In basic economic theory, labor is a separate factor of production that can be characterized by various techniques. On a general level, a simple description of the development of the amount of work performed can be made, expressed by various simple or compound indicators that quantify the value of a unit of work. However, it is much more beneficial to use expressions in proportion to the output achieved, which can be characterized as labor productivity. In this sense, labor productivity is a partial indicator of productivity and is expressed by the relationship:

$$\text{Labor productivity} = \frac{\text{output volume (added value)}}{\text{volume of input (form of work)}} \quad (1)$$

The stated general relationship can be transformed in different ways depending on the form of the output and the form in which the production factor of work is expressed. The agricultural sector is very specific in this respect, primarily characterized by a large extent of different working hours, and therefore, for example, the standard methodology derived from the number of employees is not adequate here. For the above reason, in agriculture, it is advisable to convert to the number of employed workers or other forms of work unit.

The presented work deals with the quantification of labour productivity in the whole economy of the Czech Republic, and also with the determination of labour productivity in the agricultural primary production sector.

The paper uses a time series analysis based on the calculation of basic measures of dynamics in the form of growth rates, estimation of trend functions and autoregressive model, which are used to express the development of a selected economic variable over time and then applied in the field of forecasting activities. The authors set the following research questions:

- Q1: Are there statistically significant structural breaks in labour productivity over time?
- Q2: What is the evolution of labour productivity in the national economy as a whole and in the agriculture over time?
- Q3: What are the appropriate tools for forecasting the evolution of analyzed time series?

Growth rate indicators (Hindls et al., 2018) are used to determine the answers to these questions:

$$\partial_t = \frac{y_t - y_{t-1}}{y_{t-1}} \cdot 100 \quad (2)$$

Subsequently, trend functions (Cipra, 2008) are estimated:

$$y_t = \gamma_0 + \gamma_1 x_t + u_t \quad (3)$$

where:

t	...	number of observations $t = 1 \dots T$,
y	...	endogenous variable,
x_t	...	time vector,
γ_0	...	constant,
γ_1	...	parameter of time vector,
u_t	...	random variable.

In case when the trend function does not meet the basic assumptions about the random component, the autoregressive model AR(p) is used, where p is the number of lags of the endogenous variable, and which is a suitable tool for constructing forecasts of the evolution of the studied economic variable.

$$y_t = \gamma_0 + \varphi_1 y_{t-1} + \dots + \varphi_p y_{t-p} + u_t \quad (4)$$

where:

φ_1	...	parameter of lagged variable.
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To verify that the assumptions about the random component are met, the LM test for autocorrelation of residuals, the White test for homoskedasticity and the Chow test are performed to assess the stability of the parameters and detect any structural break in the time series. The results of the tests are evaluated based on the estimated p-value, which indicates the probability with which the null hypothesis cannot be rejected. The null hypotheses together with alternative hypotheses are shown below.

LM test

H_0 : autocorrelation of residues is present

H_1 : autocorrelation of residues is not present

White test

H_0 : heteroskedasticity is not present

H_1 : heteroskedasticity is present

Chow test

H_0 : no significant structural break

H_1 : significant structural break

The Chow test is recommended when the time series shows the presence of a structural break in approximately similarly long segments of the time series using the graphical method.

The analysis itself is based on the time series of selected indicators containing annual observations in the period 1995 – 2020. The data set was collected using the LUISS database run by Luiss Lab of European Economics at Luiss University in Rome in Italy. The database provides the updates to the EU KLEMS (EU capital, labor, energy, materials and services

inputs) productivity database extended by the estimates of intangible investment coherent with INTAN-Invest⁴.

3. Results and Discussion

For the basic characterization and modeling of the labor productivity, basic macroeconomic indicators, necessary for quantifying an adequate level of productivity, were first extracted from the source database. This is mainly the gross added value expressed in the prices of the previous year, as well as the recalculated number of employed persons and the number of hours worked by these persons. All the mentioned indicators are given for the national economy of the Czech Republic (i.e. all NACE sectors) and at the same time only for the agricultural sector for a suitable comparison of differences, see Table 1.

Table 1. Selected characteristics for the labor market (CZ)

per/ var	VA_A_PYP (mil)	VA_T_PYP (mil)	EMP_A (th.)	EMP_T (th.)	H_EMP_A (th.)	H_EMP_T (th.)
2000	74301	2133573	226.36	4859.4	464450	9234010
2001	77385	2240534	226.85	4846.4	441887	8836536
2002	80066	2401510	192.46	4876.8	372346	8837763
2003	73671	2533894	186.05	4838.1	362242	8703898
2004	77558	2706443	190.12	4828.9	363782	8757937
2005	81285	2976889	181.21	4922.7	349552	8875156
2006	69715	3187909	175.63	4989	335581	8926422
2007	59017	3378871	170.38	5093.2	333019	9040417
2008	81990	3620229	170.06	5204.1	332365	9313295
2009	101086	3474313	169.57	5110.1	325728	9089851
2010	55634	3685490	155.68	5057.3	305731	9098481
2011	55822	3676989	165.33	5043.4	327808	9105793
2012	87478	3638129	165.35	5064.6	319834	8997041
2013	90470	3676927	170.22	5080.9	329325	8964295
2014	104841	3819141	168.55	5109	327706	9062346
2015	111960	4120083	164.46	5182	322031	9075987
2016	107652	4269232	162.61	5264.3	320931	9339114
2017	96313	4539121	163.39	5345.8	323607	9496559
2018	109450	4749180	165.52	5417.1	332005	9667734
2019	109680	5022730	160.34	5430.4	314702	9698776
2020	119686	4957406	161.57	5337.2	314057	8949707

Note: VA - gross added value, PYP - prices of the previous year, A - Agriculture CZ, T - total CZ (all NACE), EMP - number of persons employed, H_EMP - hours worked by persons engaged

Source: Luiss - Lab of European Economics

In the subsequent part, the quantification of the labor productivity indicator is carried out according to the methodological procedure, in the variant of the total labor productivity per worker and alternatively in the conversion to one hour worked. At the same time, these productivity indicators are separately quantified for the entire national economy and as well as the agricultural sector, see Table 2.

⁴ https://economy-finance.ec.europa.eu/economic-research-and-databases/economic-databases/eu-klems-capital-labour-energy-materials-and-service_en ; <http://www.intaninvest.net/>

Table 2. Labor productivity

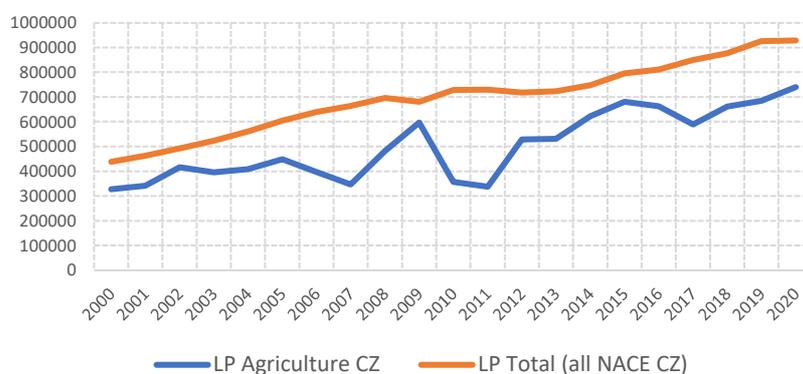
per/ var	LP_A_EMP (CZC/ person)	diff yt/ y(t-1) (%)	diff yt/ y(2000) (%)	LP_T_EMP (CZC/ person)	diff yt/ y(t-1) (%)	diff yt/ y(2000) (%)	LP_A_H_ EMP (CZC/ hours)	diff yt/ y(t-1) (%)	diff yt/ y(2000) (%)	LP_T_H_ EMP (CZC/ hours)	diff yt/ y(t-1) (%)	diff yt/ y(2000) (%)
2000	328242.6	-1.6	0.0	439063.7	7.8	0.0	160.0	-4.0	0.0	231.1	7.3	0.0
2001	341128.5	3.9	3.9	462308.0	5.3	5.3	175.1	9.5	9.5	253.6	9.7	9.7
2002	416013.7	22.0	26.7	492437.6	6.5	12.2	215.0	22.8	34.4	271.7	7.2	17.6
2003	395974.2	-4.8	20.6	523738.5	6.4	19.3	203.4	-5.4	27.1	291.1	7.1	26.0
2004	407942.4	3.0	24.3	560469.0	7.0	27.7	213.2	4.8	33.3	309.0	6.2	33.7
2005	448568.0	10.0	36.7	604731.8	7.9	37.7	232.5	9.1	45.4	335.4	8.5	45.2
2006	396942.4	-11.5	20.9	638983.7	5.7	45.5	207.7	-10.7	29.9	357.1	6.5	54.6
2007	346384.6	-12.7	5.5	663410.9	3.8	51.1	177.2	-14.7	10.8	373.8	4.7	61.8
2008	482124.0	39.2	46.9	695650.7	4.9	58.4	246.7	39.2	54.2	388.7	4.0	68.2
2009	596131.4	23.6	81.6	679888.7	-2.3	54.8	310.3	25.8	94.0	382.2	-1.7	65.4
2010	357361.3	-40.1	8.9	728749.4	7.2	66.0	182.0	-41.4	13.7	405.1	6.0	75.3
2011	337639.9	-5.5	2.9	729063.7	0.0	66.0	170.3	-6.4	6.4	403.8	-0.3	74.8
2012	529047.5	56.7	61.2	718343.4	-1.5	63.6	273.5	60.6	71.0	404.4	0.1	75.0
2013	531488.7	0.5	61.9	723672.0	0.7	64.8	274.7	0.4	71.7	410.2	1.4	77.5
2014	622017.2	17.0	89.5	747536.4	3.3	70.3	319.9	16.5	100.0	421.4	2.7	82.4
2015	680773.4	9.4	107.4	795082.0	6.4	81.1	347.7	8.7	117.3	454.0	7.7	96.5
2016	662025.7	-2.8	101.7	810976.6	2.0	84.7	335.4	-3.5	109.7	457.1	0.7	97.8
2017	589466.9	-11.0	79.6	849097.2	4.7	93.4	297.6	-11.3	86.0	478.0	4.6	106.9
2018	661249.4	12.2	101.5	876698.3	3.3	99.7	329.7	10.8	106.1	491.2	2.8	112.6
2019	684046.4	3.4	108.4	924928.2	5.5	110.7	348.5	5.7	117.9	517.9	5.4	124.1
2020	740768.7	8.3	125.7	928838.5	0.4	111.5	381.1	9.3	138.2	553.9	7.0	139.7

Note: LP - labor productivity, A - Agriculture CZ, T - total CZ (all NACE), EMP - number of persons employed, H_EMP - hours worked by persons engaged

Source: own calculation

From the point of view of the achieved values of basic labor productivity per worker and from Figure 1, it is possible to state that the total labor productivity in the national economy reaches higher values (on average 694936.6 CZC/person/year) than in the agricultural sector (on average 502635.1 CZC/person/year) and at the same time steadily and evenly increases in the observed period of 2000 - 2020. Labor productivity in agriculture itself is quite fluctuating, experiencing sharp fluctuations in several periods, and the average growth rate is significantly lower, with a significant increase being visible basically only since 2011.

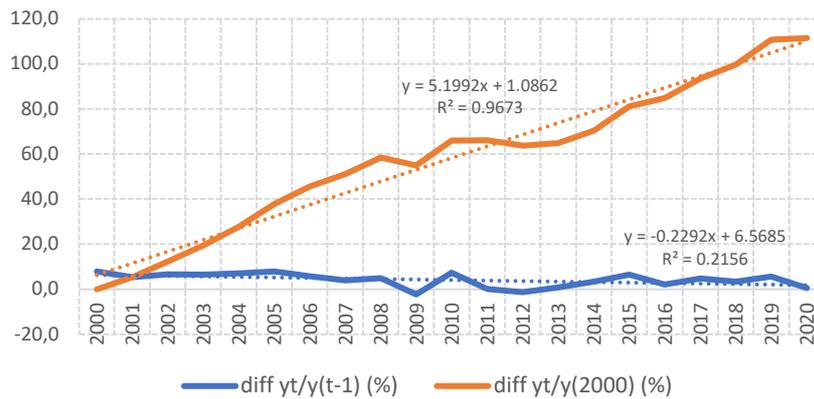
Figure 1. Labor productivity in Czech Republic (CZC/person)



Source: own calculation

The development of labor productivity in the national economy can be characterized in more detail according to Figure 2, which shows year-on-year and basic changes of the monitored indicator.

Figure 2. Change in labor productivity in Czech Republic all NACE (%)

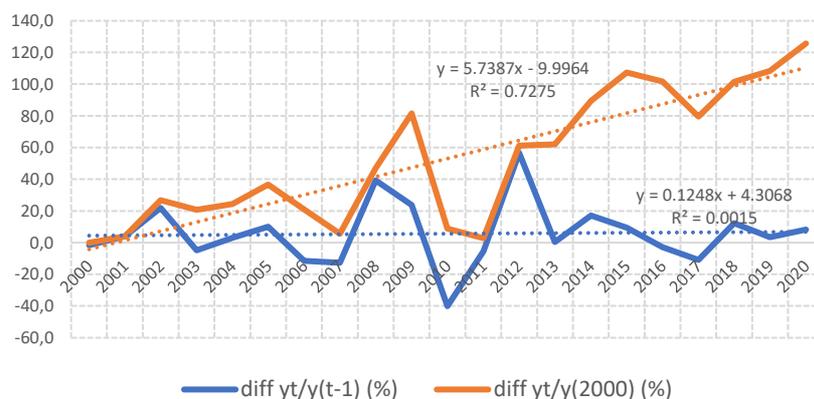


Source: own calculation

From the achieved values, it can be concluded that the total labor productivity in the Czech Republic steadily increases by an average of 5% per year compared to the base level of 2000, but when taking into account the year-on-year change, it is evident that the rate of growth slightly decreases, i.e. the added value per worker is overall increasing but with decreasing increment.

The situation is different in the agricultural sector (see Figure 3). Primarily, it is noticeable that both basic and year-on-year changes in productivity have a large variance in the monitored period and often show negative values, i.e. there is often a short-term decline. Compared to the base level of 2000, changes in labor productivity fluctuate enormously in the period 2007 - 2012, where there are two-way fluctuations of up to 80% compared to 2000. Overall, however, taking into account the average change, there is an average increase in labor productivity in agriculture as well by about 5% per year, which is very similar to the values of the change in labor productivity in the national economy. What is different is the comparison of the average year-on-year change, which is positive in the agricultural sector, and therefore it can be stated that labor productivity is increasing at a slightly accelerating rate in the monitored period.

Figure 3. Change in labor productivity in Agriculture Czech Republic (%)



Source: own calculation

Table 3 shows an estimate of the trend function, which confirms the presence of a deterministic trend that indicates rising labour productivity of Czech agriculture, with an annual increase of 18 788 CZK per worker. The model meets the assumptions

of a random component in all the tests carried out and is also verified statistically. The Chow test demonstrates that the recorded structural break detected in 2007 is not statistically significant and hence it is not necessary to include a dummy variable in the model to eliminate the effect of significant outliers in the time series. According to the Ministry of Agriculture (2007), year 2007 was assessed as a year with unfavourable weather conditions with a negative impact on the yield and quality of most crop production, which was reflected in a high increase in the selling prices of crop commodities.

Table 3. Estimation of the trend function of agriculture labour productivity in the Czech Republic (PP_A_EMP) in 1995-2022

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
const	202670	26647.1	7.606	<0.0001	***
time	18788.1	1725.46	10.89	<0.0001	***
R-squared	0.83		Adjusted R-squared	0.82	
F(1, 24)	118.56		p-value	<0.0001	
LM test	1,288		p-value	0,268	
White test	4,353		p-value	0,113	
Chow test	1,853		p-value	0,180	

Source: own calculation in SW Gretl *Notes: * $\alpha = 0.1$, ** $\alpha = 0.05$, *** $\alpha = 0.01$*

Table 4 shows the estimates of the autoregressive model for the labour productivity indicator in the national Czech economy. For this economic variable, the trend function was found to be an inappropriate tool for determining the evolution over time since the model shows the spurious regression due to the failure to meet the assumption of the absence of autocorrelation of residuals, and also the time vector does not show the presence of a deterministic trend and is statistically insignificant. The content of the table shows that the AR(1) model is verified, and it is possible to observe an inertia in the growth of labour productivity in Czech agriculture. Even in the case of the observed break year 2008, this fluctuation is not shown to be statistically significant.

Table 4. Estimation of the trend function of labour productivity of total economy in the Czech Republic (PP_T_EMP) in 1995-2022

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
const	45220.0	11961.8	3.780	0.0010	***
PP_T_EMP_1	0.970103	0.0186880	51.91	<0.0001	***
R-squared	0.991		Adjusted R-squared	0.991	
F(1, 24)	2694.706		p-value	<0.0001	
LM test	0,089		p-value	0.768	
White test	4.062		p-value	0.131	
Chow test	0.746		p-value	0.486	

Source: own calculation in SW Gretl *Notes: * $\alpha = 0.1$, ** $\alpha = 0.05$, *** $\alpha = 0.01$*

4. Conclusion

The paper was focused on the examination of the labor productivity in the Czech national economy and agriculture, its long-term tendency as well as short-term variation in the period from 1995 to 2020. There were three working questions defined and the related issues considered as following.

Firstly, the presence of the structural breaks was detected and evaluated using the graph of the selected time series as well as the suitable tests. Even the presence of the structural breaks is obvious - of the time series of the labor productivity in the Czech agriculture in year 2007 and in the time series of the labor productivity in the Czech economy in year 2008, their statistical significance was not proven.

Secondly, the development of the labor productivity in the Czech national economy as well as the Czech agriculture was examined. Even the long-term tendency of all analyzed indicators (except the number employed in agriculture) can be considered as increasing over the time, the short-term fluctuations can be seen as well. It can be concluded that the development of the labor productivity in the Czech national economy is smoother than the development of the labor productivity in the Czech agriculture. Moreover, the level of labor productivity is higher in the national economy than in the Czech agriculture in long-term viewpoint.

Finally, the question of the suitable method for forecasting of the labor productivity was considered. The analysis showed that for the purposes of forecasting Autoregressive model (AR) should be used rather than just a trend function due to the short-term fluctuations detected in analyzed time series.

In addition, it can be stated that the level of labor productivity is affected by many factors. Besides, the labor productivity of agriculture should be evaluated carefully due to the specific and unique role of the agriculture in the national economy. Even the extent of number of workers in agriculture as well as its share in the output of national economy is decreasing in long-term, the importance of the agricultural sector is indisputable.

References

- Bárány, Z. L. and Siegel, C. (2021). Engines of sectoral labor productivity growth. *Review of Economic Dynamics*, vol. 39, pp. 304–343. <https://doi.org/10.1016/J.RED.2020.07.007>
- Bochtis, D., Benos, L., Lampridi, M., Marinoudi, V., Pearson, S. and Sørensen, C. G. (2020). Agricultural Workforce Crisis in Light of the COVID-19 Pandemic. *Sustainability* 2020, vol. 12, no. 19, p. 8212. <https://doi.org/10.3390/SU12198212>
- Cipra, T. (2008). *“Finanční ekonometrie”*, Praha, Ekopress, ISBN 978-80-86929-43-9
- Garrone, M., Emmers, D., Lee, H., Olper, A. and Swinnen, J. (2019). Subsidies and agricultural productivity in the EU. *Agricultural Economics*, vol. 50, no. 6, pp. 803–817. <https://doi.org/10.1111/AGEC.12526>
- Garrone, M., Emmers, D., Olper, A. and Swinnen, J. (2019). Jobs and agricultural policy: Impact of the common agricultural policy on EU agricultural employment. *Food Policy*, no. 87, p. 101744. <https://doi.org/10.1016/J.FOODPOL.2019.101744>

- Giannakis, E. and Bruggeman, A. (2018). Exploring the labour productivity of agricultural systems across European regions: A multilevel approach. *Land Use Policy*, no. 77, pp. 94–106. <https://doi.org/10.1016/J.LANDUSEPOL.2018.05.037>
- https://economy-finance.ec.europa.eu/economic-research-and-databases/economic-databases/eu-klems-capital-labour-energy-materials-and-service_en
- <http://www.intaninvest.net/>
- Hindls, R., Arltová, M., Hronová, S., Malá, I., Marek, L., Pecáková, I. and Řezanková, H. (2018). “*Statistika v ekonomii*“, Praha, Professional Publishing, ISBN 978-80-88260-09-7
- Kołodziejczak, W. (2020). Employment and Gross Value Added in Agriculture Versus Other Sectors of the European Union Economy. *Sustainability* 2020, vol. 12, no. 14, p. 5518. <https://doi.org/10.3390/SU12145518>
- Kónya, I., Krekó, J. and Oblath, G. (2020). Labor shares in the old and new EU member states - Sectoral effects and the role of relative prices. *Economic Modelling*, no. 90, pp. 254–272. <https://doi.org/10.1016/J.ECONMOD.2020.05.010>
- Loizou, E., Karelakis, C., Galanopoulos, K. and Mattas, K. (2019). The role of agriculture as a development tool for a regional economy. *Agricultural Systems*, no. 173, pp. 482–490. <https://doi.org/10.1016/J.AGSY.2019.04.002>
- LUISS database, 2023, [on-line], Available: <https://euklems-intanprod-llee.luiss.it/download/> [Accessed: 15 March. 2023]
- Mamonova, N. and Franquesa, J. (2020). Populism, Neoliberalism and Agrarian Movements in Europe. Understanding Rural Support for Right-Wing Politics and Looking for Progressive Solutions. *Sociologia Ruralis*, vol. 60, no. 4, pp. 710–731. <https://doi.org/10.1111/SORU.12291>
- Martino, R. (2015). Convergence and growth. Labour productivity dynamics in the European Union. *Journal of Macroeconomics*, no. 46, pp. 186–200. <https://doi.org/10.1016/J.JMACRO.2015.09.005>
- McErlean, S. and Wu, Z. (2003). Regional agricultural labour productivity convergence in China. *Food Policy*, vol. 28, no. 3, pp. 237–252. [https://doi.org/10.1016/S0306-9192\(03\)00035-6](https://doi.org/10.1016/S0306-9192(03)00035-6)
- Ministerstvo zemědělství, 2007, [Online], Available: <https://eagri.cz/public/web/mze/ministerstvo-zemedelstvi/vyrocní-a-hodnotící-zpravy/publikace-zemedelstvi/?pos=10> [Accessed: 05 May. 2023]
- Nowak, A. and Róžańska-Boczula, M. (2021). The Competitiveness of Agriculture in EU Member States According to the Competitiveness Pyramid Model. *Agriculture* 2022, vol. 12, no. 1, p. 28. <https://doi.org/10.3390/AGRICULTURE12010028>
- Obadić, A., Arčabić, V. and Rogić Dumančić, L. (2023). Club convergence of labor market institutions in the European Union. *Economic Analysis and Policy*, no. 77, pp. 876–896. <https://doi.org/10.1016/J.EAP.2022.12.021>
- Pawlak, K., Smutka, L. and Kotyza, P. (2021). Agricultural Potential of the EU Countries: How Far Are They from the USA? *Agriculture* 2021, vol. 11, no. 4, p. 282. <https://doi.org/10.3390/AGRICULTURE11040282>

Sven Smit, A., Tilman Tacke, A., Susan Lund, M., James Manyika, D. and Francisco Lea Thiel, S. (2020). The future of work in Europe. www.mckinsey.com/mgi.

Zsarnóczai, J. S. and Zéman, Z. (2019). Output value and productivity of agricultural industry in Central-East Europe. *Agricultural Economics (Czech Republic)*, vol. 65, no. 4, pp. 185–193. <https://doi.org/10.17221/128/2018-AGRICECON>

Ženka, J., Slach, O., Krtička, L. and Žufan, P. (2016). Determinants of microregional agricultural labour productivity – Evidence from Czechia. *Applied Geography*, no. 71, pp. 83–94. <https://doi.org/10.1016/J.APGEOG.2016.04.004>

SCIENTIFIC RESEARCH AND DEVELOPMENT ANALYSIS OF TYPICAL RURAL AREAS IN BULGARIA

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Annotation: Rural areas are taking up a significant part of the European Union territory. It is important to monitor their progress and behavior, having in mind all social and agricultural specifics. Expenditures in the research and development field are important, as they are leading to a better educational environment and contributing to rural areas' growth. The main goal of this article is to analyze and review different social and agricultural indicators for typical rural areas in Bulgaria. Results are giving information about the current status and the dynamics in the typical rural areas from a social point of view, emerging digitization as part of future means of learning and acquiring new knowledge.

Key words: rural areas, human capital, employment rate, unemployment rate, research and development

JEL classification: R1, P25, E24

1. Introduction

According to the European Commission, over 80% of the territory of the EU is taken by rural areas and for this reason, as Georgieva-Stankova et. al (2018) pointed out that villages and rural areas fall into the agenda of various analyses, assessments and policies. They present a research field for the study and analysis of new models of economic, civil and social behavior, and as such, remain at the center of our attention.

The purpose of the study is to analyze typical rural areas in Bulgaria and to draw opportunities about regional development and prospects for increasing the interest to rural areas as an attractive force for human capital. Lots of researches considered the problem of rural areas in different countries such as Grigoryeva (2012) for youth unemployment in Czech Republic, Rosenzweig (1988) for family's income in rural areas and Chambers (1983) for complex rural development.

For the purpose of the study, it is necessary to start by defining some terms, such as: "Urbanization". Marinov (2021) mentioned that the etymology of the term urbanization is very complex, there are different interpretations of a large number of authoritative scholars dealing with this matter. The word comes from the Latin *urbs*, hence the adjective "urban" in translation - urban or more urban. In the 14th century the term "urbanity" enters in the literature as a concept, referring to the emergence and development of cities.

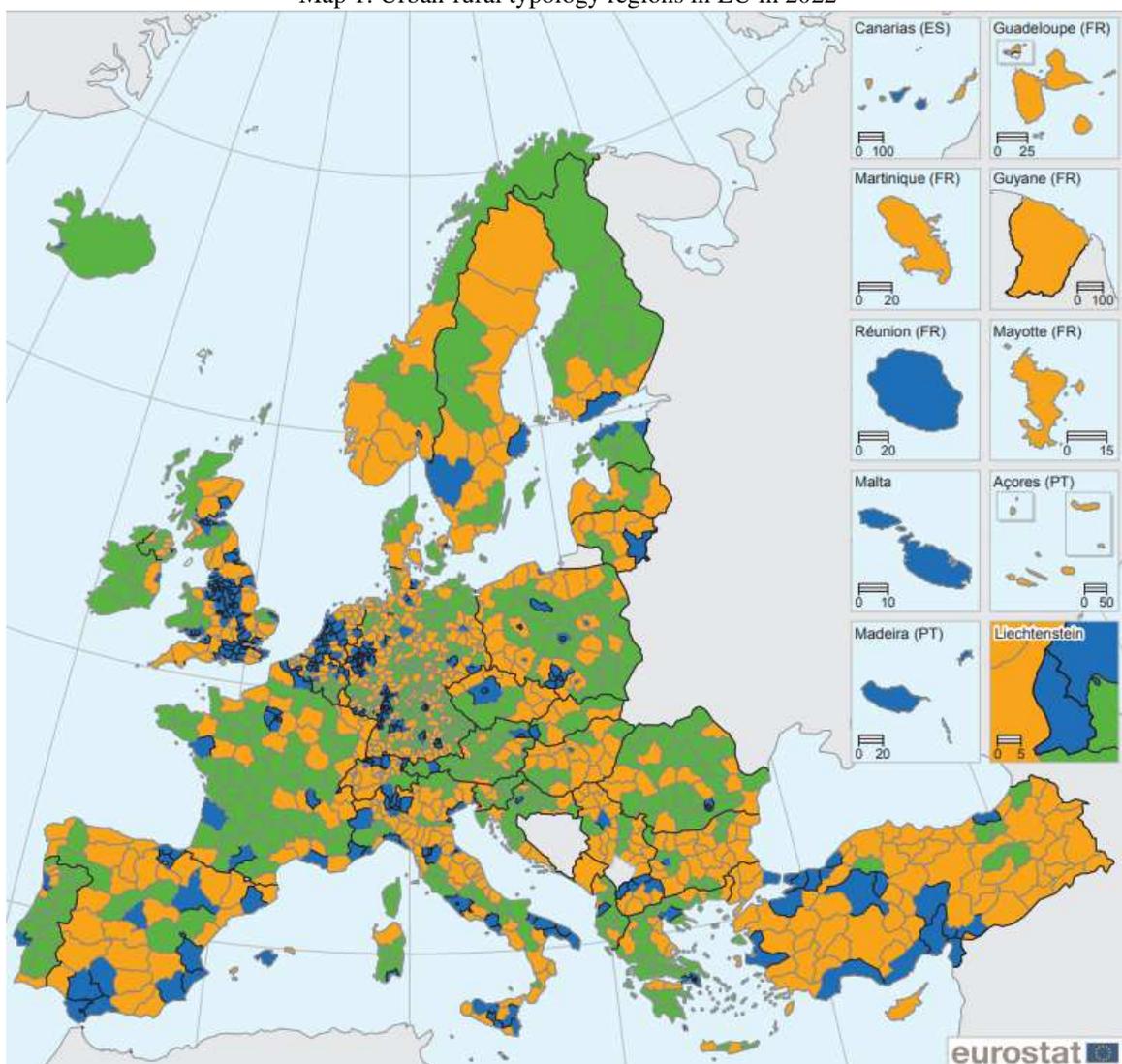
Markov et. al (2016) confirmed that according to the nomenclature of territorial units for statistics – NUTS, defined by Eurostat (2023), Bulgaria's territory is divided into two statistical zones. They are formed from the 6 statistical regions, which correspond to level

NUTS 2. Statistical regions are formed from the 28 districts, which correspond to the NUTS 3 level. At the LAU 1 level, there are 265 administrative-territorial units (municipalities). It is also necessary to define what exactly is meant by typical rural areas. The typology "urban-rural territories" is presented by Eurostat in the Guide to typologies of regions (2020). The main criteria for defining urban-rural regions is the population. Therefore, there are several approaches that could be used to correctly allocate the territories according to NUTS 3 and they can be divided into three groups:

- "Predominantly rural" if the share of the population living in rural areas is higher than 50%
- "Intermediate areas" if the share of the population living in rural areas is between 20% and 50%
- "Predominantly urban" if the proportion of the population living in rural areas is less than 20%.

Now, since there are clear criteria for determining the regions of the territory in Bulgaria according to the NUTS 3 typology, it will be possible to determine exactly which regions meet the criteria and make sure the study is directed to correct regions – only the typical rural regions.

Map 1. Urban-rural typology regions in EU in 2022



Source: Eurostat, 2022

The groups distributed in this way can also be considered at the NUTS 3 level, for the proper separation of the typical rural areas subject to the research.

2. Materials and Methods

The tasks for accomplishing the research goal include:

- 1) selecting proper territory type – typical Rural areas in Bulgaria - according to NUTS 3 classification; In our case these are: Vidin, Razgrad, Silistra, Targovishte, Smolyan, Kardjali and Sofia Region. These regions are covering the requirements to have more than 50% of their population located in rural areas.
- 2) collect and classify the information based on the official National Statistical Institut, Bulgaria and Eurostat;
- 3) analyzing and processing the information, followed by conclusions for the social, agricultural, and research and development sectors in the rural areas.
- 4) The period of this research is covering 7 years (from 2015 to 2021), which is defined as medium term period for statistical purposes.

The research methodology is based on different social coefficients and factors, like employment and unemployment rate, and the relative share of the educational level per capita in Bulgaria and also to the typical rural areas. The area of research includes seven regions and they all are classified as the same type – Predominantly rural (typical rural).

Calculations are done with Statistical software SPSS and also visualized according the Eurostat data and National statistical institute in Bulgaria.

Employment rate

The population in the country aged 15 years and over are divided in three mutually exclusive groups - persons employed, unemployed and out of labour force. Employed persons are aged 15 – 64 years who during the reference period: worked for at least one hour for pay or profit; did not work but had a job or business from which they were temporarily absent due to holydays or illness.

The employment rate is calculated using the following formula:

$$Cz = \frac{Pz}{Pt} \cdot 100 , \quad (1)$$

Where

Cz – Employment coefficient

Pz – Employed persons in the age group 15-64

Pt – Total number of persons in the age group 15-64

Multiply by 100 to get a coefficient in percentage.

Unemployment rate

Persons aged 15 - 74 years who were not employed during the reference week, according to the above definition, and were currently available for work, i.e. were available for paid employment or selfemployment before the end of the two weeks following the reference week; and were actively seeking work in the four-week period ending with the reference week or found a job to start within a period of at most 3 months from the end of the reference week.

The unemployment rate is calculated using the following formula:

$$Ur = \frac{Pu}{Pt} \cdot 100, \quad (2)$$

Where

Ur – Unemployment rate

Pu – Unemployed persons in the age group 15-64

Pt – Total number of persons in the age group 15-64

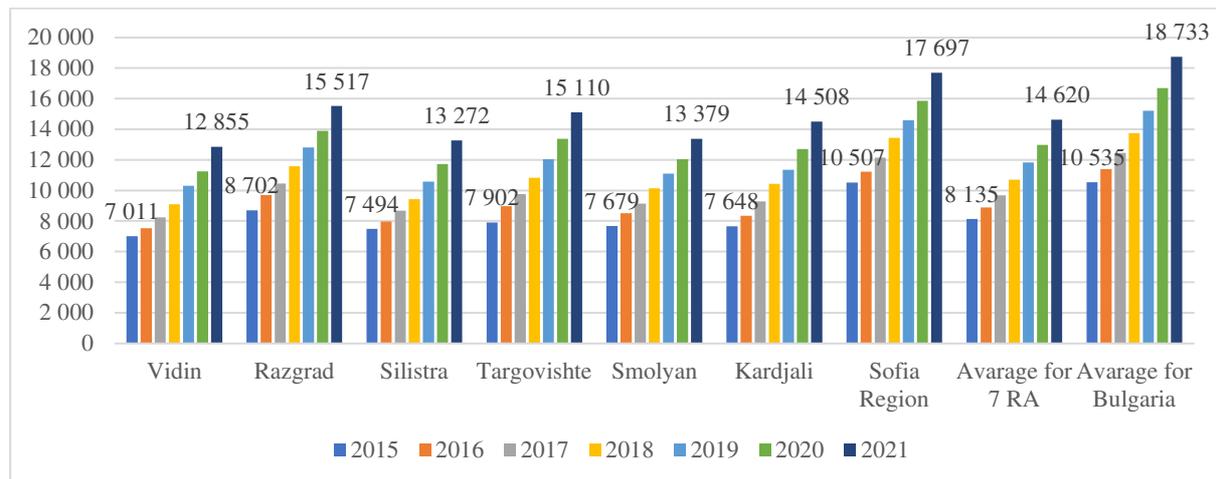
Multiply by 100 to get a coefficient in percentage.

In order to guarantee proper information processing, the following methods are used: analysis and synthesis; inductive, deductive, and translational methods; grouping, systematization, classification; statistical methods for characterizing dynamic and variation statistical series; structural analysis; econometric methods; cluster analysis.

3. Results and Discussion

The average annual salary of employed persons provides information on whether typically rural regions follow the same trend both nationally and at the European Union level. This indicator is basic and serves as a base and information on whether the population in these areas is experiencing difficulties compared to the rest of the country. From Figure 1, it can be seen that there is a steady trend of an increase in the average salary, and in the Razgrad region, for the considered period of 7 years, a 100% increase is observed. The tendency in the regions of Vidin, Silistra and Smolyan to maintain an average salary close to the average for Bulgaria is negative.

Figure 1. Average annual salary of persons employed in employment and service legal relationship (BGN)



Source: National Statistical Institute, Regional statistics, Bulgaria

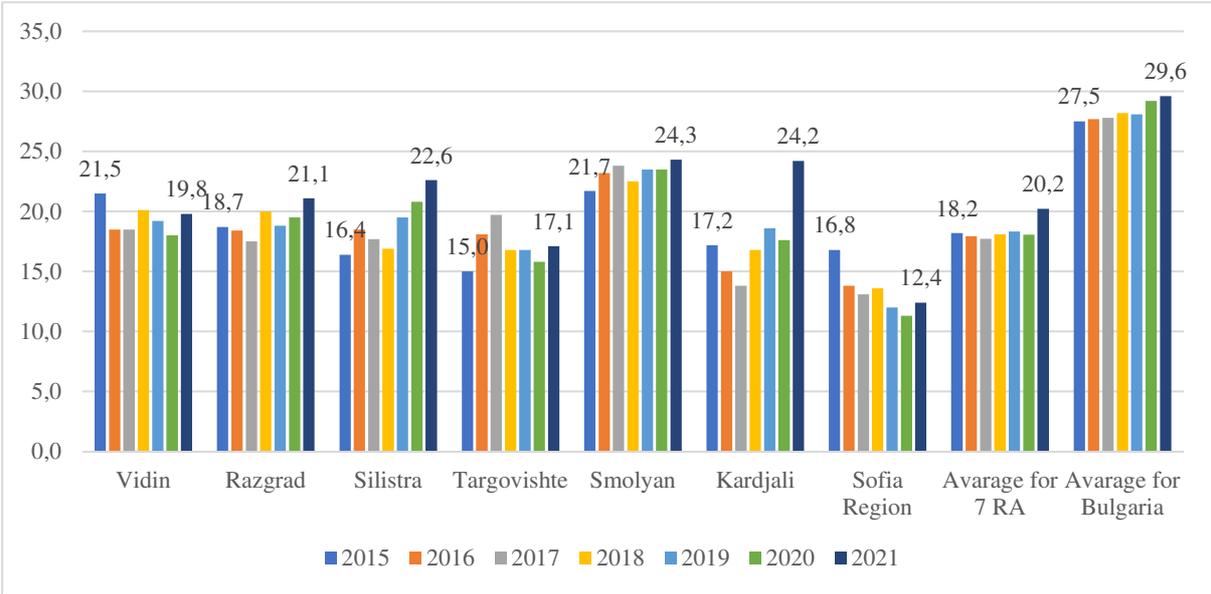
Similar results are observed there during the considered period, and on this criterion, in 2015 a difference of about 30-34% lower average salary is observed, and at the end of the period lower average values of about 30-32% are observed. The Sofia region has the best results of all regions and at the end of the considered period the difference is only about 5% of the average for the country with equal values at the beginning. The average values

for the seven typically rural areas at the end of the considered period are about 22% lower than the average for the country and no big difference is observed compared to the beginning of the period. Also, Bulgaria's typically rural areas lag drastically behind those in the EU, with the average values for the seven areas being almost twice as low as those in European countries.

For greater interest and increase of human capital in typically rural areas in Bulgaria, it is necessary to have access and conditions for attracting a population with higher education, which in turn affects the other social indicators. In the considered regions, a lower share of the population in the 25-64 age group with higher education is observed compared to the national average.

Analyzing the data from Figure 2, we must note the decline in this indicator in two of the considered regions (Vidin and Sofia region). If we compare the beginning and the end of the research period, a decrease in the population with higher education of 1.7% and 4.4% respectively is observed. This trend can be explained for the Sofia region by its proximity to the capital, where the opportunities for development and higher pay are better, and thus for the seven-year period there is a decrease in the share of graduates. For the Vidin region, on the one hand, we have an aging population, without a high distribution rate, and on the other hand, as the poorest region, it is normal for the population with higher education to look for opportunities in more developed regions.

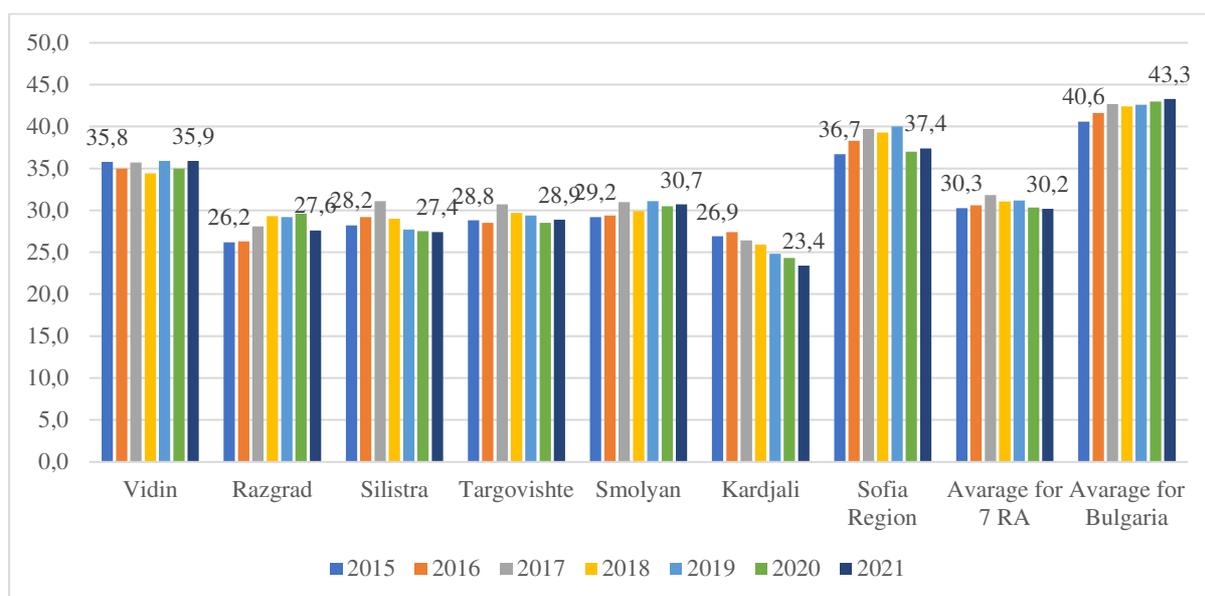
Figure 2. Relative share of the population aged between 25 and 64 with higher education (%)



Source: National Statistical Institute, Regional statistics, Bulgaria

For the rest of the regions, we have an increase in the share of the population with higher education, with the biggest difference being in Kardjali region - 7%, followed by Silistra (6.2%), Smolyan (3.3%), Razgrad (2.4%) and Targovishte (2.1%). Unfortunately, the average share of college graduates in rural areas rose by only 2 percent over the 7-year period and lags nearly 10 percent behind the national average.

Figure 3. Doctors in medical and health facilities as of 31.12. per 10,000 population (number)



Source: National Statistical Institute, Regional statistics, Bulgaria

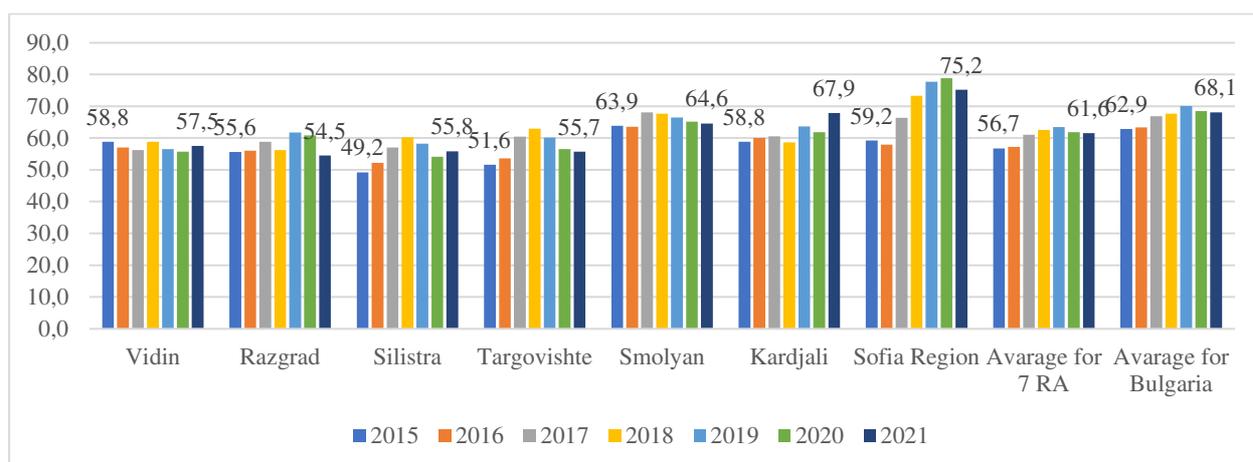
To retain and even increase human capital in typically rural regions, it is not enough to have a high average salary or better access to education, but suitable living conditions are also required. Basic public services such as health and education must be expanded. In this regard, when comparing the data for doctors in medical facilities in typically rural areas per 10,000 people of the population, it is evident that in typically rural areas there are on average about 30 doctors, while this figure for the country is about 43 in 2021, i.e. the attractiveness of typically rural areas declines with the more limited access to health care.

The data by regions show the biggest drop in Kardjali and Silistra, and the most stable results in terms of this indicator are observed in Vidin and Sofia regions, which are close to about 10% of the national average.

The employment rate in typically rural areas in Bulgaria shows that only in the Sofia region we have a significant increase for the period under review of 16%, and in 2021 it is the only region with an employment rate above the national average, exceeding it by about 7%.

All other typically rural areas are below the national average, with Kardjali region being the closest, at only 0.2%. For some regions with lower values a negative trend is observed at the end of the considered period compared to its beginning - Vidin and Razgrad with about a 1% difference.

Figure 4. Employment rate - 15 - 64 completed years (%)

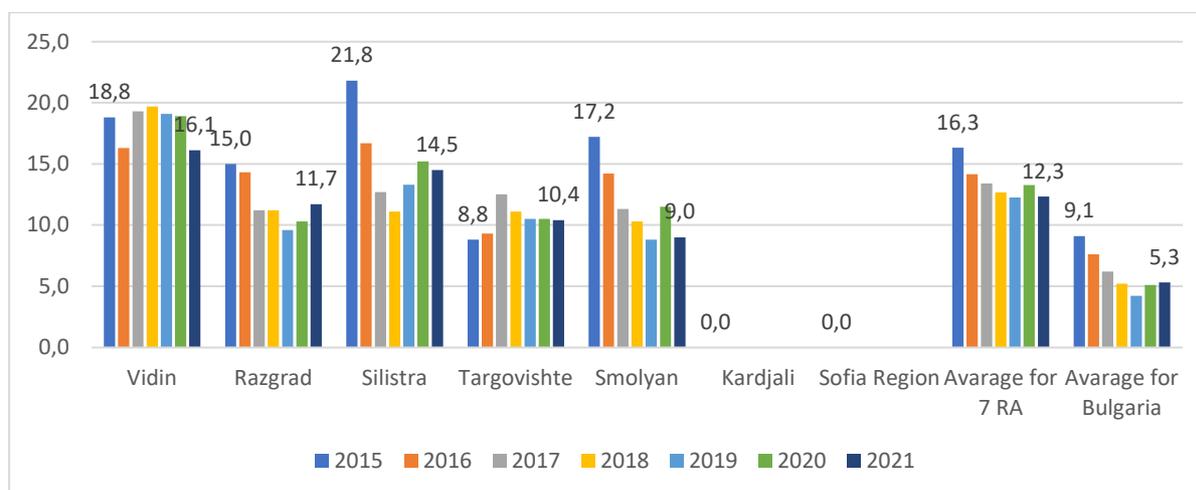


Source: National Statistical Institute, Regional statistics, Bulgaria

Excluding Kardjali, the greatest growth in employment was observed in Silistra region with a positive difference of 6.6% and Targovishte with a 4.1% increase.

The average value of the employment rate in typically rural areas remains lower than the average for the country, and the difference deepens, whereas at the end of the considered period it is greater compared to the beginning in 2015.

Figure 5. Unemployment rate 15 – 64 years of age (%)



Source: National Statistical Institute, Regional statistics, Bulgaria

The data in Figure 5 show large differences both between typically rural areas and between the seven area averages and the national rate. The national statistics lack data for Kardjali and Sofia region. However, the remaining rural areas are indicative of the unemployment rate.

Vidin region has the highest unemployment rate, reaching 16.1% in 2021, which is three times more than the average value for Bulgaria (5.3%). The data for Silistra is similar, with a 14.5% unemployment rate, but on the other hand, there is also great progress in a positive aspect, with a reduction in unemployment of 7.3%. Regarding this change,

the biggest margin is observed in Smolyan region, where in 2015 the unemployment rate is 17.2%, falling to 9% in 2021.

The only region that has a negative growth is Targovishte, where the unemployment rate increases from 8.8% (2015) to 10.4% (2021).

Despite positive trends in most typically rural areas, averages are more than double the national average.

Research and development spending in predominantly rural areas is indicative of the potential and opportunities for upskilling and investment in innovation and new technologies. Unfortunately, there is a decline in this indicator for Vidin and Kardjali regions, while in the others there is even a slight increase. However, the average values are much lower than those for Bulgaria and on average for the seven typically rural regions we have R&D spending 8.37 times lower than the national average at the end of the period under review, while at the beginning of the period, in 2015, this difference was 6.47 times. This speaks of a rather large difference and to some extent reluctance to invest in R&D.

Table 1. Costs for scientific research and development (R&D) - thousand BGN

	2015	2016	2017	2018	2019	2020	2021
Vidin	490	1 025	487	692	846	334	229
Razgrad	no data						
Silistra	613	no data					
Targovishte	no data	no data	235	201	224	249	no data
Smolyan	1 578	1 292	no data	no data	no data	708	2 171
Kardjali	no data	3 168	no data	no data	no data	2 757	no data
Sofia Region	16 100	9 668	9 429	9 028	7 528	9 345	11 346
Average for the 7 RA	4 695	3 788	3 384	3 307	2 866	2 679	4 582
Average for Bulgaria	30 373	26 224	27 151	29 604	35 790	36 564	38 357

Source: National Statistical Institute, Regional statistics, Bulgaria

The opportunities to attract a greater share of human capital in R&D is in turn important for the higher potential of innovations and offering innovative solutions in typically rural areas. Table 2 shows that for all typically rural areas there is a peak in the number of R&D personnel in the middle of the considered period. In Vidin, there is a significant decline, more than twice as few personnel works in this area at the end of the considered period (2021). The only more stable region, without major changes in the staff employed in R&D, is the Sofia region with almost constant data and an increase in staff to 386 people in 2021. On the other hand, if we look at the data from a national perspective, ten times lower average values are observed of personnel employed in R&D at the end of the period, while this difference was 12 times at the beginning of the period in 2015.

Table 2. Personnel engaged in scientific research and development (R&D) – number

	2015	2016	2017	2018	2019	2020	2021
Vidin	48	51	24	57	43	25	23
Razgrad	21	no data	24	33	30	39	38
Silistra	40	no data	48	42	83	81	51
Targovishte	no data	no data	15	24	no data	12	no data
Smolyan	71	86	no data	263	218	214	180
Kardjali	3	24	no data	27	56	43	40
Sofia Region	343	425	369	447	309	396	386
Average for the 7 RA	88	147	96	128	123	116	120
Average for Bulgaria	1 057	1 154	1 115	1 236	1 250	1 253	1 236

Source: National Statistical Institute, Regional statistics, Bulgaria

4. Conclusion

The following conclusions can be summarized from this analysis:

- Employment rate is slightly lower or similar the average for Bulgaria, but still satisfactory, considering the level of unemployment rates in these areas. Without sufficient human capital and a high average age of the population inhabiting these regions, it is natural to observe high values of unemployment and an outflow of young people looking for work and opportunities in neighboring larger areas.
- The average salary in the seven typically rural regions in Bulgaria is below the national average with 22%, which additionally affects the share of graduates and given the low remuneration, the population with higher education seeks realization in areas with better social conditions and wages;
- Doctors per capita in rural areas are significantly less than the national average, which is a negative indicator from the point of view of attractiveness to typically rural regions and their prosperity. The lack of access to health care makes the areas undesirable for young families to establish and settle there;
- Total R&D employment and innovation costs are decreasing in typically rural areas. This does not allow the local population to fully participate in the development of innovations in certain areas.

In conclusion, we can say that typical rural areas in Bulgaria lag behind the average national levels in various indicators: R&D, employment rate, unemployment, etc. In the last two years of the research period, the effect of the pandemic at the global level was also observed, which changed migration processes and the distribution of resources in rural areas. Investments in innovation are less and staff employed are also decreasing, indicating stagnation in insufficient power to handle and cover such force majeure situations.

The solution for making the typical rural areas more attractive is to provide more services with higher level of digitalization in sectors that are currently lagging compared to same type regions in EU. Living conditions in rural areas should be improved, and thus jobs will increase, there will be an improvement in average wages and other indicators.

A good prospect for further research is to track and analyze accurate data on migration processes in the period 2019-2023 in rural areas to see if there is connection with global processes and if this affects human capital and potential in typical rural areas.

Acknowledgements

We express our gratitude for the financial support of the National Scientific Program “INTELLIGENT PLANT PRODUCTION” to Component 4: Artificial Intelligence and Digital Technologies - Engine of Innovative Management Systems, Sectoral Dynamics and Change in Quality of Life. WP 4.3. Rural development and human capital driven by artificial intelligence and digital technologies

References

Applying the Degree of Urbanisation, A methodological manual to define cities, towns and rural areas for international comparisons, European Commission (2020), [Online], Available: <https://ec.europa.eu/eurostat/documents/10186/11395216/DEGURBA-manual.pdf/3a6bab6a-3fb1-4261-ad5b-e604cb67dc0d>, Accessed on 10 February 2023.

Chambers, R. (1983). „*Rural development: putting the last first*“, New York: Routledge, ISBN 978-0-582-64443-4

Eurostat, Statistics Explained, Territorial typologies manual- urban-rural typology, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies_manual_-_urban-rural_typology, accessed Apr 24 2023.

Georgieva-Stankova, Yarkova and Mutafov, (2018). “Can depopulated villages benefit from the social and economic incorporation of ethnic and immigrant communities? A survey for Bulgaria” *Trakia Journal of Sciences*, No 2, pp 140-154, 2018, ISSN 1313-3551 [Online] doi:10.15547/tjs.2018.02.011 Available: [.](#) [accessed Apr 24 2023].

Global Human Settlement Layer, The classes of the Degree of urbanisation, European Commission (2023). [Online], Available: <https://ghsl.jrc.ec.europa.eu/degurbaDefinitions.php>

Grigoryeva, N. (2012). ‘The Problem Of Youth Unemployment in Rural Area’, *Agris on-line Papers in Economics and Informatics*, vol. 4, no. 1, pp. 3 - 12, ISSN 1804-1930

Marinov, P. (2021). Urbanization - formation, factors and stages of the continent Europe, 6. Iksad International Congress on Social Sciences, Széchenyi István University, Hungary, ISBN 978-625-7636-29-2, p.511-517

Markov, Toneva and Mutafov, (2016). Rural Areas in Bulgaria -Identification and Main Characteristics. *Proceedings of the Agrarian perspectives XXV*, Prague, pp. 200 - 205, ISSN 2464-4781

National Statistical Institute, Bulgaria (2023). Methodology, [Online] Available: https://www.nsi.bg/sites/default/files/files/metadata/LFS_Methodology_EN.pdf accessed Apr 24 2023.

National Statistical Institute, Bulgaria (2023). Regional statistics, Regions: Vidin, Razgrad, Silistra, Targovishte, Kardjali, Smolyan, Sofia District (2023), [Online], Available: <https://www.nsi.bg/en/content/797/regional-statistics>

Rosenzweig, M. (1988). 'Labor Markets In Low-Income Countries', Handbook of Development Economics, no. 15, vol. 1, pp. 713 – 762, ISBN 978-0-444-70337-8,[Online] Available: <http://www.sciencedirect.com/science/article/pii/S1573447188010186> DOI: [https://doi.org/10.1016/S1573-4471\(88\)01018-6](https://doi.org/10.1016/S1573-4471(88)01018-6)

EVALUATION OF KNOWLEDGE AND PREFERENCES OF UNIVERSITY STUDENTS IN THE CONTEXT OF FOOD LABELING

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Annotation: Food consumption is a necessary condition for human existence itself, and the role of the agrarian sector has an irreplaceable role in the national economy of all countries of the world. In this context, the last few decades have witnessed a growing interest in the quality of food and efforts to make the market more transparent so that consumers can make informed purchasing decisions. An educated consumer is a "person of tomorrow", and the acquired knowledge will enable him to cope better in the complex everyday reality. Higher education, which is oriented towards the education of experts for agricultural and food practice, must therefore reflect the current problems of the agrarian sector. The aim of the article is to evaluate the orientation of university students of a selected university in the field of food labeling and to reveal their consumer preferences in terms of the monitored issue. The data for the primary research was obtained through quantitative research using a questionnaire survey method in electronic form. The implementation was carried out in the autumn months of 2022. The total number of respondents was 328 university students aged 18-26 years. The results show that the respondents very often confuse the designations of the PDO and PGI labels and do not have a clear understanding of exactly what each of the brands expresses and which products it represents on the food market. The students showed better knowledge in the context of the Regional food label and also in relation to products certified as organic. The majority of respondents identified price as the most important factor when buying food. The results indicate the interest of university students in the issue of food labeling. Acceptance of this fact can thus become a competitive advantage for companies operating in the food market.

Key words: Consumer, education, food, food labeling, preferences

JEL classification: L66, F10

1. Introduction

Consumption of food is a necessary condition for the very existence of man. Since the beginning of mankind, food production has been a mean for mankind's satiation and survival. This is why for many centuries the agrarian sector was the dominant economic sector, whose prosperity determined the level of the rest of the economy of a country or a continent (Corvo, 2016; Coff, 2006). For a long time, it was primarily the quantity of production that was important, ensuring sufficient energy content of food. However, the rapid technological developments and the dynamics of economic, political and social change in recent decades have significantly changed people's lifestyle and dietary perceptions. (Chhabra et al., 2021; Capone et al., 2014). Consumers are increasingly interested in a balanced and healthy diet. Their demands for information accuracy, food safety and quality are also increasing (Bandara et al., 2016). Increasing consumer motivation in the context of health care is a prerequisite for improving the population's dietary habits (Van Loo et al., 2017). Diet and nutrition have an individual and societal dimension, as they play a fundamental role in the daily life of each individual and influence the quality of life and thus the health of the population as a whole (Wahl et al., 2018).

The wide range of food products on the market places considerable demands on consumers in deciding which product to purchase, as they have only limited financial resources to spend in their real lives. One of the tools to facilitate this decision-making process is food labelling. Food labelling can be seen as a means of differentiating the quality of food products, enabling consumers to make informed purchasing decisions (Grunert and Aachmann, 2016). Certification as a tool for product differentiation declares meeting of higher standards and offers consumers an alternative purchasing option to the standard one (Wang et al., 2020). Food labelling is a widely used dynamic system that is constantly evolving and expanding (Shangguan et al. 2019).

Within the European area, food labelling captures a great deal of interest and is also enshrined in EU legislation. (Glogovetan et al., 2022; Cheftel, 2006). Ipsos (2013) conducted a web-based survey of food labelling schemes in use in EU Member States, Iceland and Norway. The total number of programmes identified was 901, 78% of which were certifications, i.e. programmes where third parties are expected to be involved. The highest number of schemes was recorded in Spain (20%) and Germany (12.5%). In third place was a group of four countries - Italy, the Czech Republic, France and Portugal - where the number of identified food labelling schemes ranged from 5.9% to 7.8%. The main schemes adopted by the European Commission under the European Union's food quality policy are Protected Designation of Origin, Protected Geographical Indication and Traditional Speciality Guaranteed. The purpose of these designations is to protect against misuse and imitation and to promote diversity in agricultural production (Grunert and Aachmann, 2016).

Recently, a growing number of studies have investigated the impact of food labelling on consumer behaviour (Shangguan et al., 2019). The decision to purchase a product is very closely linked to the perception of the value of the product in the consumer's mind. Food labelling can therefore be seen as one of the most important factors influencing this decision-making when coupled with confidence in the accuracy and comprehensiveness of the information (Bandara et al., 2016). Temple and Fraser (2014) highlight the importance of choosing an appropriate labelling format so that logos communicate with consumers in a way that is easy to understand, conveys all the necessary information and enables them to make informed choices about the quality of food and the health aspects of their consumption. Soedeberg Miller and Cassady (2015) emphasize the role of prior knowledge for informed consumer purchasing decisions.

The process of cognitive learning enables the customer to effectively use the information provided on product labels, to distinguish their importance and to understand them (Soedeberg Miller and Cassady, 2015). Education today cannot be understood as a closed process, but as a continuous process over time, as our whole society is currently developing in the field of knowledge and technology (Kukulska-Hulme, 2012). An educated consumer is the man of tomorrow and the knowledge gained will enable him to better cope with the complex everyday reality. Higher education, which is oriented towards the education of professionals for agricultural and food industry, must therefore reflect the current problems of the agricultural sector. In higher education, environmental education is an important tool in shaping students' personal identity (Payne, 2010) and plays a significant role in shaping attitudes towards sustainable consumption (Zsoka et al., 2013).

The aim of the paper is to evaluate the orientation of university students of a selected university in the field of food labelling and to reveal their consumer preferences in light of the present's study topic.

The present article consists of several logically interconnected parts. In the Introduction chapter, the theoretical framework of the problem is set out. The Materials and Methods chapter describes the methods used and characterizes the sample of respondents to the survey. The Results and Discussion chapter presents the resulting findings, which are confronted with other research and scientific articles. The Conclusion chapter summarizes the main results and suggests limitations of the paper along with possible directions for further research.

2. Materials and Methods

The theoretical framework of the paper was developed on the basis of the study of secondary sources; i.e., scientific articles and literature through the method of document examination, taking into account the criteria of their cognitive value according to Hendl (2015). Further up-to-date information has been obtained from relevant official internet sources. Basic statistical methods and descriptions were used for self-reporting and results.

The actual data was obtained through quantitative primary research, which was conducted using a questionnaire survey, which took place in the winter semester of the 2022/23 school year, specifically in the fall of 2022. The target group was full-time university students of a selected educational institution - the Faculty of Economics and Management of the Czech University of Life Sciences in Prague. Respondents were aged 18-26, which is the period when young people in the Czech Republic are studying at university and completing their education. The total number of respondents was 328 ($n = 328$), of which 64.3% (211) were female and 35.7% (117) were male. The predominance of women in the overall sample of survey participants is consistent with the fact that the selected university also has a predominantly female student population (Beranová, 2019). In terms of degree level, more than half (53.7%, 176) of the survey participants were studying at the Bachelor's level, and 46.3% (152) were studying at the Master's level. The majority of respondents indicated the capital city of Prague as their place of residence 61.9% (203), followed by the Central Bohemian Region 23.8% (78). Other regions were represented by lower numbers.

Statistical Means for Analysis

The contingency table is used to clearly display the relationships between two statistical variables. The type of contingency table is determined by the number of rows r and the number of columns s , that is, $r \times s$ (Hindls et al., 2007). χ^2 is a measurement of the overall dissimilarity of n_{ij} and m_{ij} . The greater the difference between the observed and expected values, the higher the test statistic χ^2 .

$$m_{ij} = \frac{n_i \cdot n_j}{n} \quad (1)$$

$$\chi^2 = \sum_{i=1}^{r \times s} \frac{(\text{frequency observed}_i - \text{frequency expected}_i)^2}{\text{frequency expected}_i} \quad (2)$$

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^s (n_{ij} - m_{ij})^2 / m_{ij} \quad (3)$$

i and j are row and column indices, n_{ij} are observed marginal frequencies, n_i and n_j are marginal totals by rows and columns, n is grand total of observations, m_{ij} are expected frequencies. The χ^2 value is compared to the critical value χ^2 with a chi-square distribution of $(r-1)(s-1)$ degrees of freedom at selected level of significance. The null hypothesis is rejected if χ^2 value is greater than the table value. A completely equivalent expression of the test is a comparison of the p-value, obtained from the calculated statistics, with the value $(1 - \text{selected level of probability})$. This test is asymptotically valid and therefore can only be used when a sufficient number of observations are available. All expected values should be greater than one (Hendl, 2015), while the table should not contain more than 20% of the theoretical frequencies of occurrence (frequencies) less than 5. If null values occur in any of the fields, we proceed to analyze the derived table created by merging a small number of categories (Hendl, 2015; Howell, 2011).

Cramér's V was used to determine the degree of association between variables (Blaikie, 2003).

$$V = \sqrt{\left(\frac{\chi^2}{n(\min(r, s) - 1)}\right)} \quad (4)$$

The null hypotheses for research are summarized in the following table (Table 1.).

Table 1. Summary of established hypotheses

No. of Hypothesis	Text of Hypothesis
H01	Interest in labels on food packaging does not depend on the gender of the respondent.
H02	Interest in labels on food packaging does not depend on the respondent's level of study.

Source: Own research, 2022

The following abbreviations have been used in the article: PDO = Protected Designation of Origin, PGI = Protected Geographical Indication, EU = European Union, TSG = Traditional Speciality Guaranteed.

3. Results and Discussion

Approximately three-quarters (75.3%, 247) of the total number of participating (n = 328) university students stated that they were somewhat concerned about the labels on food packages when purchasing food. Less than one quarter (23.8%, 78) of the respondents expressed a great interest in the issue, and 51.5% (169) of the respondents chose the answer "I am rather interested". Approximately 25% (81) of the respondents declared their disinterest in this labelling. Within the group of people responding in this way, 17.4% (57) chose the answer "rather not interested" and 7.3% (24) "not at all interested". For this question, the answers of the respondents were examined in more detail in relation to their gender and the degree of study. The results of the stated null hypotheses are presented in the following tables (Table 2 and 3).

Table 2. Interest in labelling on food packaging depending on the gender of the respondent

Gender/Answers	I'm very interested	I'm rather interested	I rather don't care	I don't care at all	Total
Male	19	55	24	19	117
Female	59	114	33	5	211
Total	78	169	57	24	328
Percentage					
Male	16.2	47.0	20.5	16.2	100.0%
Female	28.0	54.0	15.6	2.4	100.0%
Total	23.8	51.5	17.4	7.3	100.0%

Source: Own research, 2022

The χ^2 statistic value of 25.89 is higher than the critical value of 7.81 by three degrees of freedom at the 0.95 significance level. Therefore, the null hypothesis can be rejected. Therefore, whether a respondent is concerned about labelling on food packaging when buying food depends on his/her gender. The dependence, measured by Cramer's V , is moderate ($V = 0.28$). The differences between the observed and expected frequencies suggest

that women show a higher interest in the issue at hand in this case. A full 82% (173) of the total number of female respondents (n = 211) showed interest in labelling on food packaging when purchasing food. Within this question, 28% (59) of women expressed a great interest and 54% (114) declared a rather great interest in the issue. Men chose affirmative responses in only 63.2% (74) of the total 117. 16.2% (19) of them chose the answer "very interested" and 47% (55) stated rather interested.

Table 3. Interest in labelling on food packaging depending on the respondent's level of study

Level of Study/Answers	I'm very interested	I'm rather interested	I rather don't care	I don't care at all	Total
Bachelor's degree	39	87	32	18	176
Master's degree	39	82	25	6	152
Total	78	169	57	24	328
Bachelor degree					
Bachelor's degree	22.2	49.4	18.2	10.2	100.0%
Master's degree	25.7	53.9	16.4	3.9	100.0%
Total	23.8	51.5	17.4	7.3	100.0%

Source: Own research, 2022

The calculated value of the χ^2 statistic of 5.28 is less than the critical value of the χ^2 distribution (7.81) by three degrees of freedom at the 0.95 significance level. Therefore, the null hypothesis cannot be rejected. We could not show a relationship between the level of study in which the respondent is studying and his/her interest in labelling on food packaging when purchasing food. A slight preponderance of total positive responses (79.9%) can be observed for undergraduate students studying at Master's level compared to respondents studying at Bachelor's level (71.6%).

Respondents who indicated that they were interested in some form of food labelling (n = 247) were presented with an overview of individual products offered in retail in the Czech Republic with the selected label (organic food, PDO, PGI, Traditional Speciality Guaranteed and Regional Food) in the following questions.

Respondents were asked to assign the correct label to each product group. The best ranked label was Regional Food, which was correctly assigned by more than a third of respondents (35.2%, 87) of the total number of respondents to this question (n = 247). Products from this group were most often confused with products labelled Traditional Speciality Guaranteed, at 21.9% (54). Less than a quarter (23.5%, 58) correctly identified the Protected Designation of Origin (PDO) based on a review of specific products. Almost a third of respondents (31.6%, 78) thought that the products mentioned carried the designation Regional Food. Similar results were seen for the Protected Geographical Indication (PGI) label, which was chosen correctly by 24.7% (61) of respondents. In the case of the PGI label, respondents most often confused this label with products sold under the Traditional Speciality Guaranteed label (27.5%, 68).

These results suggest that respondents do not know which products have which labels and are able to confuse them very often. This situation is likely to arise mainly in connection with the place names of the products, which obviously creates complications for consumers. On the basis of the above, the complexity of the issue of food labelling from a regional point of view can be noted. Annunziata et al. (2019), based on their survey of young people aged 18-26 years, also found low levels of understanding of food labelling among this group, with the exception of organic labelling.

In the next part of the questionnaire survey, respondents (n = 328) were informed about how the selected food labels (Organic Food, Protected Designation of Origin, Protected Geographical Indication and Regional Food) are defined. In this context, students were asked to indicate what characteristics they attributed to each label. The spectrum of respondents' views is summarised in Table 4 below.

Table 4. Characteristics attributed by respondents to individual food labels

Property/label	Organic Food	PDO	PGI	Regional Food
Health benefits	69.5% (228)	13.7% (45)	11.6 (38)	12.5 (41)
Nutritional properties	46.3% (152)	16.5% (54)	13.4 (44)	14.6 (48)
Quality and safety	51.5% (169)	40.2% (132)	29.6 (97)	20.4 (67)
Considers production conditions	43.9% (144)	20.7 (68)	22.3 (73)	11.3 (37)
Support for local producers	9.5% (31)	44.5 (146)	43.3 (142)	58.5 (192)
Taste	18.9% (62)	15.5 (51)	12.5 (41)	16.5 (54)
Good accessibility	11.3% (37)	12.8 (42)	11.6 (38)	34.5 (113)
Link to the region	6.4% (21)	29.3 (96)	37.2 (122)	71.3 (234)

Source: Own research, 2022

The results show a high level of confidence in organic certification among students, as 70% (69.5%, 228) of the respondents attribute the health benefits to it. Approximately half of the participants expressed an assumption of quality and safety of such labelled foods (51.5%, 169), and 46.3% (152) of the respondents assumed good nutritional properties. The PDO and PGI labels were almost identical in terms of the students' beliefs about the characteristics of the labelled foods, as can be seen in Table 4. The results indicate higher beliefs about quality and safety for PDO (40.2%, 132) than for PGI (29.6%, 97). For Protected Designation of Origin, respondents anticipate a stronger link to the region in just under 40% (37.2%, 122).

For the Regional Food label, respondents most often expect a good link with the region (71.3%, 234) and support of local producers (58.5%, 192). Approximately one-third (34.5%, 113) of people expect good accessibility in the context of this designation.

Furthermore, preferences in terms of the origin of the food purchased by the respondents were surveyed. More than four-fifths of the students (81.7%, 268) of the total number of respondents (n = 328) stated that they prefer food of domestic origin to foreign production. This information demonstrates young consumers' confidence in the quality of domestic food and gives an optimistic outlook for future developments for Czech producers and traders within the agri-food sector.

In terms of the final food purchase decision, respondents cited the price of the product as the most important factor, with nearly 70% (68.3%, 224) of the total number of college students (n = 328) choosing this factor. The second most common factor chosen by respondents was the perceived enjoyment associated with consuming the product (42.4%, 139). Other factors also cited by respondents included health aspects (34.1%, 112) and food composition (29.9%, 98). Price as a factor influencing food purchase decisions has been the subject of much research (Chilla et al., 2020, Tam et al., 2017, Rubio et al., 2014). Molinillo et al. (2020), based on their research on the buying habits of young millennials for organic food, link the willingness to pay a higher price for these products to interest in healthy lifestyles and social consciousness. Araya et al (2022) highlight the importance of consumer belonging to a specific socioeconomic group in the context of purchasing labelled foods.

Wahl et al. (2018) state the importance of sensory attributes of food, as sensory experiences play an important role in the choice of food purchased. Sadílek (2019) considers price, origin and appearance as the most important factors for Czech consumers when buying food. In the context of the price and willingness to pay factor for certified products, Vecchio and Annunziata (2011) report that consumers who show a deep knowledge of PDO food labelling showed a significantly higher willingness to pay more for a product so labelled.

Vlaeminck et al. (2014) consider clear, standardised and easy to interpret food labels as an effective tool to promote organic consumption and sustainability. This is also confirmed by Besler et al. (2012), who believes that the main barriers to the use of food labelling are the lack of understanding of concepts and symbols and ambiguity in the presentation of information.

Arena et al. (2015) highlights current health problems in the developed world stemming from poor lifestyle habits, including poor nutrition, rising obesity rates and physical inactivity. The authors see prevention and opportunities for improvement in this area in the widespread promotion of healthy lifestyles. As part of the general process of consumer education, emphasis should be placed on individuals acquiring the skills to act responsibly with themselves and others in terms of nutrition and consumption (Wahl et al., 2018). Changes in consumer behaviour in the context of their attitudes towards the environment can be achieved by raising public awareness. This is a process based on long-term and continuous influence on individuals from a young age through the educational process (UNEP, 2018).

Cha et al. (2014) investigated the associations between health literacy, diet quality and food label use among young adults aged 18-29 years. Based on their research, the authors find a direct association between health literacy levels and food label use. The strong interest of university students in sustainability issues in food consumption is also confirmed by Kamenidou et al. (2019). Sogari et al. (2018) emphasize the role of universities in intervening in healthy eating, as this period is very important for young people to form lifelong healthy habits. Kukulska-Hulme (2012) emphasises the importance of the role of the university teacher as a person who should be a professional role model for young people. She further states that not only students but also university teachers have to educate themselves throughout their professional life in the context of changing current conditions of the external environment and new technologies brought by everyday practice. Sadílek (2019) highlights the need to expand and increase the intensity of promotional and communication activities in the Czech Republic in order to increase consumer preferences in favour of food quality labelling.

4. Conclusion

The results show that approximately three quarters of university students show some form of interest in the labelling of the food they purchase. Respondents very often confuse PDO and PGI labels and are not clear about exactly what each label represents and which products it represents on the food market in the Czech Republic. Students showed better knowledge in the context of the Regional Food label and in relation to products certified as organic. Most respondents identified price as the most important factor when buying food, followed by the anticipated enjoyment of the food. Knowledge of the composition of food and its suitability for human health was perceived as important by about a third of respondents. The results indicate that young university students are interested in the issue of food labelling.

The theoretical contribution of the paper is a review of the literature review of the problem. The practical contribution of the paper is the presentation of the results of the evaluation

of the orientation of university students of the selected university in the field of food labelling. In terms of further possible research direction, a comparison with other fields of study according to their professional orientation is considered.

Acknowledgements

This work was supported by the Internal Grant Agency of Faculty of Economics and Management, Czech University of Life Sciences Prague - grant number 2022B0004 – “Models of imperfect competition in agricultural and food commodity markets in the Czech Republic and their environmental impacts”.

References

- Annunziata, A., Mariani, A. and Vecchio, R. (2019). “Effectiveness of sustainability labels in guiding food choices: Analysis of visibility and understanding among young adults”, *Sustainable Production and Consumption*, vol. 17, pp. 108-115, ISSN 2352-5509, DOI 10.1016/j.spc.2018.09.005
- Araya, S., Elberg, A., Noton, C. and Schwartz, D. (2022). “Identifying Food Labeling Effects on Consumer Behavior”, *Marketing Science*, vol. 41, no. 5, pp. 982-1003, ISSN 0732-2399, DOI 10.1287/mksc.2022.1356
- Arena, R., et al. (2015). “Healthy lifestyle interventions to combat noncommunicable disease—a novel nonhierarchical connectivity model for key stakeholders: a policy statement from the American Heart Association, European Society of Cardiology, European Association for Cardiovascular Prevention and Rehabilitation, and American College of Preventive Medicine”, *European Heart Journal*, vol. 36, no. 31, pp. 2097-2109, ISSN 0195-668X, DOI 10.1093/eurheartj/ehv207
- Bandara, B. E. S., De Silva, D. A. M., Maduwanthi, B. C. H. and Warunasinghe, W. A. A. I. (2016). “Impact of Food Labeling Information on Consumer Purchasing Decision: With Special Reference to Faculty of Agricultural Sciences”, *Procedia Food Science*, vol. 6, pp-309-313, ISSN 2211-601X, DOI 10.1016/j.profoo.2016.02.061
- Beranová, M. (2019). “Finanční gramotnost studentů vysokých škol se zaměřením na zemědělství v České republice”, dissertation work, Czech University of Life Science Prague. [Online], Available: <https://www.pef.czu.cz/cs/r-17582-uchazeci/r-7028-doktorske-studium/r-8125-alumni/r-14796-alumni-2019>, [Accessed: 3 Jun. 2023] (In Czech)
- Besler, H. T., Buyuktuncer, Z. and Uyar, M. F. (2012). “Consumer Understanding and Use of Food and Nutrition Labeling in Turkey”, *Journal of Nutrition Education and Behavior*, vol. 44, no. 6, pp. 584-591. ISSN 1499-4046, DOI 10.1016/j.jneb.2012.01.005
- Blaikie, N. (2003). “*Analyzing Quantitative Data: From Description to Explanation*”, London, SAGE Publications, ISBN 9780761967590
- Capone, R., El Bilali, H., Debs, P., Cardone, G. and Driouech, N. (2014). “Food System Sustainability and Food Security: Connecting the Dots”, *Journal of Food Security*, vol. 2, no. 1, pp. 13-22, ISSN 2372-0107, DOI 10.12691/jfs-2-1-2
- Cha, E. et al. (2014). “Health Literacy, Self-efficacy, Food Label Use, and Diet in Young Adults”, *American Journal of Health Behavior*, vol. 38, no. 3, pp. 331-339. ISSN 10873244, DOI 10.5993/AJHB.38.3.2
- Cheftel, J. C. (2005). “Food and nutrition labelling in the European Union”, *Food Chemistry*, vol. 93, no. 3, pp. 531-550, ISSN 0308-8146, DOI 10.1016/j.foodchem.2004.11.041

- Chhabra, S., Bakshi, A. and Kaur, R. (2021). "Role of Nutraceuticals in Health Promotion and Disease Prevention: A Review in the Indian Context", *Current Topics in Nutraceutical Research*, vol. 19, no 2, ISSN 1540-7535, DOI 10.37290/ctr2641-452X
- Chilla, T., Fink, B., Balling, R., Reitmeier, S. and Schober, K. (2020). "The EU Food Label 'Protected Geographical Indication': Economic Implications and Their Spatial Dimension", *Sustainability*, vol. 12, no. 14, art. 5503, ISSN 2071-1050, DOI/10.3390/su12145503
- Coff, C. (2006). "*The Taste for Ethics: An Ethic of Food Consumption*", New York: Springer Science+Business Media, ISBN 978-1-4020-4553-0
- Corvo, P. (2016). "*Food Culture, Consumption and Society*", London: Palgrave Macmillan London, ISBN 978-1-137-39817-8
- Glogoveţan, A.-I., Dabija, D.-C., Fiore, M. and Pocol, C. B. (2022). Consumer Perception and Understanding of European Union Quality Schemes: A Systematic Literature Review. *Sustainability*, vol. 14, no. 3, art. 1667, ISSN 2071-1050, DOI 10.3390/su14031667
- Grunert, K. G. and Aachmann, K. (2016). "Consumer reactions to the use of EU quality labels on food products: A review of the literature", *Food Control*, vol. 59, pp. 178-187, ISSN 0956-7135, DOI 10.1016/j.foodcont.2015.05.021
- Hendl, J. (2015). "*Přehled statistických metod zpracování dat: Analýza a metaanalýza dat*", Praha: Portál, ISBN 978-80-262-0981-2
- Hindls, R., Hronová, S., Seger, J. and Fischer, J. (2007). "*Statistika pro ekonomy*", Praha: Professional publishing, ISBN 8086946436
- Howell D.C. (2011). "*Chi-Square Test: Analysis of Contingency Tables*", In: Lovric M. (eds) International Encyclopedia of Statistical Science, Berlin, Heidelberg, Springer Verlag, ISBN 978-3-642-04898-2
- Ipsos, Consumer market Study on the functioning of voluntary food labelling schemes for consumers in the European Union EAHC/FWC/2012 86 04: Final report by the Ipsos and London Economics Consortium, London, 2013, [Online], Available: https://commission.europa.eu/publications/voluntary-food-labelling-schemes-study_en, [Accessed: 10 Mrch. 2023]
- Kamenidou, I. C., Mamalis, S. A., Pavlidis, S. and Bara, and E.-Z. G. (2019). "Segmenting the Generation Z Cohort University Students Based on Sustainable Food Consumption Behavior: A Preliminary Study", *Sustainability*, vol. 11, no. 3, ISSN 2071-1050, DOI 10.3390/su11030837
- Kukulka-Hulme, A. (2012). "How should the higher education workforce adapt to advancements in technology for teaching and learning?", *The Internet and Higher Education*, vol. 15, no. 4, pp. 247-254, ISSN 1096-7516, DOI 10.1016/j.iheduc.2011.12.002
- Molinillo, S., Vidal-Branco, M. and Japutra, A. (2020). "Understanding the drivers of organic foods purchasing of millennials: Evidence from Brazil and Spain", *Journal of Retailing and Consumer Services*, vol. 52, art. 101926, ISSN 0969-6989, DOI 10.1016/j.jretconser.2019.101926
- Payne, P. (2010). "Identity and Environmental Education", *Environmental Education Research*, vol. 7, no. 1, pp. 67-88, ISSN 1350-4622, DOI 10.1080/13504620124658
- Rubio, N., Oubiña, J. and Villaseñor, N. (2014). "Brand awareness-brand quality inference and consumer's risk perception in store brands of food products", *Food Quality and Preference*, vol. 32, pp. 289-298, ISSN 0950-3293, DOI 10.1016/j.foodqual.2013.09.006

- Sadilek, T. (2019). Consumer preferences regarding food quality labels: the case of Czechia. *British Food Journal*, vol. 121, no. 10, pp. 2508-2523, ISSN 0007-070X, DOI 10.1108/BFJ-03-2019-0150
- Shangguan, S. et al. (2019). “A Meta-Analysis of Food Labeling Effects on Consumer Diet Behaviors and Industry Practices”, *American Journal of Preventive Medicine*, vol. 56, no. 2, pp. 300-314, ISSN 0749-3797, DOI 10.1016/j.amepre.2018.09.024
- Soederberg Miller, L. M. and Cassady, D. L. (2015). “The effects of nutrition knowledge on food label use. A review of the literature”, *Appetite*, vol. 92, pp. 207-216, ISSN 0195-6663, DOI 10.1016/j.appet.2015.05.029
- Sogari, G., Velez-Argumedo, C., Gómez, M. and Mora, C. (2018). “College Students and Eating Habits: A Study Using an Ecological Model for Healthy Behavior”, *Nutrients*, vol. 10, no. 12, ISSN 2072-6643, DOI 10.3390/nu10121823
- Tam, R., Yassa, B., Parker, H., O'Connor, H. and Allman-Farinelli, M. (2017). “University students' on-campus food purchasing behaviors, preferences, and opinions on food availability”, *Nutrition*, vol. 37, pp. 7-13, ISSN 0899-9007, DOI 10.1016/j.nut.2016.07.007
- Temple, N. J. and Fraser, J. (2014). “Food labels: A critical assessment”, *Nutrition*, vol. 30, no. 3, pp. 257-260, ISSN 0899-9007, DOI 10.1016/j.nut.2013.06.012
- UNEP, United Nations Environment Programme, Single-use Plastic: A Roadmap for Sustainability, Nairobi, (2018). [Online], Available: <https://www.unep.org/resources/report/single-use-plastics-roadmap-sustainability>, [Accessed: 19 Mrch. 2023]
- Van Loo, E. J., Hoefkens, C. and Verbeke, W. (2017). “Healthy, sustainable and plant-based eating: Perceived (mis)match and involvement-based consumer segments as targets for future policy”, *Food Policy*, vol. 69, pp. 46-57, ISSN 0306-9192, DOI 10.1016/j.foodpol.2017.03.001
- Vecchio, R. and Annunziata, A. (2011). “The role of PDO/PGI labelling in Italian consumers' food choices”, *Agricultural Economics Review*, vol. 12, pp. 80–98, ISSN 1109-2580, DOI 10.22004/ag.econ.178224
- Vlaeminck, P., Jiang, T. and Vranken, L. (2014). “Food labeling and eco-friendly consumption: Experimental evidence from a Belgian supermarket”, *Ecological Economics*, vol. 108, pp. 180-190. ISSN 0921-8009, DOI 10.1016/j.ecolecon.2014.10.019
- Wahl, M., Angele, C. M. and Majchrzake, D. (2018). “Sinnhaftes Lernen – vom Einsatz der Lebensmittelsensorik in der Ernährungs- und Verbraucherbildung”, *Haushalt in Bildung und Forschung*, vol. 7, no. 3, pp. 111-122. ISSN 2193-8806, DOI 10.3224/hibifo.v7i3.09
- Wang, J., Tao, J. and Chu, M. (2020). “Behind the label: Chinese consumers' trust in food certification and the effect of perceived quality on purchase intention”, *Food Control*, vol. 108, ISSN 0956-7135, DOI 10.1016/j.foodcont.2019.106825
- Zsóka, Á., Szerényi, Z. M., Széchy, A. and Kocsis, T. (2013). “Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students”, *Journal of Cleaner Production*, vol. 48, pp. 126-138, ISSN 0959-6526, DOI 10.1016/j.jclepro.2012.11.030

POLYPHENOLS AND ANTIOXIDANT ACTIVITY INTO ANCESTRAL, ORGANIC AND FUNCTIONAL AMAZONIAN PLANTS FOR FOOD AND HEALTH

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Annotation: Indigenous people all over the world have a deep knowledge and connection with environment and organic agricultural practices, to care food and health. Some Indigenous Amazonian families have reported until 886 uses from 107 cultivated species in their garden's systems called chacras or collected in their forest. A manner to reinforce their ancestral knowledge and sustainable practices is through laboratory analyses to confirm functional properties in species for food and health. With this aim, we study polyphenolic and total antioxidant activities effects into Amazonian plants for health and nutrition, that have importance for Indigenous communities. Firstly, we participated in workshops and interviewed Achuar and Kickwa Indigenous families to select promising species that are susceptible to value addition and are associated with functional food; we choose five species to analyses: *Psidium guajava* (guayaba), *Maytenus macrocarpa* (chuchuhuaso), *Theobroma cacao* (cocoa), *Allium ursinum* (ajo silvestre) and *Ilex guayusa* (guayusa). Then, we collected leaves and barks -for the laboratory studies-at the Experimental Centre for Research and Production in the Amazon (CEIPA); the species were identified in the Amazonian Herbarium of Ecuador (ECUAMZ). Secondly, we studied plants' contents in Universidad Estatal Amazonica's laboratory. The hydroalcoholic extracts were made with the ultrasound assisted extraction method. Folin Ciocalteu technique was used to determine the content of total phenolic compounds. Antioxidant activity was determined by FRAP (Ferric ion reducing antioxidant power) and ABTS (2,2-azinobis(3-ethylbenzthiazoline)-6-sulfonic acid); it was based on the ability of an antioxidant to stabilize the ABTS colored cation radical. The highest levels ($p \leq 0.05$) of polyphenols were observed in guayaba leaves, cocoa seeds and chuchuhuaso bark. In the remaining materials studied the polyphenol contents was minor than in the Chilean red wine taken as reference. In all cases antioxidant activity is related to polyphenolic activity; guayaba leaves and cocoa seeds are higher ($p \leq 0.05$) in antioxidant activities. The state university, together with other universities in Ecuador, is working with these species used by local populations, and should increase the exploration of secondary metabolites sources for the pharmaceutical, cosmetic and functional food sectors, involving the interest of Indigenous students to develop local uses and economies.

Key words: Antioxidants, beneficial species, UEA results, ethnobotany

JEL classification: I12, I14, I15, I23, I25, I31

1. Introduction

According to World Health Organization, a high percentage of the world's population, especially in developing countries, uses traditional herbal treatments for their primary health care needs (Nélida et al., 2020), the current social situation shows encouraging signs in the field of acceptance of herbal medicine as complementary medicine with a renewed global interest in studying the effects that plants have on health (Lima et al., 2019). However, in many countries, traditional knowledge on the use of medicinal and food plants has been largely lost; moreover, their availability has been reduced by the degradation of natural environments, especially in the tropical region (Pete et al. 2020). Ethnobotanical research can therefore help to prevent the loss of knowledge and simultaneously protect biodiversity (Bermúdez et al., 2005).

The Amazon rainforest is home to around 30 000 plant species, many of them are food and medicinal plants; although indigenous peoples, throughout their history, have a great diversity in their cultural ecosystems, the current trend is to replace the use of many of these foods with industrialized products that circulate through market networks (Rivas et al., 2010). Indigenous peoples' traditional food systems contain a wealth of information on food species that can be used for human nutrition (Kuhnlei, 2006). The Ecuadorian Amazon Region (RAE) represents one of the most biodiverse areas on the planet and is a source of secondary metabolites for the pharmaceutical, cosmetics and functional foods sectors (Radice et al., 2017).

With this background, it is necessary to promote all the knowledge about Amazonian plants of ancestral use that are beneficial for health and food, as well as to work on research to determine the bioactive principles of interest in laboratories in the universities in this region. This is a manner in what universities and local communities may work together for local development.

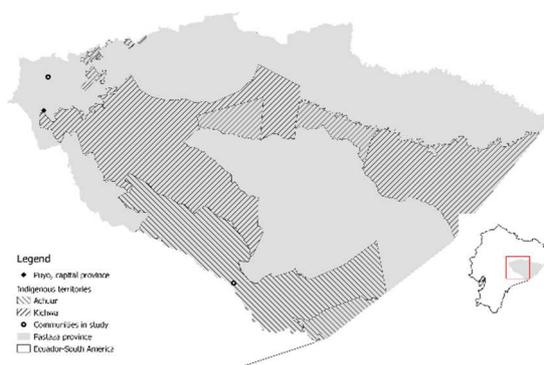
The rescue of ancestral knowledge about the benefits of plants in food and health allows for natural foods and drugs to replace chemical elements that are harmful to health (Priyamvada et al., 2022). Synthetic medicines have a negative impact on the environment (Moreno et al., 2013). The use of diversified indigenous farming systems in biodiverse farms is a priority to produce organic foods that are beneficial to health (Arias et al., 2016).

Consequently, the first objective, is to select Amazonian plants that are important to Achuar and Kichwa communities living far from cities; plants are promising species susceptible to value addition, associated with functional food, and recently were used against Covid-19 during the pandemic. The second objective is to determine polyphenolic and antioxidant activity in these plants, that indicate possible health benefits. Both objectives contribute to long term perspective for local development to support rural Indigenous families in Amazon region.

2. Materials and Methods

The study implies six Kichwa communities located near western portion's Andean foothill, and Charapacocha, an Achuar community located in Amazonian lowland, near Easter Peruvian' frontier, all in Pastaza province, in the central part of the Ecuadorian Amazonia (Figure 1); altitudinal ranges goes between 1200-340 meters over sea level; pluviosity ranges from 6000-4000 mm per year in the upper portion to 2500 mm in Charapacocha; temperature varies between 18-24 °C in the upper zone to 24-26 °C in Charapacocha; relative humidity ranges from 80 to 90%; the climate is megathermal rainy; the low zone is catalogued like Amazonian lowland forest vegetation formation; the upper zone corresponds to Piemontane evergreen forest, montane cloud forest and montane evergreen forest of the Eastern Andes vegetation formation.

Figure 1. Communities and Indigenous territories in study, Pastaza province-Ecuador



Source: Field data and <https://www.raisg.org/es/mapas/>

To the first objective, selecting Amazonian plants that are important to Achuar and Kichwa communities living far from cities, we use qualitative analysis. With participatory observation we share with Indigenous families into two workshops, one held at Charapacocha's achuar Indigenous community, and other held in the Experimental Centre for Research and Production in the Amazon (CEIPA), the State Amazonian University (Universidad Estatal Amazónica (UEA)' research center, that also has different species collected in the Amazonian Herbarium of Ecuador (ECUAMZ). Both workshops discussed local development perspectives and established necessary relationship between people in rural areas with universities in the territory, to promote socio-economic advances.

Starting with the Indigenous testimony about ancestral plants, biodiversity and community aspiration related in workshops, we applied semi-structured interviews to five heads of families and community leaders, both Achuar and Kichwa. They provided information about food culture, diet, cultural acceptance, collection, and production in the jungle and in the cycle of the Amazonian agro-biodiversity system, sales to market, main promising species susceptible to value addition, association with functional food, health and whether species are or not used against Covid-19 during the pandemic. We show a part of the results in this paper. Then, a literature reviewed was made and five species were chosen for laboratory analyses.

For the second objective, for the laboratory studies, the selected species' leaves and barks were collected at the Experimental Centre for Research and Production in the Amazon and identified in the Amazonian Herbarium of Ecuador (ECUAMZ). The plant material was washed with potable water and prepared according to the methodology of Azwanida (2015).

Obtaining extracts.

The extracts of the selected plants were obtained using the ultrasound assisted extraction-UAE method (Branson Ultrasonics, USA). For the extraction, an ethanol: water mixture was used in a 9:1 ratio, with a ratio of 400 mL of solvent per 50 g of powdered sample (Ance et al. 2022).

Determination of total phenolic compounds and antioxidant activity.

To determine the content of total phenolic compounds, the technique of Proestos and Varzakas (2017) was used. Antioxidant activity was determined by FRAP (Ferric ion reducing antioxidant power) and ABTS (2,2-azinobis(3-ethylbenzthiazoline)-6-sulphonic acid); it was based on the ability of an antioxidant to stabilize the colored cation radical ABTS (Re et al, 1999).

3. Results and Discussion

Indigenous peoples and rural communities have a tradition of food sufficiency based on their relationship with nature, their own cultivable resources in biodiverse farms and those of stationary collection in the forest. Workshops reveals families with a deep knowledge about small agricultural practices; they report until 886 uses over 336 vegetable species collected from jungle or from their subsistence cultivated spaces called chakras (IQBSS, 2013), however the principal species consumed are yucca (*Manihot sculenta*) and banana (*Musa spp.*), so, major contents in carbohydrates. Table 1 summarize the results of semi structured interviews conducted with head family's members. It shows the main products that the families obtain from the jungle and the Amazonian diversified gardens called chakras.

Table 1. Important plants for Achuar and Kichwa Indigenous communities, obtained from chakras or jungle

Family numbered	Most collected plants from the jungle, (common name)	Most consumed plants produced in the chakra, (common name)	Main uses	
			Food	Health
1	Chontaduro, palm heart, wild mushrooms, guayusa, guayaba, chuchuhuaso, ajo	Yucca, banana, maize, cocoa, chinese potato, beans, peanuts, wild grapes, achiote	X	X
2	Wild aniseed, chontaduro, palm heart, wild mushrooms, chuchuhuaso, Ayahuasca, ishpingu, sacha inchi, cat's claw, ajo.	Yucca, banana, maize, chinese potato, beans, peanuts, cocoa, guayaba, guayusa, wild grapes, peanuts, guabas, ají	X	X
3	Chontaduro, palm heart, guayusa, guava, chuchuhuazo, ayahuasca, cat's claw, ajo	Yucca, banana, maize, chinese potato, beans, peanuts, guayaba, wild grapes, peanuts, oranges, cocoa.	X	X
4	Chontaduro, palm heart, wild mushrooms, chuchuhuazo white cocoa, ishpingu, paparagua, ajo, guayusa, wantuk, shiwa	Yucca, banana, maize, chinese potato, beans, peanuts, wild grapes, sugar cane, guayaba, barbasco.	X	X
5	Wild garlic, chuchuhuazo, guayusa, guaba, sacha inchi, cat's claw, shiwa.	Cassava, banana, maize, chinese potato, peanuts, beans, wild grapes, guayaba, cocoa.	X	X

Source: Interviews to Achuar and Kichwa families, April 11th/2023

Considering the declarations in the workshops and interviews, a selection and review of the specialized literature was carried out, with some promising plants previously reported. Table 2 shows food plants with functional, medicinal, flavoring, cosmetic, ritual, and toxic values selected from the workshops and families' interviews.

Table 2. Selected useful plants according to workshops, interviews, and results in the reviewed literature

Common name	Scientific name	Ancestral uses	Reference
Achiote	<i>Bixa orellana</i>	Food colouring. Use in burns	Lourido & Martínez (2010)
Ají	<i>Capsicum sp</i>	Spicy seasoning. Antimicrobial	Colivet et al. (2010)
Ajo silvestre.	<i>Allium ursinum</i>	Flavouring, antioxidant, antiproliferative	Nemanja et al. (2020)
Anís silvestre	<i>Tagetes filifolia Lag</i>	Flavouring agent, bioinsecticide	Camarillo et al. (2009)
Ayahuasca	<i>Banisteriopsis caapi</i>	Contact with the spirit world by shamans	Rojas (2014)
Barbasco	<i>Lonchocarpus utilis</i>	Toxic to fish	Marinos et al. (2004)
Cacao	<i>Theobroma cacao</i>	Antioxidant, food, beverage	Ramírez et al. (2013)
Chontaduro	<i>Bactris gasipaes</i>	Oil, soap, food and feed	Guedes et al. (2015)
Chuchuhuaso	<i>Maytenus macrocarpa</i>	Rheumatism	Milan et al. (2019)
Guayaba	<i>Psidium guajava</i>	Antioxidant, vitamin, antidiarrheal	Campos et al. (2021)
Guayusa	<i>Ilex guayusa</i>	Antioxidant, vitamin, medicinal, fertility	Gamboa et al. (2018)
Ishpingu	<i>Ocotea quixos</i>	Flavouring spice	Valarezo et al. (2021)
Sacha inchi	<i>Plukenetia volubilis</i>	Omega 3, antioxidant, immunomodulator.	Denny et al. (2021)
Uña de gato	<i>Uncaria tomentosa</i>	Antioxidant, anticarcinogenic	Ali et al. (2021)
Shiwa	<i>Oenocarpus bataua</i>	Hair care oil	Palacios et al. (2018)

Source: Workshop November 11th -14th 2013, and families' interviews April 11th/2023

One focus of current food development is primarily consumer-related; it takes into consideration the transformations that food, nutrients and bioactive substances have on the human body and their effect on health and well-being (Bhaskaran et al. 2002).

Today's food is more complex and must meet increasingly demanding environmental, safety, quality, and presentation requirements, among others. From this perspective, the focus of the development of the functional food industry must necessarily shift to the consumer in order to respond to their motivations, emotions, tastes and concerns for a healthy life. This empowerment of the 21st century consumer has reversed the traditional food signal, from the supply side to one conceived from the demand side and its link with consumer health, which recognizes the benefits provided by the consumption of some substances of plant origin, mainly through a contribution of bioactive substances in food (Valenzuela et al., 2014). In parallel, from the perspective of the 21st century consumer, there is a strict correlation between food and health; new trends point to an inclusive approach towards indigenous communities, respectful of their worldview and based on a process of mutual learning, community empowerment and limited access to ancestral knowledge (Sidali et al., 2016).

Laboratory results in total phenolic compounds and antioxidant activity (ABTS and FRAP), are presented in table 3. The highest levels ($p \leq 0.05$) of phenolic compounds were observed in guayaba leaves, cocoa seeds and chuchuhuaso bark results, that are presented. In the remaining materials studied, the polyphenol contents are lower than in the Chilean red wine taken as reference. Guayaba leaves and cocoa seeds are higher ($p \leq 0.05$) in antioxidant activity. In all cases antioxidant activity is related to polyphenolic activity (Caicedo et al. 2018).

Table 3. Content of total phenolic compounds and antioxidants in hydroalcoholic extracts of Amazonian plants, in mg.mL^{-1} .

Table 3. Total phenolic compounds and antioxidants in hydroalcoholic extracts, in mg.mL^{-1}

Plants for analysis	Polyphenols hydroalcoholic extract	FRAP hydroalcoholic extract	ABTS hydroalcoholic extract
Guayaba leaves	35.32 ^a	15.451 ^a	543.763 ^b
Cocoa	24.44 ^b	10.239 ^a	324.540 ^a
Chuchuhuaso	19.90 ^b	8.540 ^b	108.,376 ^b
Wild garlic	11.73 ^c	7.780 ^b	97.034 ^c
Guayusa	1.288 ^d	1.288 ^c	4,23 ^d
Red wine (reference)	8.983 ^c	8.983 ^d	0.040 ^c

Source: Analyses in Laboratory in the project Amazonian functional biopreparations beneficial to health.

Polyphenolic compounds are biologically active substances and there is ample evidence from in vitro studies, animal models and human intervention studies that these compounds provide benefits to the body against various diseases. These beneficial properties include protection against cellular and subcellular injury, inhibition of tumors growth, activation of hepatic detoxification systems and blocking of metabolic pathways that can lead to carcinogenesis (Mercado et al., 2013).

This work contributes to current knowledge on antioxidants and their role in human health (Coronado et al., 2015). The so-called "health market" is currently having an impact on consumers and is expanding every day around the world (Franco, 2003), where foods with antioxidants of animal or vegetable origin, natural or industrialized, are part of the daily diet (Drago et al., 2006) and, in addition to providing nutrients, have these bioactive components. Especially in relation to covid19 despite medical advances with drugs and vaccines, plant-based compounds could provide an array of suitable candidates to test against this virus (Condori et al., 2023).

4. Conclusion

The results of surveys conducted with head of families and leaders from Achuar and Kichwa Amazonian Indigenous communities, show the mean products that families consume and obtain from the jungle and the Amazonian chakras.

The highest levels of phenolic compounds are observed in guayaba leaves, cocoa seeds and chuchuhuaso bark. In the remaining materials studied, the polyphenol contents are lower than in the Chilean red wine taken as reference.

Antioxidant activity is related to polyphenolic activity, guayaba leaves and cocoa seeds are higher in these antioxidant activity by the two methods studied.

The ancestral knowledge of the forest peoples can be enhanced for their own benefit, in alliance with universities, through research into foods with functional properties, such as antioxidants, dietary fiber, prebiotic and probiotic biopreparations, with the agrobiodiverse system in farms being the way to reproduce these useful species.

Acknowledgements

The author would like to thanks to Achuar and Kichwa Indigenous people, to their families and leaders, for those participation in the research and for sharing generously their lives, knowledge and expectations. Thanks too to Amazonian State University (Universidad Estatal Amazonica) for funding the internal project Amazonian functional biopreparations for health benefits, code AGR-003-2016-2020.

References

- Ali, Z., Hajer A., Carly B. and Robert L. (2021). "Treatment with *Uncaria tomentosa* Promotes Apoptosis in B16-BL6 Mouse Melanoma Cells and Inhibits the Growth of B16-BL6 Tumours". *Molecules*. vol. 26, no. 4, p. 1066, doi: 10.3390/molecules26041066
- Ance, B., Arturs, P., Dace, B. and Agnese, B. (2022). "The Potential Use of Herbal Fingerprints by Means of HPLC and TLC for characterization and identification of herbal extracts and the distinction of latvian native medicinal plants". *Molecules*, vol. 27, p. 2555. <https://doi.org/10.3390/molecules27082555>
- Arias G. R., Carpio A. T., Herrera, A. and González R. (2016). "Sistema indígena diversificado de cultivos y desarrollo local en la amazonia ecuatoriana". *Cultivos Tropicales*, vol. 37, no. 2, pp. 7-14. <https://www.redalyc.org/pdf/1932/193246554001.pdf>
- Azwanida, N. (2015). "A Review on the Extraction Methods Use in Medicinal Plants, Principle, Strength and Limitation". *Med Aromat Plants*, vol. 4, no. 3, doi:10.4172/2167-0412.1000196
- Bermúdez, A., Oliveira-Miranda, M. and Velázquez, D. (2005). "La investigación etnobotánica sobre plantas medicinales: Una revisión de sus objetivos y enfoques actuales". *INCI* [online]. vol.30, no. 8, pp. 453-459. http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0378-18442005000800005&lng=es&nrm=iso. ISSN 0378-1844
- Bhaskaran, S. and Hardley, F. (2002). "Buyer beliefs, attitudes and behavior: foods with therapeutic claims". *J. Consumer Marketing*, vol. 19, pp. 591-606. https://www.researchgate.net/publication/37376994_Buyer_beliefs_attitudes_and_behaviour_Foods_with_therapeutic_claims
- Caicedo, W., Flores A. and Pérez M. (2018). "Content of phenolic compounds in powders of six Amazonian vegetables and its effect as a phytobiotic additive for pigs". *MOL2NET*, 2018, 4, doi:10.3390/mol2net-04. International Conference Series on Multidisciplinary Sciences <http://sciforum.net/conference/mol2net-03>

Camarillo, G., Ortega L., Serrato, M. and Rodríguez Cesáreo. (2009). “Actividad biológica de *Tagetes filifolia* (Asteraceae) en *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae). Biological activity of *Tagetes filifolia* (Asteraceae) on *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae)”. *Rev. Colomb. Entomol.* vol.35, no. 2, ISSN 0120-0488. On-line version ISSN 2665-4385

Campos e Silva, R. et al. (2021). “Monoterpenes and Sesquiterpenes of Essential Oils from Psidium Species and Their Biological Properties”. *Molecules*, vol. 26, p. 965, <https://doi.org/10.3390/molecules26040965> <https://www.mdpi.com/journal/molecules>

Colivet, J., Belloso, G. and Hurtado, E. (2006). “Comparación del efecto inhibitor de extractos de ají dulce (*Capsicum chinense*) sobre el crecimiento de *Escherichia coli* y *Bacillus* sp. Saber”. *Revista Multidisciplinaria del Consejo de Investigación de la Universidad de Oriente*, vol. 18, no. 2, pp. 168-173. <https://www.redalyc.org/pdf/4277/427739430009.pdf>

Condori, E., Soares, S. and Herrera, O. (2023). “Medicinal Plants in Peru as a Source of Immunomodulatory Drugs Potentially Useful Against COVID-19”. *Rev. Bras. Farmacogn.* vol. 33, no. 2, pp. 237–258. doi: 10.1007/s43450-023-00367-w

Coronado, M., Vega S., Gutiérrez, R., Marcela, V. and Claudia R. (2015). “Antioxidants: present perspective for the human health”. *Rev. Chil. Nutr.*, vol. 42, no. 2, <https://scielo.conicyt.cl/pdf/rchnut/v42n2/art14.pdf>

Denny, M. Cárdenas, L., Gómez, J. and Andrés, J. (2021). “Biological Activity of Sacha Inchi (*Plukenetia volubilis* Linneo) and Potential Uses in Human Health: A Review”. *Food Technol Biotechnol*, vol.59, no. 3, pp. 253–266. doi: 10.17113/ftb.59.03.21.6683

Drago, S., María, E., López, M. and Sainz, T. (2006). “Componentes bioactivos de alimentos funcionales de origen vegetal”. *Revista Mexicana de Ciencias farmacéuticas*, vol. 37, no. 4, pp. 58-68. <https://www.redalyc.org/pdf/579/57937408.pdf>

Franco, A. (2003). “Globalizar la salud”. *Gac Sanit* [online]. vol. 17, no. 2, pp. 157-163. http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0213-91112003000200011&lng=es&nrm=iso. ISSN 0213-9111

Gamboa, F., Muñoz, C., Numpaqué, G., Gonzalo, L., Gutierrez, S. and Tellez, N. (2018). “Antimicrobial Activity of *Piper marginatum* Jacq and *Ilex guayusa* Loes on Microorganisms Associated with Periodontal Disease”. *Int. J. Microbiol.* 4147383. Published online 2018 Sep 25. doi: 10.1155/2018/4147383

Guedes, M., Soares R., Moura, M., Sousa de Brito, E. and Elesbão, R. (2015). “Amazonian Native Palm Fruits as Sources of Antioxidant Bioactive Compounds”. *Antioxidants* (Basel). vol. 4, no. 3, pp. 591–602. Doi 10.3390/antiox4030591

Instituto Quichua de Biotecnología Sacha Supay (IQBSS). (14 y 15 de noviembre de 2013): Manejo y conservación de la agrobiodiversidad en sistemas de producción ancestral del pueblo Kichwa de Pastaza. I Encuentro por la vida en armonía, el territorio y la multitud de vidas en plenitud de Pastaza. Puyo

Kuhnlein, H. V. (2006). “The joys and pains of sampling and analysis of traditional food of indigenous peoples”. *J. Food Compos. Anal.*, vol. 13, pp. 649-658. <https://www.sciencedirect.com/science/article/abs/pii/S0889157599908578>.

- Lima, L., Guzman, Y., López, V. and Satchwell, R. (2019). “La medicina tradicional herbolaria en los sistemas de salud convencionales”. *Rev. Hum. Med.* [online], vol. 19, no. 1, pp. 201-217. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1727-81202019000100201&lng=es&nrm=iso. ISSN 1727-8120
- Lourido, Hetzel de la C. and Martínez, G. (2010). “La *Bixa orellana* L. en el tratamiento de afecciones estomatológicas, un tema aún por estudiar”. *Rev. Cubana Farm* [online]. 44(2): 231-244. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0034-75152010000200012&lng=es&nrm=iso. ISSN 0034-7515
- Marcela, V. and Claudia R. (2015). “Antioxidants: present perspective for the human health”. *Rev. Chil. Nutr.*, vol. 42, no. 2, <https://scielo.conicyt.cl/pdf/rchnut/v42n2/art14.pdf>
- Marinos, C., Castro, J. and Nongrados, D. (2004). “Efecto biocida del «barbasco» *Lonchocarpus utilis* (Smith,1930) como regulador de larvas de mosquitos”. *Rev. Peru Biol.* [online]. vol. 11, no. 1, pp. 87-94. <http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1727-99332004000100011&lng=es&nrm=iso>. ISSN 1727-9933
- Mercado-Mercado G., Carrillo L., Wall-Medrano A., López, J. and Álvarez-Parrilla E. (2013). “Compuestos polifenólicos y capacidad antioxidante de especias típicas consumidas en México”. *Nutr. Hosp.* [online]. vol. 28, no. 1, pp. 36-46. <http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0212-16112013000100005&lng=es&nrm=iso>. ISSN 1699-5198. <https://dx.doi.org/10.3305/nh.2013.28.1.6298>
- Milan, M., Jakub, T., Veronika, R., Karolina, T., Petra, K., Ladislav, K., Peter, K. and Karel, Š. (2019). *Maytenus macrocarpa* (Ruiz & Pav.) Briq.: Phytochemistry and Pharmacological Activity. *Molecules*, vol. 24, p. 2288; doi:10.3390/molecules24122288 www.mdpi.com/journal/molecules
- Moreno-Ortiz, V., Martínez-Núñez, J., Kravzov-Jinich, J., Pérez-Hernández, L., Moreno-Bonett, C. and Altagracia-Martínez, M. (2013). “Los medicamentos de receta de origen sintético y su impacto en el medio ambiente”. *Rev. Mex. Cienc. Farm*, vol. 44, no. 4. <https://www.redalyc.org/pdf/579/57930578003.pdf>
- Nélida, S., Pasionaria, R., Guiomar, V., Gladys, E. and Ríos, P. Analía Ortíz. (2020). “Etnobotánica y uso de plantas medicinales en unidades familiares de salud de Caaguazú, Paraguay”. *Caldasia* [online]. vol. 42, no. 2, pp. 263-277. <http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0366-52322020000200263&lng=en&nrm=iso>. ISSN 0366-5232. <https://doi.org/10.15446/caldasia.v42n2.76907>
- Nemanja, S. et al. (2020). “Antioxidant and Antiproliferative Activity of *Allium ursinum* and Their Associated Microbiota During Simulated *in vitro* Digestion in the Presence of Food Matrix”. *Front Microbiol.* vol. 11, p. 601616. doi:10.3389/fmicb.2020.601616
- Palacios, B., Enríquez, D., and Sosa, A. (2018). “Oil productivity potential of *Oenocarpus bataua* Mart, in the Ecuadorian Amazon, Taisha Canton”. *Bosques Latitud Cero* 2018, vol. 8, no. 1, pp. 32-43. <https://revistas.unl.edu.ec/index.php/bosques/article/view/412/348>
- Pete, S. et al., (2020). „Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification?” *Glob Change Biol.* vol. 26, pp. 1532–1575. <https://doi.org/10.1111/gcb.14878>

- Priyamvada, T. et al. (2022). „Postbiotics: Current Trends in Food and Pharmaceutical Industry”. *Foods*, vol. 11, p. 3094. <https://doi.org/10.3390/foods11193094>
- Proestos, C., and Varzakas, T. (2017). “Aromatic Plants: Antioxidant Capacity and Polyphenol Characterisation”. *Foods*, vol. 6, p. 28; doi:10.3390/foods6040028
- Radice, M. et al. (2017). “Determinación de polifenoles en cinco especies amazónicas con potencial antioxidante”. *Revista Amazónica Ciencia y Tecnología Volumen*, vol. 6, no. 1, pp. 55-64. <https://dialnet.unirioja.es/servlet/articulo?codigo=6145606>
- Radice, M., Pérez, M., Silva, L., Bravo, L. and Riofrio, A. (2017). “Polyphenol extracts from Cocoa (*Theobroma cacao*) and Chuchuhuasi (*Maytenus macrocarpa*) as potential natural Amazonian antioxidants”. *MOL2NET, International Conference Series on Multidisciplinary Sciences*. <http://sciforum.net/conference/mol2net-03>
- Ramírez, M., Cely, N., Hugo, V. and Ramírez, S. (2013). “Actividad antioxidante de clones de cacao (*Theobroma cacao* L.) finos y aromáticos cultivados en el estado de Chiapas-México”. *Perspect Nut Hum* [online]. vol. 15, no. 1, pp. 27-40. <http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0124-41082013000100002&lng=en&nrm=iso>. ISSN 0124-4108
- Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M. and Rice-Evans, C. (1999). “Antioxidant activity applying an improved ABTS radical cation decolorization assay”. *Free Radic Biol Med*. vol.26, no. 9-10, pp. 1231-1237. <https://pubmed.ncbi.nlm.nih.gov/10381194/>
- Rivas, X., Pazos, S., Castillo, S. and Pachon, H. (2010). “Alimentos autóctonos de las comunidades indígenas y afrodescendientes de Colombia”. *ALAN* [online]. vol. 60, no. 3, pp. 211-219. http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0004-06222010000300001&lng=es&nrm=iso>. ISSN 0004-0622
- Rojas-Bolívar, D. (2014). “Ayahuasca: el encuentro de dos paradigmas”. *Revista de Neuro-Psiquiatría*, vol. 77, no. 1, pp. 40-47. Universidad Peruana Cayetano Heredia Lima, Perú. <https://www.redalyc.org/pdf/3720/372033985005.pdf>
- Sidali, K., Yépez, P. and Garrido-Pérez, E. (2016). “Food Tourism in Indigenous Settings as a Strategy of Sustainable Development: The Case of *Ilex guayusa* Loes”. in the *Ecuadorian Amazon. Sustainability*, vol. 8, p. 967. doi:10.3390/su8100967
- Valarezo, E., Vullien A. and Conde-Rojas, D. (2021). “Variability of the Chemical Composition of the Essential Oil from the Amazonian Ishpingo Species (*Ocotea quixos*)”. *Molecules*, vol. 26, p. 3961. <https://doi.org/10.3390/molecules26133961> <https://www.mdpi.com/journal/molecules>.
- Valenzuela, A., Valenzuela, R., Sanhueza, J. and Morales, G. (2014). “Alimentos funcionales, nutraceuticos y foshu: ¿vamos hacia un nuevo concepto de alimentación?” *Rev. Chil. Nutr.* vol. 41, no. 2, pp. 198-204. https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0717-75182014000200011

PRESTIGE OF OCCUPATION VERSUS AGE AND EDUCATIONAL STRUCTURE OF WORKERS IN AGRICULTURE IN THE CZECH REPUBLIC

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Annotation: The future influx of young workers into a certain industry is influenced by several factors, including the industry's attractiveness or the profession's prestige, the population's demographic structure and the number of graduates of educational fields in a given industry. The agricultural sector suffers from an unfavourable age workforce structure and a lower interest in working there. These aspects bring the risk of rural depopulation or a reduction in competitiveness due to a lower willingness to innovate. The image of Czech agriculture as an employer plays an important role in choosing a profession. The main goal of the contribution was to assess the development of the Czech public's opinions on the prestige of selected types of occupations, with special attention to the occupation of a private farmer, through statistical analysis. Prestige, in this sense, shows the degree of esteem, power, and influence that an individual receives and that is demonstrated to him by others in connection with the performance of a given profession. Long-term research on the prestige of a profession shows that in the ranking of a selected profession's prestige, the first position has been occupied by doctors: mostly with a gap of more than ten points ahead of the following professions (scientists, nurses, teachers). This group is followed in 6th to 10th place by professions, including a private farmer whose prestige has slightly increased in recent years. Overall, the prestige ranking of professions shows little variability over time. The profession's financial evaluation and power status are important; however, they are only partial criteria for the order and the prestige people attribute to individual professions. Characteristics such as social usefulness, demandingness and responsibility of a certain profession play a significant role in the evaluation of the prestige of a profession. Employment in agriculture has been declining for a long time as qualification requirements in the industry are increasing, generational change in agriculture is not going well, and the workforce in agriculture will continue to age, mainly because of the demographic development in the Czech Republic. The outflow of workers and the ageing of the workforce is and will be a significant problem for Czech agriculture. It is necessary to increase the attractiveness and prestige of professions in agriculture, especially among Generation Z.

Key words: occupational prestige, farmer, age structure, employment, wage, Czech agriculture, public opinion survey, trend, time series

JEL classification: C14, C22, Q10

1. Introduction

Czech society has undergone a transformation of its social structure, especially after the revolutionary year of 1989. These changes also influenced the development of individual professions, which was also reflected in the perception of their prestige.

Thanks to the excess offer of vacancies over demand, people - participants in the labour market can choose a profession that is not only better valued but also more respected in society. Economist and sociologist Thorstein Bunde Veblen was probably the first to formulate and define the concept of occupational prestige in the book *The Theory of the Leisure Class* in 1898. Veblen's theory is the interconnectedness of prestige with heroism (Veblen, 1999) because, according to his words: "Occupations that can be attributed to heroism are valued, respectable, noble-minded; other activities which do not

contain an element of heroism, and especially those which are servile or subservient, are menial, degrading and vulgar”.

Occupational prestige is the social status allocated to individuals based on their occupations (Hughes et al., 2022; Fujishiro et al., 2010). In turn, social status – alternatively called prestige (Cheng et al., 2013) or sociometric status (Son et al., 2023; Anderson et al., 2012) – is the respect, admiration, and voluntary deference accorded to others based on their perceived instrumental social value (Anderson et al., 2015), an interpersonal judgment about the ability of others to help advance one’s own goals (Leary et al., 2014). Previous work about occupational prestige has also operationalised it as a function of status (Hughes et al., 2022; Nam and Boyd, 2004; Hauser and Warren, 1997; Nakao and Treas, 1994) or status-adjacent constructs like desirability (Goldthorpe and Hope, 1972) or power (Treiman, 1976).

To provide conceptual clarity and connect occupational prestige to the broader status literature, we define it in these terms: the respect, admiration, and voluntary social deference accorded to an individual based on the perceived instrumental societal value of their occupation.

According to Goyder (2009), the population’s opinions on the profession’s prestige are mainly based on income and education. They are the means to reach the end. For inner satisfaction of needs, self-realisation, recognition or respect, society is not a seeker of education and income but a seeker of social status. Magnusson (2009) tested the impact of gender on occupational prestige. The paper shows on Swedish data that the association between the proportion of females in an occupation and occupational prestige is non-linear. Mixed occupations (41-60% of females) have the highest prestige. Based on German data, Krueger et al. (2022) state that occupations that are predominantly male or female tend to be rated as more prestigious than mixed-gender occupations when controlling for pay and educational requirements, suggesting a segregation premium in the symbolic valuation of work in Germany. In addition, there is no evidence of a gendered in-group bias in Germany; both men and women consider gender-segregated occupations to be more prestigious, with no preference for occupations dominated by their own gender. Tuček and Machonín (1993) divide occupational prestige into two interrelated social functions. Firstly, it is a “relatively stable structure of spiritual or moral compensations”, i.e., a certain measure of social status. Secondly, it is a manifestation of the “subjective dimension of the objectively existing vertical social differentiation of jobs and professions,” i.e., it is part of social superiority and inferiority relations. Further to the issue, Petrussek (1996) adds that complete consensus in assessing the prestige of persons and professions is not possible; the judgment of prestige depends strongly on the social position of the person making the judgment. Nevertheless, the relative consensus in judging prestige is surprisingly high in modern societies.

The prestige of the profession as such is one of the pillars of social stratification, which also includes material security and power (Jennings et al., 2022). Prestige itself is associated with respect and influence in society (Šanderová, 2022), and the social prestige of occupation is linked to political ideologies, based on the Swiss evidence (Abrassart and Wolter, 2023). The perception of the prestige of an occupation by companies is a complex social phenomenon in which a whole range of personal and social characteristics are reflected (Machonín and Tuček, 1993).

In the territory of Czechoslovakia, the first post-revolutionary empirical research on occupational prestige was carried out in 1990. The main goal of the research was to monitor changes in the attitudes of Czech society and, in particular, the dynamism of society in post-communist Czechoslovakia. In the initial research, up to 70 professions were assessed. In addition to the assessment of the prestige of the profession, research also analysed the income differentiation of selected professions (Červenka, 2018; Tuček and Machonín, 1993). The development tendency or stability in the thinking and opinions of society about the prestige of the profession can be observed even now. The Public Opinion Research Centre (PORC), formerly the Institute for Public Opinion Research (IPOR) under the Czech Statistical Office, continuously deals with research on the prestige of the profession. PORC is a research department of the Institute of Sociology of the Academy of Sciences of the Czech Republic. It repeatedly conducts this type of survey on a representative sample of the population of the Czech Republic over the age of 15 in the form of quota selection, and 26 selected occupations are evaluated.

As Havlová (1996) states, the research on occupational prestige can be considered an important part of the investigation of a social structure itself. It also functions roughly as a measure of social status. The analysis of occupational prestige and its results are used in debates about the social structure of society. This means revaluation, or the undervaluation of certain professions and the related consequences in the economy and society. Abroad, studies are being prepared with the aim of confirming or refuting the influence of a race on the level of wages or salary, where the prestige of the profession is one of the key factors of the research (Hughes et al., 2022; Grodsky and Pager, 2001).

As Kapr (1967) points out, occupational prestige rankings can be partly distorted, as some observations are influenced by the respondents' personality characteristics. It means that sometimes they can evaluate professions biasedly and give rather personal likes and dislikes to individual professions. Another personality influence that has some impact on the location of a certain occupation is the lust, aspiration, or desire of the interviewee for such an occupation (Grodsky and Pager, 2001). Knowledge and awareness of a specific profession also have a certain influence on the placement in the final ranking. Socially more well-known professions tend to be placed closer to the beginning or end of the final prestige scale.

The weakened position of the agricultural sector as an economic driver and provider of employment has been the subject of much debate. Marsden (1995) specifically stresses the redefined role of agriculture both in social and economic life in rural areas. The transition from productivism into post-productivism (Wilson, 2001) is considered to be one of the key factors of this. The transition resulted in a weakening of the ties between farmers and other rural dwellers, accompanied by globalisation and technological change that led to a decline in the demand for agricultural labour (Čapkovičová and Hlavsa, 2015; Spěšná et al., 2009). Labour and skills shortages are a major concern in the agro-food sector across OECD countries (Ryan, 2023). This challenge is compounded by the relatively small, and declining, contribution of agriculture to GDP, and the negative public perception of the sector with relatively low wages and limited career prospects.

This paper aims to assess the data from public opinion polls on prestige rankings of selected occupations, where the special focus is put on farmers. As a partial aim we analyzed

development tendencies of agricultural wages and employment, which are one of the aspects related to the farmer’s prestige.

2. Materials and Methods

The prestige of the profession in the Czech Republic can be assessed based on long-term public opinion surveys. Data from the Czech Social Science Data Archive of the Institute of Sociology of the Academy of Sciences of the Czech Republic were used in the paper to analyse the prestige of the profession. Specifically, data matrices from surveys carried out in the years 2004-2019, falling under the research investigation bearing the designation Our Company, were used.

Approximately 1,000 people representing the population of the Czech Republic over the age of 15 were interviewed (see Table 1 for the exact sample frequency). Respondents in these surveys assigned 1 to 99 points to the presented occupations. The data collection method was a standardised interview. Data collection was carried out by trained interviewers of the PORC interview network. The selection of respondents was always intended to maintain representativeness, implemented as a quota. The interviewees’ quota characteristics were gender, age, and education. Territorial representativeness of the sets was observed by the construction of the interview network itself, where the controlled characteristics were the size of the place of residence and regions (NUTS 3). The parameters of the sample sets thus correspond to the structure of the population of the Czech Republic broken down by socio-demographic characteristics (gender, education, age) and territory.

Table 1. Characteristics of respondents from analysed surveys in the years 2004 - 2019

Demographic characteristics	Options	Share of respondents [%]			Demographic characteristics	Options	Share of respondents [%]		
		2004	2011	2019			2004	2011	2019
gender	men	47.8	47.9	48.4	education	primary	23.3	21.4	13.3
	women	52.2	52.1	51.6		secondary without leaving examination	38.2	38.3	33.8
age	15 – 29 years	28.0	25.8	18.0	secondary with leaving examination	27.8	26.9	33.7	
	30 – 44 years	23.2	25.5	27.5	higher education	10.7	13.4	19.3	
	45 – 59 years	26.6	25.9	23.8					
	60 + years	22.2	22.8	30.7					

Source: own processing; data - Public Opinion Research Centre, Institute of Sociology, Czech Academy of Sciences, ‘Our Society’ 2004; 2011; 2019 respondents over the age of 15; face-to-face interviews

The main goal of the statistical analysis of data matrices from public opinion polls was the evaluation of the positions of selected occupations in the imaginary prestige ranking. Changes over time were assessed, and the analysis was mainly focused on the prestige of “a private farmer”. The partial goal of the statistical analysis was to test the evidence of differences in the perception of the prestige of selected professions between age and educational groups of the Czech population. The non-parametric Kruskal-Wallis test and the Nemenyi’s method were used to test the established hypotheses. The significance level was set to 0.05.

The Cluster analysis was used to determine whether the prestige assessment of individual professions is based on a more general structuring of professions (e.g., physical, mental work, decision-making powers, degree of responsibility). Several methods are used in cluster

analysis to calculate distance, similarity (or dissimilarity). The most used measure of similarity of statistical units is the Euclidean distance (Řezanková et al., 2009):

$$d_1(X_i, X_j) = \sqrt{\sum_{k=1}^p (x_{ik} - x_{jk})^2} \quad (1)$$

Where: x_{ik} – the value of the k -th character of the statistical unit X_i ; x_{jk} – the value of k -th character of the statistical unit X_j ; p – the number of characters of a multidimensional variable ($k = 1, 2, \dots, p$).

Hierarchical clustering was chosen based on the hierarchical arrangement of objects and their clusters. In the paper, a merging metric called full connection was chosen, where the distance between two clusters is determined as the distance between the two most distant objects from the two clusters (the so-called farthest neighbour principle). From the point of view of the problem being solved, the advantage of complete connection was the tendency to divide cases into clusters maximally.

The long-term tendencies of selected aspects of the agrarian labour market of the Czech Republic were described and modelled using statistical methods from the field of time series analysis: average gross monthly wages in the agriculture, forestry and fishing sectors; employment in agriculture, which are based on CZSO data.

Exponential smoothing procedures with an adaptive approach to the trend component were chosen. The smoothed value is a case of a moving average, where all observed values of the smoothed series are weighted into the past with exponentially declining weights. The time series evaluated by us can be considered linear in short sections, and therefore Brown's double exponential smoothing with one discount constant was used (Cipra, 2008; Chatfield et al., 2001). Considering the ex-ante forecast, the model's quality was evaluated using the Mean Absolute method Percentage Error (MAPE).

TIBCO Statistica 14.0.0.15 software for Windows and SAS Studio was used for statistical analysis. The significance level was set to 0.05.

3. Results and Discussion

In particular, the disinterest of young people in working in agriculture is often associated with a decline in the prestige of agriculture. As empirical research from 1994 (Horská and Spěšná 1996) showed, 73% of farmers then declared a decline in the prestige of agriculture compared to 1989 (and 61% considered the role of farmers to be socially undervalued). The prestige itself is the result of many aspects - both objective and subjective. The objective ones include the already stated low level of remuneration and the decrease in the share of farmers – both in the total workforce in the national economy and rural population. The change of lifestyle in the countryside of the Czech Republic and the “de-agriculturalisation” of the character of the village can be included among the subjective ones. Here, however, each case must be assessed individually; it undoubtedly depends on how well the farmers manage to combine their activities with the social life of the village. The fact that they are often successful is also proven by the fact that in public surveys (Škodová, 2007), the profession of a private farmer ranks among the ten most prestigious professions.

According to POR surveys between 2004 and 2019, the profession of a private farmer rose from 10th place to 8th in the ranking of 26 selected professions (see Table 2).

Table 2. Results of the prestige evaluation of selected occupations in the Czech Republic in the years 2004, 2011 and 2019

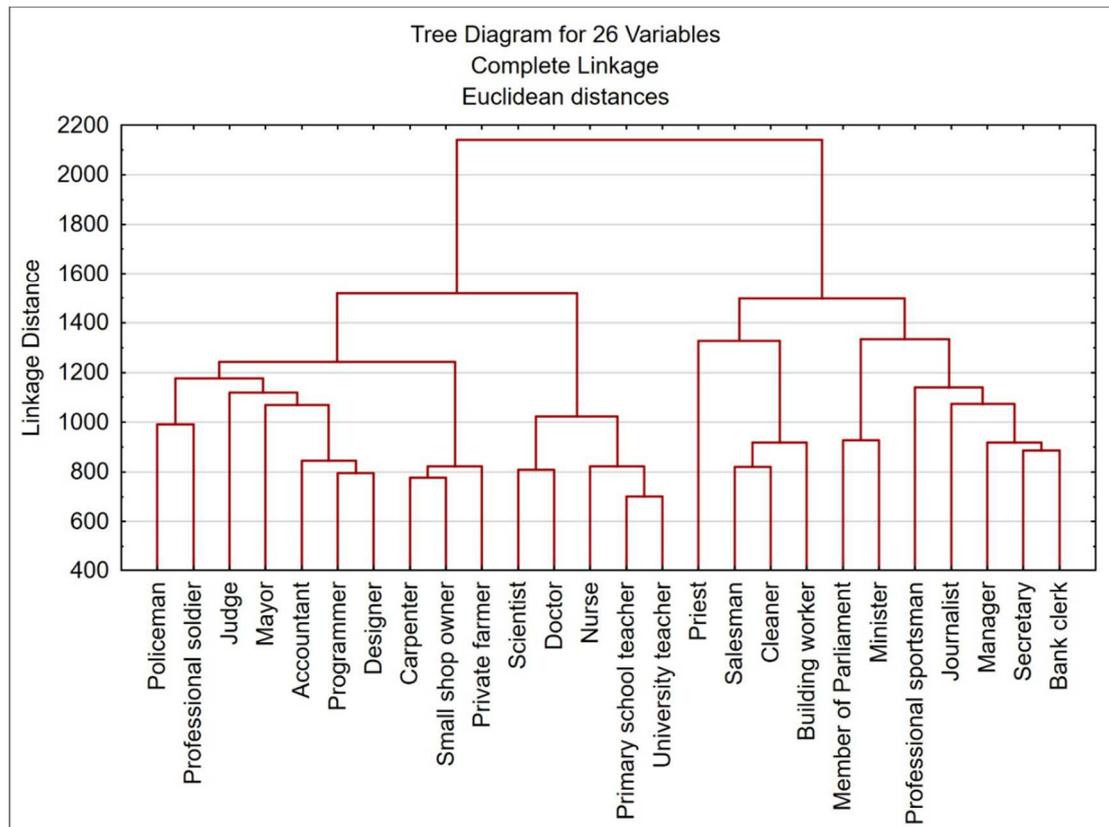
Year (Number of respondents)	2004* (n = 1027)		2011 (n = 1006)		2019 (n = 1024)		Change of serial numbers (2019-2004)
	mean	serial number	mean	serial number	mean	serial number	
Doctor	89.5	1.	89.1	1.	88.6	1.	0
Scientist	80.7	2.	75.4	2.	77.3	2.	0
Nurse			73.9.	3.	77.0	3.	-
University teacher	78.5	3.	72.4	4.	72.2	4.	+1
Primary school teacher	71.3	4.	70.3	5.	70.1	5.	+1
Judge	64.8	6.	61.0	7.	67.5	6.	0
Designer	64.1	7.	61.7	6.	61.4	7.	0
Private farmer	59.1	10.	60.3	9.	61.1	8.	-2
Policeman	47.6	20.	53.9	11.	60.8	9.	-11
Programmer	66.3	5.	60.8	8.	60.3	10.	+5
Professional soldier	44.8	22.	48.3	17.	56.4	11.	-11
Joiner	50.8	16.	53.2	12.	55.9	12.	-4
Mayor	60.1	8.	52.6	14.	53.9	13.	+5
Small shop owner	51.2	15.	51.4	15.	52.7	14.	-1
Accountant	53.5	14.	54.1	10.	51.8	15.	1
Professional sportsman	56.1	11.	51.2	16.	50.6	16.	+5
Manager	59.4	9.	53.0	13.	50.5	17.	+8
Building worker			48.1	18.	47.4	18.	-
Bank clerk	50.2	18.	46.9	19.	45.5	19.	+1
Minister	53.8	13.	38.0	24.	43.9	20.	+7
Salesman	42.8	24.	43.6	21.	45.5	21.	-3
Journalist	54.4	12.	46.5	20.	40.3	22.	+10
Secretary	43.7	23.	41.4	23.	38.8	23.	0
Priest	46.1	21.	42.8	22.	36.7	24.	+3
Cleaner	29.4	26.	34.0	25.	34.5	25.	-1
Member of Parliament	39.9	25.	27.0	26.	31.0	26.	+1

Source: own processing; data - Public Opinion Research Centre, Institute of Sociology, Czech Academy of Sciences, 'Our Society' 2004; 2011; 2019 respondents over the age of 15; face-to-face interviews
**In 2004 and 2007, the professions of electrical repairmen and lathe operators figured in the research.*
The examined list of professions has been repeated in this form since 2011 when nurses and construction workers were added.

The long-term research on the prestige of the profession shows that in the ranking of the prestige of the selected professions, the first position has been occupied by the profession of a doctor for a long time (average rating = 89 points out of 100; median = 98), mostly with more than ten points from the following professions (scientist, nurse, teacher). This group is followed in 6th to 10th place by professions with ratings between 60 and 70 points, among which is also a private farmer (average rating = 61, median = 65

points), whose prestige has seen a slight increase in recent years. Overall, the prestige ranking of professions shows little variability over time; see Table 1.

Figure 12. The result of a cluster analysis of the prestige evaluation of selected professions in 2019 in the Czech Republic



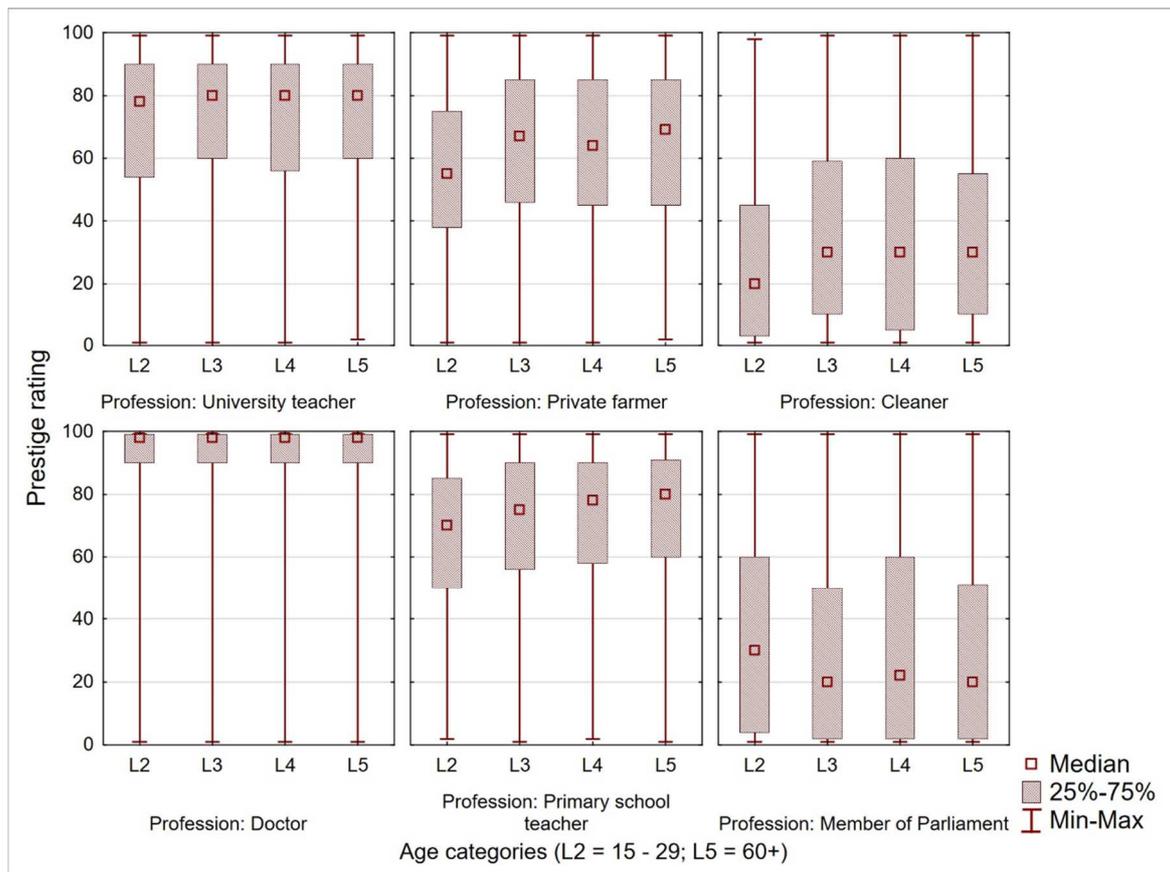
Source: own processing; data - Public Opinion Research Centre, Institute of Sociology, Czech Academy of Sciences, 'Our Society' 2019 respondents over the age of 15; face-to-face interviews

The result of the cluster analysis shows a clear, logical structuring of the “space of professions”, where the essential elements are the nature of work (physical work vs other), then the division of the political sphere, the exclusive importance of professions in education and healthcare, the separation of security forces and the exclusivity of the profession of priests. In the first phase of clustering, the profession of a private farmer is thus assigned to professions with a predominantly manual and routine nature of the work performed. As a more detailed analysis of older data showed (Červenka, 2018), this assessment correlates with the age and political orientation of the interviewees. At the same time, the evaluation of the prestige of professions with a manual and routine character is mostly significantly worse among young people and respondents in the right part of the political spectrum.

As Havlová (1996) points out, the age of the respondents or the type of profession they have can influence the assessment of the profession’s prestige. Therefore, for selected professions from the beginning (doctor, university teacher, elementary school teacher, private farmer) and the end (cleaner, member of parliament) of the imaginary occupational prestige ladder, the influence of age on the prestige evaluation of the selected occupations was tested. With 95% confidence, the effect of age on the evaluation of prestige was proven ($p = 0.0469$). A statistically significant difference was shown in the evaluation of the youngest

(15-29 years) and the oldest age categories (60+) (see Figure 2). The results of the performed statistical analyses show that the youngest generation perceives the ranking of professions similarly. However, they save more points for the highest-ranked professions (the drop in points for primary school teachers is also significant and confirms the often-mentioned position of teachers among the younger generation). Among young people, blue-collar professions have reached the lowest places in the ranking (resulting in the lack of interest in apprenticeship).

Figure 2. Evaluation of the prestige of selected professions in 2019 in the Czech Republic according to age categories (L2 = 15 – 29 years; L3 = 30 – 44 years; L4 = 45 – 59 years; L5 = 60+)



Source: own processing; data - Public Opinion Research Centre, Institute of Sociology, Czech Academy of Sciences, 'Our Society' 2019 respondents over the age of 15; face-to-face interviews

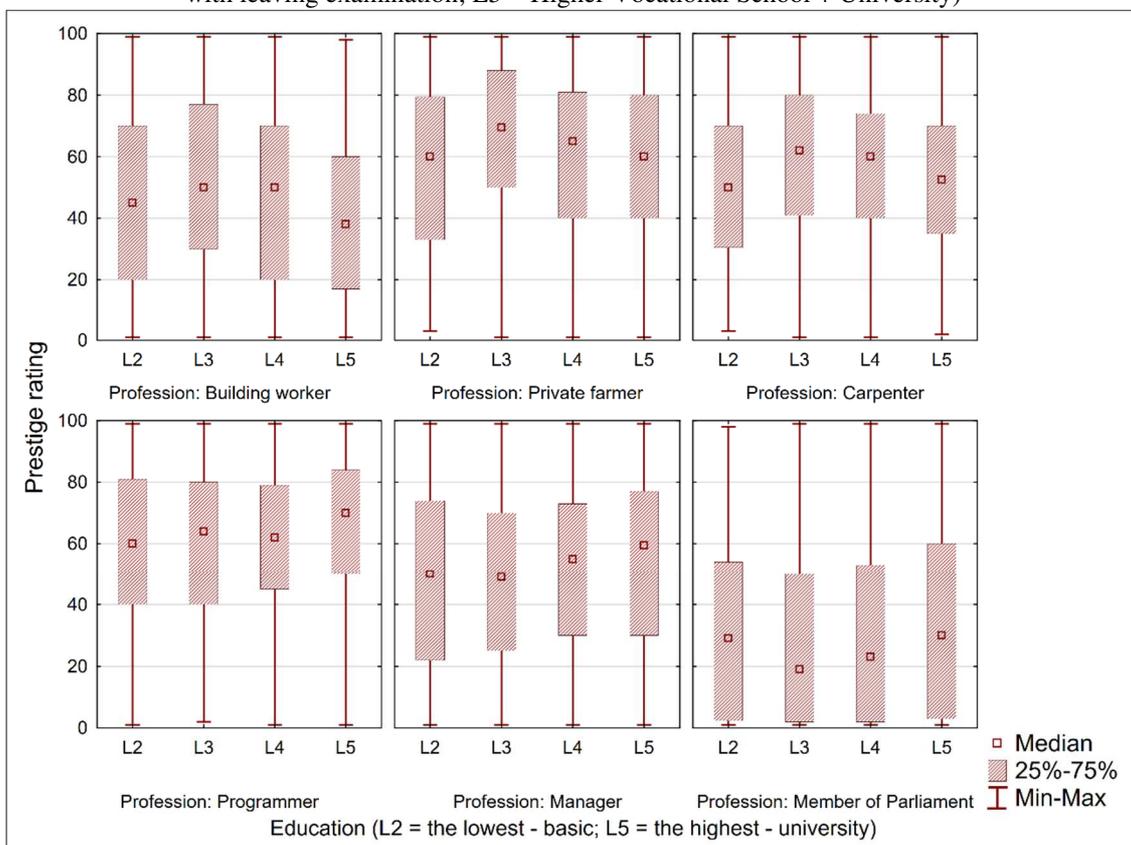
Although the prestige of the profession of a private farmer has increased slightly in recent years (see Table 1), the scale of prestige varies by generation (the results are in accordance with Červenka, 2018). For the youngest generation (15-29 years), it is statistically significantly lower ($p = 0.0013$) compared to older age categories (see Figure 2).

A more detailed analysis then demonstrated the expected connection between the social status of the interviewee and the point evaluation of certain professions ($p = 0.0042$). As expected, respondents with an apprenticeship rate the prestige of blue-collar professions significantly higher than university students (see Figure 3). These results are only partially consistent with the study by Hughes et al. (2022), which states that across occupations, correlations between occupational prestige ratings, educational attainment, and income were high (0.73 to 0.78), indicating convergent validity – as expected for indicators of the same

psychological construct. Occupations with higher prestige, in general, require more education and pay higher wages than occupations with lower prestige.

In the profession of a private farmer, a statistically significant difference in the evaluation of prestige was proven between the respondents' levels of education ($p = 0.0068$). The occupation of a private farmer is rated the highest by respondents with an apprenticeship and respondents with secondary education without a high school leaving examination (average 64.6 points and overall 7th place in the order of 26 occupations). In the case of professions that require a university education, the difference between the given groups is not so striking - statistically significant - scientists, designers or managers are evaluated almost equally. However, programmers and journalists are perceived differently.

Figure 3. Evaluation of the prestige of selected professions in 2019 in the Czech Republic according to respondents' education (L2 = primary; L3 = secondary without leaving examination + trained; L4 = secondary with leaving examination; L5 = Higher Vocational School + University)



Source: own processing; data - Public Opinion Research Centre, Institute of Sociology, Czech Academy of Sciences, 'Our Society' 2019 respondents over the age of 15; face-to-face interviews

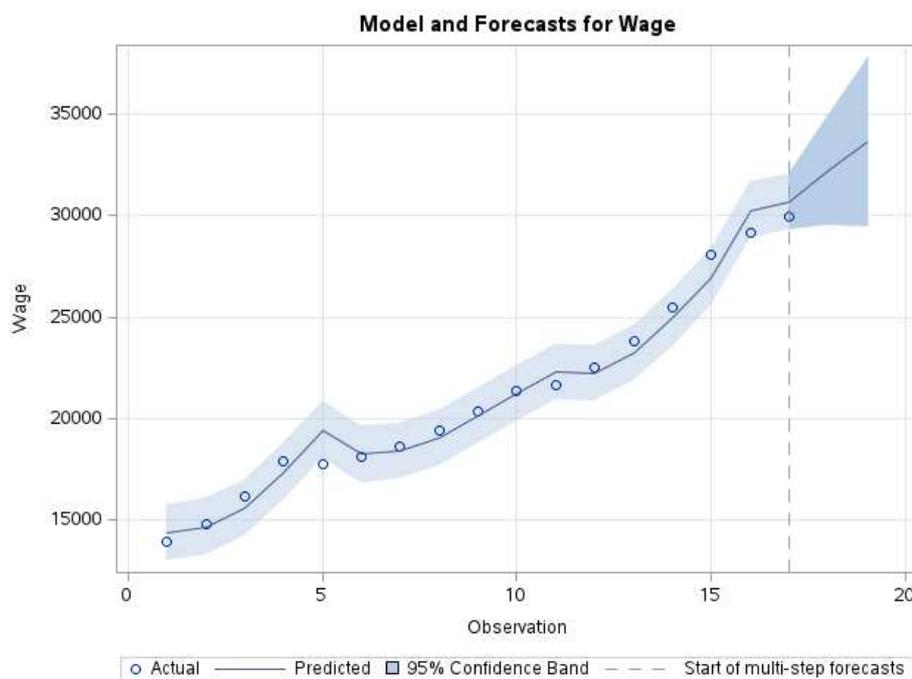
On the basis of the results of the investigation and the analyses carried out, it can be stated that the perception of the prestige of the profession represents a relatively complex, internally differentiated social phenomenon in which the influences of age, gender, education, life attitudes and the value scale are reflected in different parts and on a different scale. Moreover, as Červenka (2018) adds, the influences of fashion trends and even political orientation and opinions on current social developments are also reflected in it.

The objective characteristics of the agricultural profession (especially low wages, low education and qualifications, unfavourable working conditions and characteristics of the work performed, and limited participation in decision-making and management), which can

simultaneously be understood as positions on the axes of vertical differentiation of society, are one of the basic dimensions of the socio-economic status (Jennings et al., 2022; Petrusek, 1990; Machonin and Tuček, 1964). They are reflected in the prestige (Červenka, 2018; Tuček and Machonin 1993, 1994) of the agricultural profession in society and, as such, cannot contribute to increasing interest in working in the sector. From a study by Hughes et al. (2022), it follows that more prestigious occupations tend to involve abstract reasoning and complex cognitive tasks, and less prestigious occupations tend to involve demanding physical work.

The wage level in agriculture is a barrier to the entry of young and specially qualified people into the sector. The significant wage disparity in relation to industry and the national economy has long been and is generally known as the cause of the lack of interest in working in agriculture. Similar long-term tendencies are confirmed by Ryan (2023), Bílková (2015) or Spěšná et al. (2009). The development of wages in agriculture shows similar development tendencies as the development of wages in the national economy, with the difference that wages in agriculture are about 20 - 25% lower in the long term. Similar long-term tendencies are confirmed by Ryan (2023), Bílková (2015) or Spěšná et al. (2009). The development of agricultural wages in the years 2005 - 2021 was analysed through Brown's double smoothing with the smoothing constant 0.82 and the MAPE value = 2.63 %. Based on the results, it can be stated that if the historical development is maintained, wage growth can be expected soon, but even so, the predicted value for the years 2022 - 2023 is around 31 - 33 thousand CZK (in the national economy it is around 40 thousand CZK, see CZSO, 2023a). Even soon, wages in agriculture cannot be expected to approach wages in the national economy significantly.

Figure 4. Development of gross wages in agriculture in 2005-2021 with an estimate for 2022 - 2023



Source: own analysis based on the data of the CSO (Czech Statistical Office)

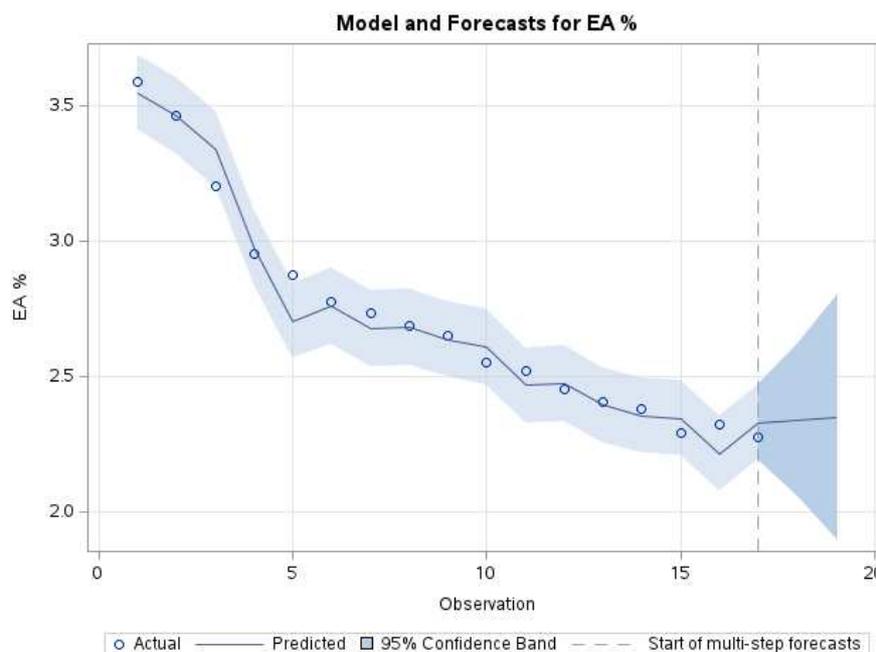
It can be stated that university-educated (especially young) farmers are affected by low wages in the sector (incl. deep wage disparities of managers compared to comparable jobs

in the industry) as the most significant barrier when deciding whether to enter or stay in the industry.

The lack of young, highly qualified workers in the department is not caused by the insufficient capacity of agricultural colleges (universities) or the lack of interest of young people in studying at them. In addition to physical, time-consuming and socially underappreciated work, the reason for the industry's unattractiveness for graduates is also the level of remuneration, which confirms Bílková (2015). In empirical research, only low share of graduates declares an interest in working in agricultural production (Spěšná, 2009; Trhlíková et al., 2017).

The employment rate shows a long-term downward trend; in the last period, it ranged between 2.3 - 2.5 %. The development of the years 2005 – 2021 was modelled by Brown's double exponential smoothing with a smoothing constant of 0.89 and a MAPE value of 1.82 %. The development of employment can be expected at a similar level in the near term, which corresponds to an estimate of 95-98 thousand workers. As far as the structure is concerned, roughly three-quarters are represented by employees; the rest are entrepreneurs, including family members (CSO, 2023b). This structure has also not changed significantly in recent periods and can be expected in the near soon as well. Many factors will influence the further development of employment in the agricultural sector. It will not only be about the implemented agricultural policy and the setting of supports but, in general, the overall situation on the labour market and the market of agricultural commodities. The still unfavourable age structure of agricultural workers could be helped by an influx of younger qualified workers. Note that the proportion of workers over the age of 50 years is increasing (CSO, 2023c). Attracting young, qualified workers to the sector and growing the prestige of agriculture in the eyes of the public is currently associated primarily with the development of modern technologies, the introduction of automation and robotisation and the related development of precision agriculture.

Figure 5. Development of the employment rate in agriculture in 2005-2021 with the estimate for 2022-23



Source: own analysis based on the data of the CSO

4. Conclusion

The financial evaluation of the profession and the power status associated with the performance of a function or position in the management hierarchy are important; however, they are only partial criteria for the order and the prestige people attribute to individual professions. These findings are consistent with a study by Hughes et al. (2022). The evidence shows that the benefits of having a high-prestige occupation may be different from having a high income or an extensive educational background. Characteristics such as social usefulness, demandingness and responsibility of a certain profession play a significant role in the evaluation of the prestige of a profession.

People are implicitly basing prestige judgments on beliefs about the incremental or replacement value of the workers in various occupations, not the absolute value of the work itself. At the top of the prestige scale, there are occupations where it is very difficult for workers to be replaced because of lengthy and specialised training. At the bottom of the scale, there are occupations that are often labelled as “unskilled” or “low-skill” positions. These labels have come under justifiable criticism (Cepla and Dempster, 2021), but they probably reflect common beliefs that such jobs could be done by almost anyone. As a result, even if an occupation involves work that is valuable to society and if people think that any given worker does not offer much added value over anyone else, the job may not be considered prestigious.

Although the prestige of the profession of a private farmer has increased slightly in recent years, the scale of prestige varies by generation. It is statistically significantly lower for the youngest generation (15 - 24 years) compared to older age categories. A more positive perception of this profession by the younger generation could be a promise for the future, a promise of a greater willingness to work in agriculture. The application of factor analysis, like the study by Červenka (2018) targeting the youngest age group, could then help reveal other important factors influencing the prestige of work in agriculture and the willingness of young people to enter this sector. The interest in working in agriculture is weakened in society by the action of a greater number of agents. Above all, the number of agricultural families in which children could naturally acquire a relationship with agriculture at an early age has decreased significantly.

Similarly, the contact with agriculture among children coming from cities to the countryside, among students helping individually or as a part of school events with the harvest of agricultural crops, was also limited. Any interest in animal husbandry or plant cultivation can be realised more conveniently than by integrating into agricultural activities. The influence of family traditions on the careers of qualified agricultural workers also weakened considerably (Spěšná et al., 2008).

An important specific feature of agriculture is also reflected in the agrarian labour market – dependence on agricultural land. Its area cannot practically be expanded; on the contrary, it is constantly decreasing. Thus the upper limit of the total areal framework of agriculture in the state, and therefore of agricultural employment, is given. However, this is strongly influenced by both the structure of agricultural land and the structure of crops on arable land and the extent of livestock farming (areas of intensive crops and livestock numbers are decreasing in the Czech Republic).

Employment in agriculture has been declining for a long time. The level of education in the sector is rising slightly. Due to automation and technological development in the sector,

the qualification requirements for agricultural professions are increasing, which is also shown in Ryan (2023). It can be assumed that this trend will continue in the future, and the share of skilled labour in agriculture will continue to grow. The general trend of increasing the educational level of the Czech population will also contribute to this.

Generational change in agriculture is not going well. The workforce in agriculture is ageing and will continue to age, mainly because of the demographic development in the Czech Republic. In addition to physical, time-consuming and socially underappreciated work, the reason is also the amount of remuneration. Most workers in agriculture are remunerated for their work in the form of wages, which have long been below the average wage in the Czech Republic. As pointed out by Hughes et al. (2022), if a job is poorly paid and unpleasant, that may compound the impression that the workers who hold the job do not have the skills or training to pursue better options.

The outflow of workers and an ageing workforce are significant problems and challenges for Czech agriculture. Experts describe the lack of young people in agriculture as critical. It is necessary to increase its attractiveness and prestige, especially among generations Z and younger.

References

- Abrassart, A. and Wolter, S. C. (2023). “Rejection education as the basis of the social prestige of occupations: the role of polarised ideologies and parties in Switzerland”, *ACTA POLITICA*, vol. 58, pp. 1–35, eISSN 1741-1416, DOI 10.1057/s41269-021-00230-7
- Anderson, C., Hildreth, J. A. D. and Howland, L. (2015). “Is the desire for status a fundamental human motive? A review of the empirical literature”, *Psychological Bulletin*, vol. 141, no. 3, pp. 574–601, ISSN 0033-2909, DOI 10.1037/a0038781
- Anderson, C., Kraus, M. W., Galinsky, A. D. and Keltner, D. (2012). “The local-ladder effect: Social status and subjective well-being”, *Psychological Science*, vol. 23, pp. 764–771, ISSN 0956-7976, DOI 10.1177/0956797611434537
- Bílková, D. (2015). “Wages in Czech Agricultural, Industrial and Construction Sectors”, *Proceedings of the Agrarian perspectives XXIV*, Prague, pp. 55-63, ISBN ISSN 2464-4781
- Cepla, Z. and Dempster, H. (2021). “There’s No Such Thing as a “Low”-Skill Worker”, *Center for Global Development - Ideas to Action*, [online], Available: <https://www.cgdev.org/blog/theres-no-such-thing-low-skill-worker>, [Accessed: 20 April 2023]
- Cipra, T. (2008). “*Finanční ekonometrie*”, Praha, Ekopress, ISBN 978-80-86929-43-9
- Čapkovičová, A. and Hlavsa, T. (2015). “Approaching the service-based economy: regionally differentiated employment growth in Czechia”, *Studies in Agricultural Economics*, vol. 117, no. 1, pp. 10-19, ISSN 1418-2106, DOI 10.7896/j.1507
- Červenka, J. (2018). “Prestiž vlastního povolání v hlavním zaměstnání v ČR”, *Časopis výzkumu a aplikací v profesionální bezpečnosti* [online], vol. 11, Available: <https://www.bozpinfo.cz/josra/prestiz-vlastniho-povolani-v-hlavnim-zamestnani-v-cr>, [Accessed: 9 April 2023] (In Czech)

- CzSO, Czech Statistical Office (2023a). "Časové řady základní ukazatelů statistiky práce". [Online], Available: <https://www.czso.cz/csu/czso/casove-rady-zakladnich-ukazatelustatistiky-prace-leden-2023>, [Accessed: 11 April 2023] (In Czech)
- CzSO, Czech Statistical Office (2023b). "Zaměstnanost, nezaměstnanost – časové řady", [Online], Available: https://www.czso.cz/csu/czso/zam_cr, [Accessed: 8 April 2023] (In Czech)
- CzSO, Czech Statistical Office (2023c) "Struktura mezd zaměstnanců". [Online], Available: <https://www.czso.cz/csu/czso/struktura-mezd-zamestnancu-2021>, [Accessed: 3 April 2023] (In Czech)
- Fujishiro, K., Xu, J. and Gong, F. (2010). "What does "occupation" represent as an indicator of socioeconomic status? Exploring occupational prestige and health", *Social Science & Medicine*, 71(12), 2100–2107, DOI 10.1016/2010.09.026
- Goldthorpe, J. H. and Hope, K. (1972). "Occupational grading and occupational prestige", *Social Science Information*, vol. 11, no. 5, pp. 17-73, ISSN 0539-0184
- Goyder, J. (2009). "Prestige Squeeze: Occupational Prestige in Canada Since 1965" [online]. *McGill-Queen's University Press*, [Accessed: 2023-12-04], ISBN 9780773576681
- Grodsky, E. and Pager, D. (2001). "The Structure of Disadvantage: Individual and Occupational Determinants of the Black-White Wage Gap", *American Sociological Review*, vol. 66, no. 4, ISSN 00031224, DOI 10.2307/3088922
- Hauser, R. M. and Warren, J. R. (1997). "Socioeconomic indexes for occupations: A review, update, and critique", *Sociological methodology*, vol. 27, no.1, pp. 177-298, ISSN 0081-1750
- Havlová, J. (1996). "*Profesní dráha ve 20. století: úvod do sociologie povolání*", Prague, Karolinum, ISBN 80-7184-220-6 (In Czech)
- Horská, H. and Spěšná, D. (1996). "Signály změn sociálního postavení zemědělců", Prague, Research Institute of Agriculture Economics, research study No. 30, ISBN 80-85898-33-0. (In Czech)
- Hughes, B. T., Srivastava, S., Leszko, M. and Condon, M. D. (2022). "Occupational Prestige: The Status Component of Socioeconomic Status", *PsyArXiv*, September 28, DOI 10.31234/osf.io/6qgxv
- Chatfield, C., Koehler, A.B., Ord, J.K. and Snyder, R.D. (2001). "A New Look at Models For Exponential Smoothing", *Journal of the Royal Statistical Society: Series D (The Statistician)*, vol. 50, pp. 147-159, DOI 10.1111/1467-9884.00267
- Cheng, J. T., Tracy, J. L., Foulsham, T., Kingstone, A. and Henrich, J. (2013). "Two ways to the top: Evidence that dominance and prestige are distinct yet viable avenues to social rank and influence", *Journal of Personality and Social Psychology*, vol. 104, no. 1, pp. 103–125, ISSN 0022-3514, DOI 10.1037/a0030398
- Jennings, J., Strenio, J. and Buder, I. (2022). "Occupational prestige: American stratification", *Review of Evolutionary Political Economy*, no. 3, pp. 575–598, DOI 10.1007/s43253-022-00075-6
- Kapr, J. (1967). "Prestiž povolání", *Sociologický časopis*, vol. 3, no. 6, pp. 740-748, ISSN 0038-0288 (In Czech)

- Krueger, S., Ebner, C. and Rohrbach-Schmidt, D. (2022). “Gender Composition and the Symbolic Value of Occupations: New Evidence of a U-shaped Relationship between Gender and Occupational Prestige Based on German Microdata”, *Work, Employment and Society*, eISSN 1469-8722, DOI 10.1177/09500170221117415
- Leary, M. R., Jongman-Sereno, K. P. and Diebels, K. J. (2014). “*The psychology of social status*”, New York, Springer, ISBN 978-1-4939-0867-7
- Machonin, P. and Tuček, M. (1994). “Geneze nové sociální struktury v České republice a její sociální aktéři”, *Sociologický časopis*, vol. 30, no. 3, pp. 285-305, ISSN 0038- 0288
- Magnusson, C. (2009). “Gender, Occupational Prestige, and Wages: A Test of Devaluation Theory”, *European Sociological Review* 25, no. 1, 87-101, DOI 10.1093/esr/jcn035
- Marsden, T. (1995). “Beyond Agriculture? Regulating the New Rural Spaces”, *Journal of Rural Studies* 11, 285-296, DOI 10.1016/0743-0167(95)00027-K
- Nakao, K. and Treas, J. (1994). “Updating Occupational Prestige and Socioeconomic Scores: How the New Measures Measure up”, *Sociological Methodology*, vol. 24, pp. 1–72, ISSN 0081-1750, DOI 10.2307/270978
- Nam, C. B. and Boyd, M. (2004). “Occupational Status in 2000; Over a Century of Census-Based Measurement”, *Population Research and Policy Review*, vol. 23, no. 4, pp. 327–358, DOI 10.1023/B:POPU.0000040045.51228.34
- Petrusek, M. (1990). “Sociální stratifikace československé společnosti”, *Sociologický časopis*, vol. 26, no. 3, pp. 146-168. ISSN 0038-0288
- Petrusek, M. (1996). “*Velký sociologický slovník*”. Praha, Karolinum, ISBN 80-7184-310-5
- Ryan, M. (2023). “*Labour and Skills Shortages in the Agro-Food Sector*”, OECD Publishing, DOI 10.1787/18156797
- Řezanková, H., Húsek, D. and Snášel, V. (2009). “*Shluková analýza dat*”, Praha, Professional Publishing, ISBN 978-80-86946-26-9
- Sociologický ústav (Akademie věd ČR). Centrum pro výzkum veřejného mínění. Naše společnost 2004 - listopad [datový soubor] [online]. Ver. 1.0. Praha: Český sociálněvědní datový archiv, 2005 [Accessed: 18.4.2023], DOI 10.14473/V0411 (In Czech)
- Sociologický ústav (Akademie věd ČR). Centrum pro výzkum veřejného mínění. Naše společnost 2011 - červen [datový soubor] [online]. Ver. 1.0. Praha: Český sociálněvědní datový archiv, 2011 [Accessed: 18.4.2023], DOI 10.14473/V1106 (In Czech)
- Sociologický ústav (Akademie věd ČR). Centrum pro výzkum veřejného mínění. Naše společnost 2019 - červen [datový soubor] [online]. Ver. 1.0. Praha: Český sociálněvědní datový archiv, 2019 [Accessed: 18.4.2023], DOI 10.14473/V1906 (In Czech)
- Son, S., Yang, T. and Park, J. (2023). “How organizational politics and subjective social status moderate job insecurity–silence relationships”, *Journal of Management & Organization*, vol. 29, no. 2, pp. 266-286, ISSN 1833-3672, DOI 10.1017/jmo.2022.54
- Spěšná, D., Drhlík, J. and Pospěch, P. (2008). “Agrární zaměstnanost v kontextu venkova ČR”, *Ekonomika pol'nohospodárstva*, vol. 8, no. 2, pp. 57-64, ISSN 1335- 6186 (In Czech)

- Spěšná, D., et al. (2009). “Aging of the agricultural workforce in relation to the agricultural labour market”, *Agricultural Economics – Czech*, vol. 55, no. 9, pp. 424-435, ISSN 1418-2106, DOI 10.17221/20/2009-AGRICECON
- Šanderová, J. (2022). “*Sociální stratifikace*”, Prague: Charles University, Karolinum, ISBN 978-80-246-5191-0 (In Czech)
- Škodová, M. (2007). Prestiž povolání. Praha, CVVM SOÚ AV, [online], Available: http://www.cvvm.cas.cz/upl/zpravy/100704s_eu70628.pdf dne 2009-06-26, [Accessed: 11 April 2023] (In Czech)
- Treiman, D. J. (1976). “A Standard Occupational Prestige Scale for Use with Historical Data”, *The Journal of Interdisciplinary History*, vol. 7, no. 2, pp. 283–304, ISSN: 0022-1953 E-ISSN: 1530-9169, DOI 10.2307/202737
- Trhlíková, J., et al. (2017). “Absolventi středních škol a trh práce. Odvětví: Zemědělství”, Národní ústav pro vzdělávání, [Online], Available: <https://www.infoabsolvent.cz/Temata/PublikaceAbsolventi?Stranka=9-0-120&NazevSeo=Absolventi-strednich-skol-a-trh-prace-odvetvi->, [Accessed: 24 April 2023] (In Czech)
- Tuček, M. and Machonín, P. (1993). “Prestiž povolání v České republice v roce 1992”, *Sociologický časopis*, vol. 29, no. 3, pp. 367-382, ISSN 0038-0288 (In Czech)
- Veblen, T. (1999). “*Teorie zahálčivé třídy*”, Praha, Sociologické nakladatelství, ISBN 8085850710 (In Czech)
- Wilson, G. A. (2001). “From productivism to post-productivism ... and back again? Exploring the (un)changed natural and mental landscapes of European agriculture”, *Sociologia Ruralis* 26, 77-102, DOI 10.1111/1475-5661.00007

ANALYSIS OF RETAIL PRICES OF THE CZECH FOOD MARKET

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Annotation: The aim of the article is to determine the main extremes in the price level of the examined food basket, in purchasing power, in the average rate of price growth, in price volatility, for the observed period 2011 - 2022 at the level of individual food chains in the Czech Republic. The aim is also to identify, at the level of specific foods, the main extremes in the average rate of price growth and in the price volatility of the examined foods. Furthermore, the goal is to characterize the issue of the average growth rate of food prices at the transnational level (EU27, Hungary, the Czech Republic and countries neighboring the CR). The subjects of research are the following food items: apples, bananas, bread, butter, carrots, edam, eggs, chicken, milk, onions, oranges, potatoes, rice, sugar, watermelon. The collected food prices were compared with aggregated data sets collected by the Czech Statistical Office and Eurostat. The basic methods of statistical and comparative analysis at the level of primary and secondary data were used for the analysis of individual data. The highest average price level of food was shown by Lidl (CZK 45.88), the cheapest was Kaufland (CZK 39.98). Food prices rose the fastest in Tesco (average year-on-year growth rate of 11.16%), the slowest in Lidl (7.84%). Food prices fluctuated the most in Kaufland (standard deviation CZK 9.87), the most stable prices were in Albert (CZK 8.11). The price of watermelon rose the fastest (average year-on-year growth rate of 27.62% in Billa), sugar the slowest (Kaufland -0.61%). Milk showed the most stable prices (standard deviation CZK 2.89), edam cheese 45% had the highest price volatility (CZK 36.99). Food prices rose the fastest in Hungary (6.28%), the slowest in Austria (2.92%).

Key words: Czech Republic, Development, European Union, Food prices, Purchasing power, Retail chains.

JEL classification: F60, J30, Q10

1. Introduction

International grocery chains buy food in different parts of the world and sell it through their stores around the world. These chains usually have a large influence on the food market and can influence both the production and consumption of food. Among the largest international grocery chains also operating in the Czech Republic are, for example, Tesco, Lidl or Ahold Delhaize. These companies have a large number of stores around the world and offer a wide range of food products, including fresh food, canned food, dried food, beverages and other products. Food chains often put pressure on their suppliers to lower prices and increase production efficiency. This can affect the conditions under which food is produced and can lead to lower wages for workers in the agricultural sector and worse conditions for animals. On the other hand, international grocery chains can also bring benefits to consumers, such as lower prices and a wider choice of food products (Chocholac, 2017).

Food prices are influenced by many factors: supply and demand, climate conditions, energy prices, political instability, international trade, currency exchange rates, and last but not least, education and human capital (Hamilton et al., 2020).

Food supply depends on food production, availability of raw materials, technology and policy measures (Jarzebowski, 2017). Food demand is influenced by factors such as population,

lifestyle changes, consumer preferences, and income levels (Lu et al., 2016). Adverse climatic conditions such as drought, floods or storms can affect crop yields and reduce the supply of food on the market, leading to higher prices (Devereux, 2007). Oil and other energy prices affect the cost of food production and transportation, which can lead to an increase in food prices (Alghalith, 2010). Wars, riots, and political conflicts can affect food production and distribution, which can lead to higher prices (Shemyakina, 2022). World food trade and price competition can also significantly affect food prices (Bekkers et al., 2017). Exchange rate fluctuations can affect food prices, especially if food is imported or exported (Akanni, 2020). So, overall, it can be said that food prices are influenced by many factors that interact with each other and can have different effects on food prices in different parts of the world.

The aim of the article is to determine the main extremes in the price level of the examined food basket, in purchasing power, in the average rate of price growth, in price volatility, for the observed period 2011 - 2022 at the level of individual food chains in the Czech Republic. The aim is also to identify, at the level of specific foods, the main extremes in the average rate of price growth and in the price volatility of the examined foods. Furthermore, the goal is to characterize the issue of the average growth rate of food prices at the transnational level (EU27, Hungary, the Czech Republic and countries neighboring the Czech Republic).

2. Materials and Methods

The basis for food price analysis is a unique data collection process. Data on food prices in individual retail chains selling in the Czech Republic were collected over the past twelve years, from 2011 to 2022. Monitored super/hyper markets: Albert (retail chain: Ahold), Billa (Rewe Group), Kaufland (Schwarz Gruppe), Lidl (Schwarz Gruppe), Penny Market (Rewe Group) and Tesco (Tesco). More details can be seen in Summary Table 1:

Table 1. Overview of monitored food items (1kg) and super/hyper markets

Super/Hyper Market	Retail Chain	Monitored Food Item (1kg)
Albert	Ahold	apples golden delicious (unpackaged), bananas, bread Šumava (1,200gr), butter the cheapest (250gr), carrots (unpackaged / packaged), edam 30% (box), edam 45% (box), eggs (10 pcs) chicken (standard), long grain rice, milk the cheapest (1 liter), onions (unpackaged / packaged), oranges, potatoes (unpackaged), sugar (crystals), watermelons
Billa	Rewe Group	
Kaufland	Schwarz Gruppe	
Lidl	Schwarz Gruppe	
Penny Market	Rewe Group	
Tesco	Tesco	

Source: Own processing, 2023

The subject of the research can be read from Table 1 - it is food (1 kg): apples, bananas, bread (1,200 g), butter (250 g), carrots, edam 30%, edam 45%, eggs (10 pcs), chicken, milk (1 liter), onions, oranges, potatoes, rice, sugar, watermelon.

Individual data collections were processed at one point in time (i.e. during one day) in all investigated super/hyper markets. Individual data collection was realized at three-month intervals from 2011 to the present.

The collected food prices were compared with aggregated data sets collected by the Czech Statistical Office and Eurostat. The development of food prices is also influenced by the purchasing power in the Czech Republic - the authors were inspired by the concept of Malakhov (2021): In a simplified way, this modified purchasing power methodology can be described as the calculation of the volume (in tons) of the monitored food, which the consumer is able to buy for the average wage (in CZK) in the reference period (i.e. the monitored year). For individual data analyses, basic methods of statistical and comparative analysis at the level of primary and secondary data were used: average indicators (food prices, HICP, wages), average growth rate (in %) of food prices, standard deviation to detect volatility (or we can also say fluctuations within the entire observed period) in food prices (in CZK), purchasing power (the authors determined the amount of food (in kilograms) that could be purchased in the monitored year for the average wage of the reference period).

3. Results and Discussion

For the observed period 2011 – 2022, the average price of food in Lidl showed an unrivaled highest price level at the level of CZK 45.88. The second highest average food prices were in Billa, at the level of CZK 43.91. The price levels in the Albert (CZK 41.73) and Penny (CZK 41.58) chains can also be mentioned later. The lowest average food price level could be observed in Tesco (CZK 40.67) and Kaufland (even only CZK 39.98).

The price level of the monitored foods in the individual chains is also reflected in the volume of food that the consumer is able to buy for his average salary in the monitored year. During the monitored period 2011 – 2022, the average salary could buy the most in Tesco, exactly 1,402.34 kg. The volume of food purchased for an average salary in Kaufland (1,399.08 kg) and Albert (1,329.48 kg) is also close to this volume of food. With a smaller distance, we can also mention the volume of food purchased for an average salary in Penny, which would amount to 1,288.47 kg in the monitored period. The smallest volume of food would be recorded in the chain Lidl (1,198.27 kg) and Billa (1,192.80 kg). An interesting fact can be noticed - the order of food chains sorted by consumer purchasing power does not logically correspond to the order of chains from the previous paragraph, where markets were ordered by price level. Since the authors here worked within the observed period 2011 – 2022 with average values (average prices, average wages), the mentioned illogical order may be caused by the different growth rate of average wages on the one hand (on average 4.74% y/y) and the different growth rate and by the price volatility of the average wages of the monitored chains on the other hand. This was confirmed by Peersman (2022), who deals with similar issues at the level of euro area countries.

The average wage in the Czech Republic for the period 2011 - 2022 can be seen in Table 2:

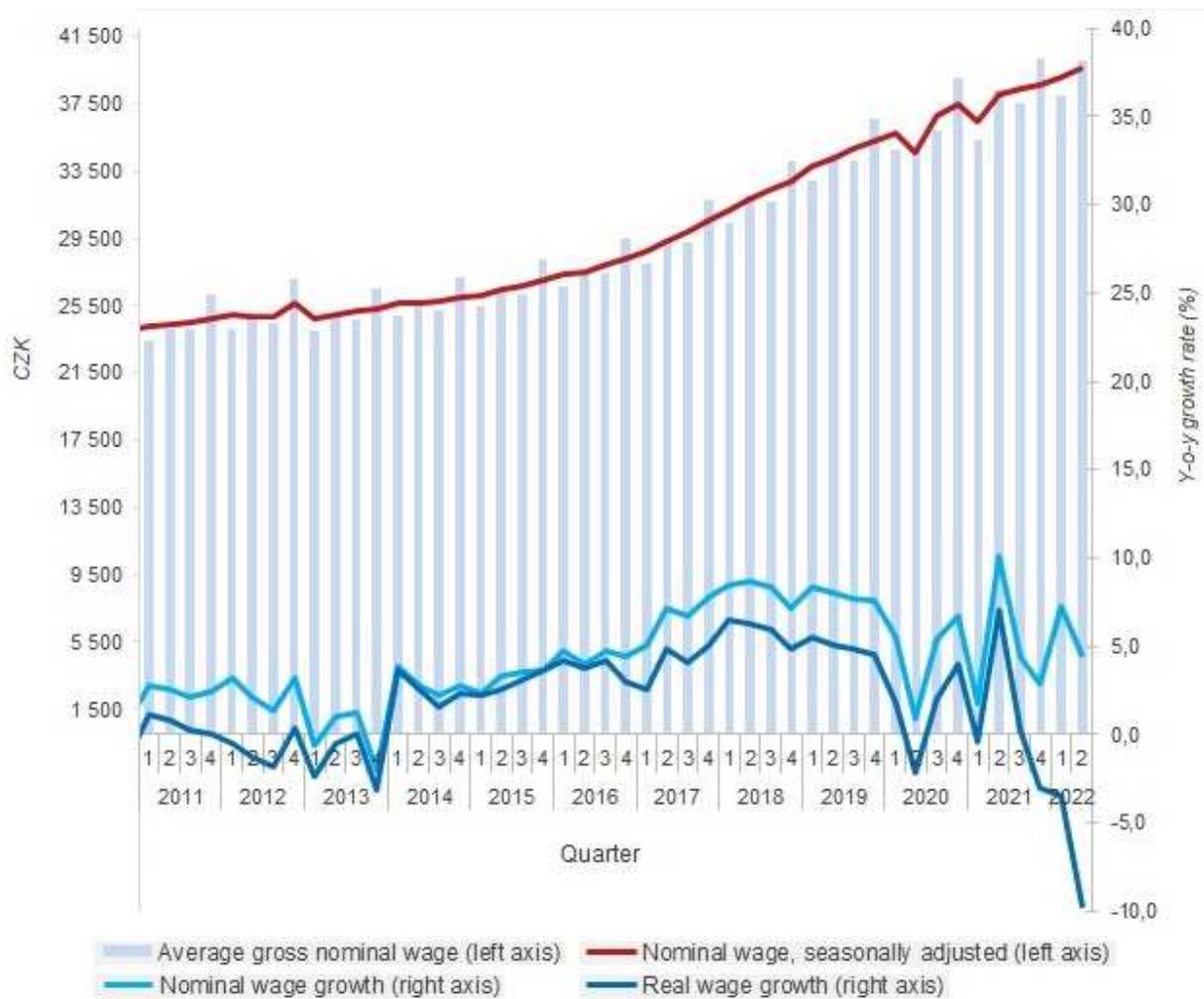
Table 2. Average wage in the Czech Republic (CZK)

year	2011	2012	2013	2014	2015	2016
average wage	24 319	25 109	25 128	25 686	26 467	27 589
year	2017	2018	2019	2020	2021	2022
average wage	29 504	31 885	34 125	35 611	37 839	40 353

Source: CZSO, 2023

Figure 1 shows the development of the average monthly wage in absolute and year-on-year terms for the monitored period 2011 - 2022. Since 2014, there has been permanent growth in both nominal and real wages, while since the peak of the growth rate in 2018 (nominally 8.1%, 5.9% in real terms (CZSO, 2023)) there was a permanent decrease in the average growth of both nominal and real wages with large fluctuations. The growth of the average real wage even reached negative values from 2020. It is possible to say that this phenomenon was caused by the coronavirus pandemic in 2020, the subsequent increase in the price of basic energy (electricity and gas) and the war in Ukraine starting in February 2022. All this contributed to an increase in inflation in the Czech economy (Zubikova, Smolak, 2022).

Figure 1. Average monthly wage – quarterly data (absolute numbers, y/y changes)



Source: CZSO, 2023; own adjustments, 2023

If we focus on the issue of the year-on-year growth rate of food prices in individual chains for the monitored period 2011-2022, then it is possible to see that the highest growth rate was recorded in Tesco. On average, food prices here reached a growth rate of 11.16%, which was significantly more than for the other monitored chains. With a relatively large distance, Kaufland showed the second highest growth rate of food prices (9.26%), followed by: Billa (8.35%), Albert (8.32%) and Penny (8.10%). The lowest average growth rate of food prices was recorded at Lidl (7.84%). The above results do not result in anything very favorable for the Czech consumer. Given that markets with a lower price level of the monitored foods showed a much higher average rate of growth of the prices of these items, it can basically be said that within the Czech food market, individual retail chains were constantly matching each other in the prices. Thus, the prices in markets were constantly rising sharply, fueling already one of the highest inflations in Europe, and the purchasing consumer ultimately paid for everything (Aliu et al., 2023).

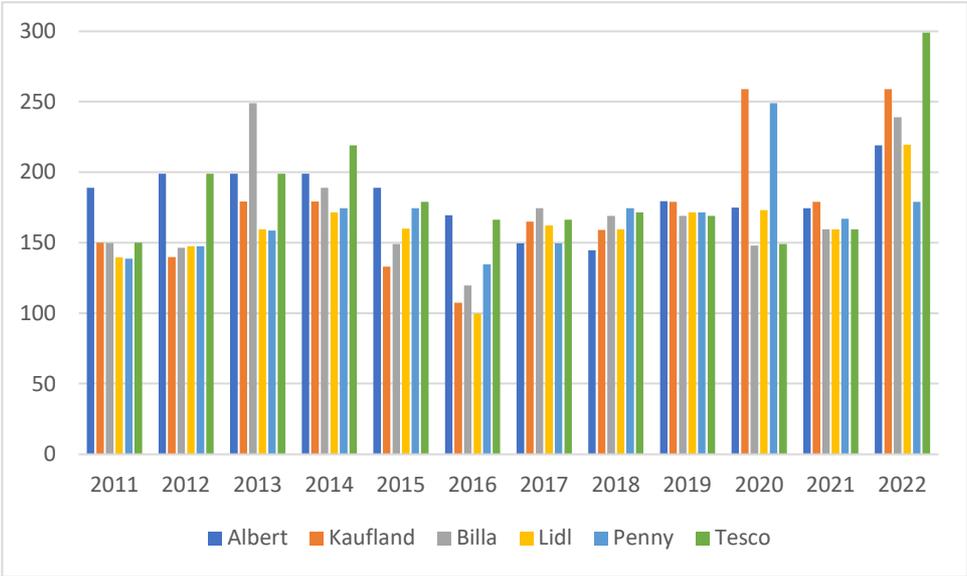
With regard to the indicator of price volatility of monitored food items for the period 2011 - 2022, it can be found that the highest standard deviation of prices was in Kaufland, at the level of CZK 9.87. The next highest price volatility was recorded at Lidl (CZK 9.21), Billa (CZK 9.16) and Tesco (CZK 9.07). With a relatively greater distance, we can mention the volatility of the prices of the monitored foods at Penny (CZK 8.39) and Albert (CZK 8.11). The last two mentioned chains therefore show a relatively stable price policy compared to other markets, which can attract a more conservative consumer to the establishments, who does not have such a strong need to take advantage of the discount promotions that are so popular in the Czech Republic (Kucerova, Zeman, 2018).

During a more detailed examination of the prices of the monitored foods for individual food chains, it is possible to observe which specific foods showed a higher average rate of price growth for the monitored period 2011 – 2022 and which, on the contrary, showed a lower rate of price growth. For example, at Tesco, which on average showed the highest year-on-year growth in food prices, it can be found that the average price of golden delicious apples grew the fastest (29.77%). On the contrary, the lowest average year-on-year price growth in Tesco was recorded by rice (4.66%). The second highest average growth rate of food prices was reported by Kaufland, and specifically the highest growth rate was the price of watermelon (22.61%). Conversely, the lowest year-on-year growth rate was for sugar (-0.61%). In Billa, the average price of watermelon also recorded the highest growth rate (27.62%), while the price of bananas recorded the lowest (-0.07%). In Albert, the highest average growth rate was recorded for the price of potatoes (13.51%) and free carrots (13.50%). On the contrary, the lowest growth rate in Albert was for edam cheese 45% (1.98%). In Penny, the price of watermelon also showed the highest rate of growth (17.35%), while milk, on the other hand, showed the lowest rate (2.36%). Lidl reported the lowest average growth rate of the monitored food basket during the monitored period, and of this basket, the highest growth was recorded for the price of butter (14.81%), on the contrary, the lowest for the price of sugar (1.89%).

If we focus on the volatility of average food prices in the monitored chains for the period 2011 - 2022, then we can say that, for example, in Kaufland, which recorded the highest average volatility of food prices in comparison with other chains, the highest standard deviation was for the price of edam 45% (CZK 43.55) and, conversely, the lowest standard

deviation could be observed for the price of packaged onions (CZK 2.53). Figure 2 shows the price development of edam 45% over the observed period in individual food chains:

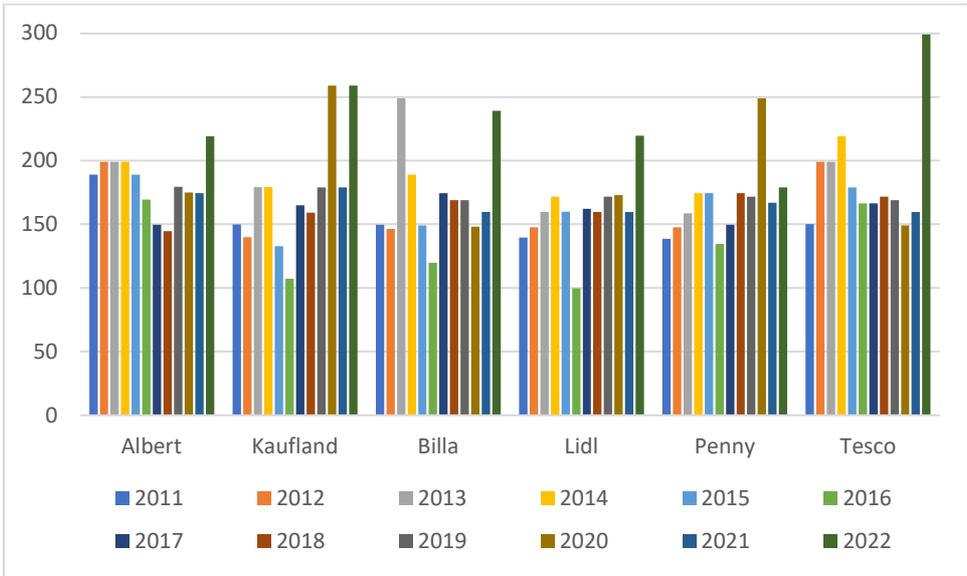
Figure 2. 1kg edam 45% price (CZK)



Source: Own processing, 2023

In Lidl, the highest price volatility was observed for edam 30% (CZK 29.45) and, conversely, the lowest volatility for milk (CZK 2.63). In Billa, edam 45% also showed the highest price volatility (CZK 36.38), bananas showed the lowest volatility (CZK 3.01). Figure 3 shows the price development of edam 45% over the observed period in individual food chains from a different perspective than the previous Figure 2:

Figure 3. 1kg edam 45% price (CZK)

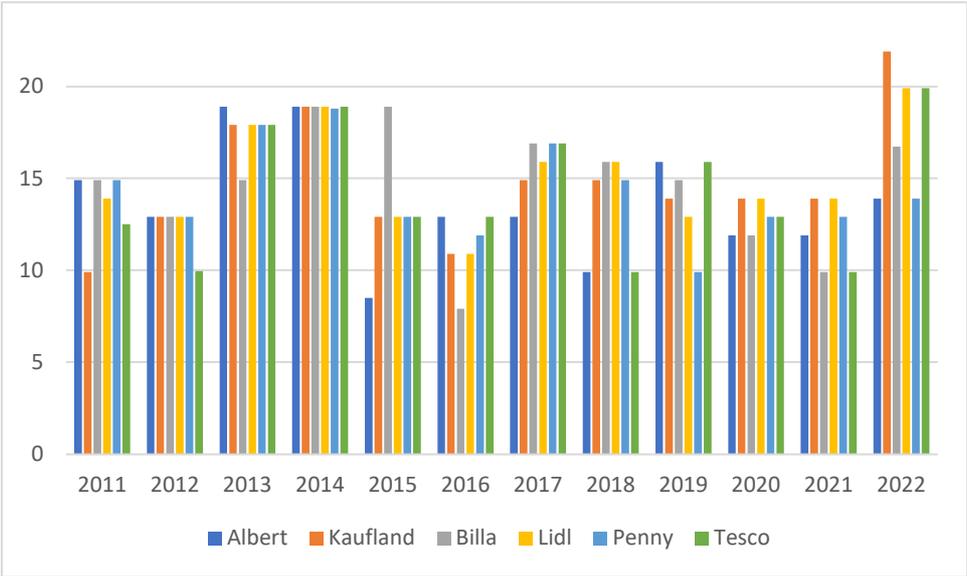


Source: Own processing, 2023

In Tesco, we can also talk about edam 45% (CZK 39.66) in the case of the highest price volatility, while the lowest volatility was for milk (CZK 3.43). In Penny, the highest price

volatility was for edam 45% (CZK 28.37), the lowest for milk (CZK 2.48). Figure 4 shows the price development of milk for the observed period in individual food chains:

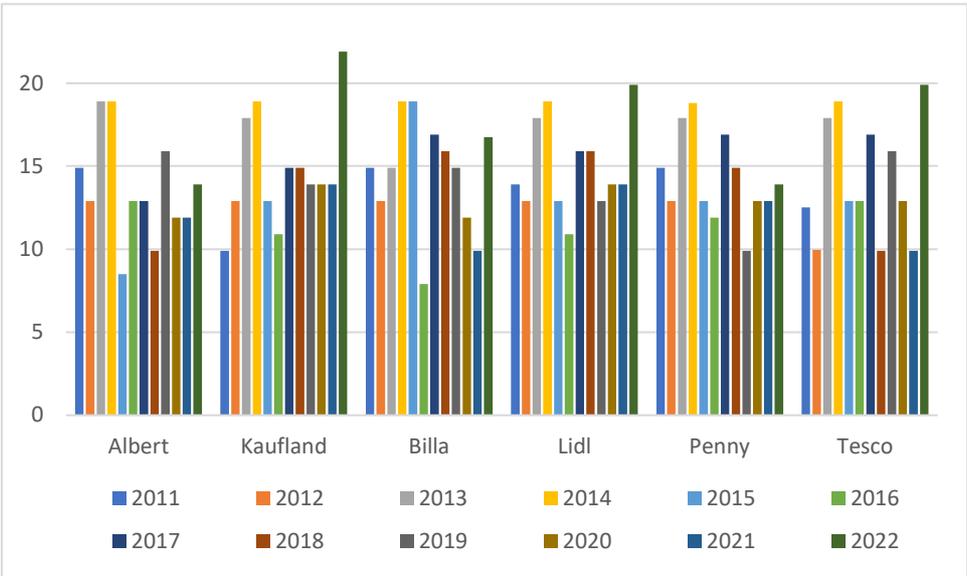
Figure 4. 1liter milk price (CZK)



Source: Own processing, 2023

In Albert, in the case of the highest volatility, we can talk about the average price of edam 30% (CZK 32.08), in the case of the lowest volatility, we can also talk about the price of milk (CZK 3.03). Figure 5 shows the price development of milk over the monitored period in individual food chains from a different perspective than the previous Figure 4:

Figure 5. 1liter milk price (CZK)

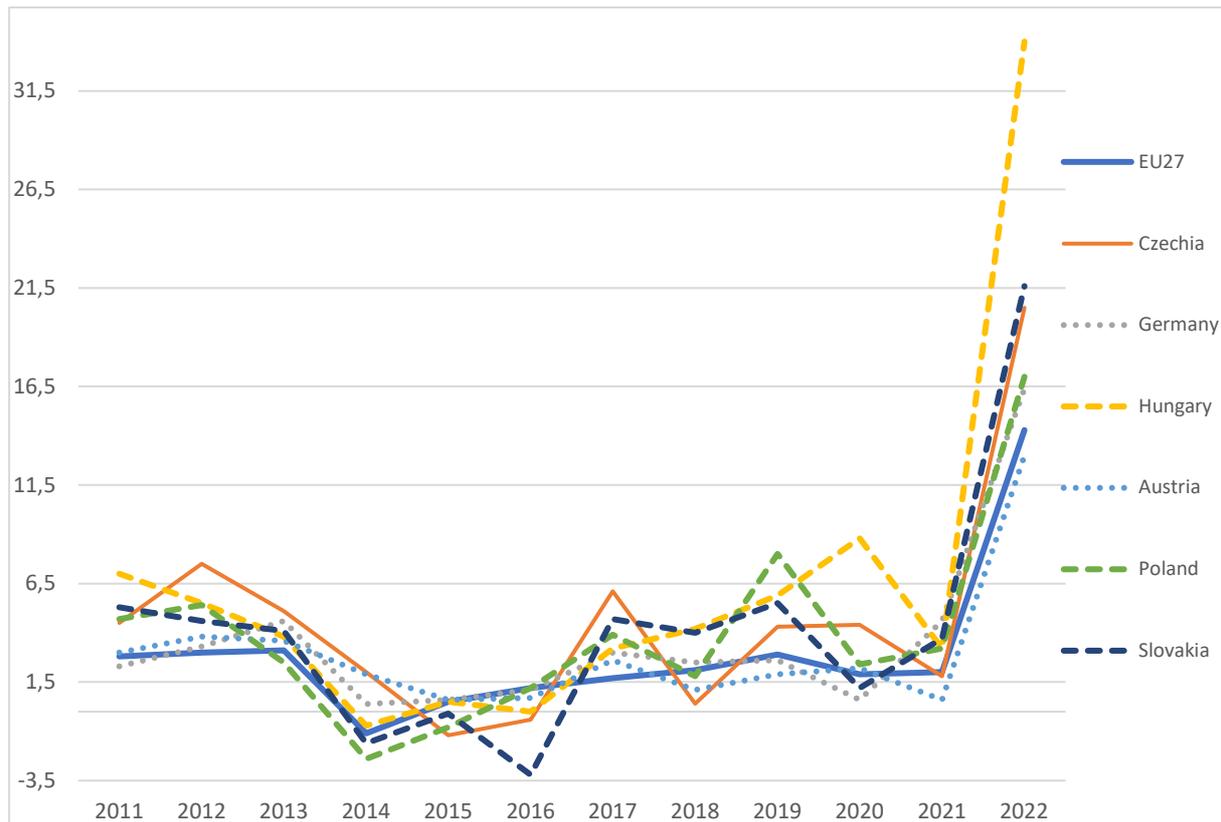


Source: Own processing, 2023

The above analyzes can of course be extended within the international context as well. The authors of the article focused primarily on the average price level of food in the Czech Republic and in countries neighboring the Czech Republic, including Hungary, as a close

neighbor and partner of the Czech Republic (a member of the Visegrad Group). The average food price level of the entire EU27 was also included in the analysis. In the monitored period 2011 – 2022, the average growth rate of food prices in the EU27 was at the level of 2.87%, which was more than half (up by approx. 56.83%) faster growth than it was during the monitored period 2011 – 2021, when the average growth rate of food prices in the EU27 was only 1.83%. The dramatic acceleration in the growth rate of food prices was due to the sharp increase in food prices in the EU27 countries in 2022, as illustrated in Figure 6:

Figure 6. Harmonised index of food consumer prices (%)



Source: EUROSTAT, 2023; own processing, 2023

It can be stated that, on average, the highest annual growth rate of food prices for the observed period 2011 – 2022 could be observed in Hungary (6.28%). The second and third highest growth rates of food prices were in the Czech Republic (4.58%) and Slovakia (4.15%). A relatively low annual growth rate of food prices was recorded in Poland (3.91%) and in Germany (3.50%). The lowest growth rate of food prices could be observed in Austria, at only 2.92%. The average year-on-year rate of price growth was consistently the lowest in Austria and Germany – food price volatility was the lowest of all monitored countries in these two "old EU member states", in such a way that, on average, food price volatility in the other monitored countries was almost double level (Abdelradi, Serra, 2015).

4. Conclusion

In the observed period 2011 – 2022, the highest average price level of food was shown by the Lidl (CZK 45.88) and Billa (CZK 43.91) retail chains, while the cheapest were the Kaufland (CZK 39.98) and Tesco (CZK 40.67) chains. This also corresponds to the point of view of purchasing power, because the consumer bought the most for his

average salary in Tesco (1,402.34 kg) and Kaufland (1,399.08 kg). The consumer bought the smallest average volume of food with his salary in Lidl (1,198.27 kg) and Billa (1,192.80 kg).

On average, food prices rose the fastest in Tesco (year-on-year average rate of price growth at the level of 11.16%), on the other hand, the slowest average year-on-year growth rate of food prices was recorded in Lidl (7.84%). The prices of individual food chains therefore generally increased sharply and practically equaled each other, which is not a favorable phenomenon for the Czech consumer.

Food prices fluctuated the most in Kaufland (standard deviation CZK 9.87), on the other hand, prices of the most stable nature could be observed for food in Albert (CZK 8.11).

With regard to specific food items, it was found that for the monitored period 2011-2022 it is not at all easy to unequivocally identify specific foods that would show similar characteristics across all chains with regard to the average annual rate of price growth. We can mention only watermelon, which rose in price the fastest in the three retail chains (Penny 17.35%, Kaufland 22.61%, Billa 27.62%), and it is also necessary to mention sugar, which on the contrary rose in price the slowest (Lidl 1.9%, Kaufland -0.61%).

As for the fluctuations in the prices of individual monitored foods, the results here are more unambiguous. Milk showed the most stable prices (standard deviation only about CZK 2.89 across all chains), on the other hand, the highest price volatility could be recorded for edam cheese 45% (CZK 36.99).

On a transnational scale, it was found that in the monitored period 2011 – 2022, food prices in the EU27 grew by an average of 2.87% year-on-year, with the EU27 countries recording the most dramatic increase in food prices in the last monitored period of 2022. The fastest growing food prices were in Hungary (average annual rate of food price growth was 6.28%). On the contrary, prices rose the slowest in Austria (2.92%), while in Austria (and in Germany) the price volatility of food was almost half that of the other monitored countries.

References

Abdelradi, F. and Serra, T. (2015). "Food-energy nexus in Europe: Price volatility approach", *Energy Economics*, vol. 48, pp. 157-167, DOI 10.1016/j.eneco.2014.11.022

Akanni, L. O. (2020). "Returns and volatility spillover between food prices and exchange rate in Nigeria", *Journal of Agribusiness in Developing an Emerging Economies*, vol. 10, no. 3, pp. 307-325, DOI 10.1108/JADEE-04-2019-0045

Alghalith, M. (2010). "The interaction between food prices and oil prices", *Energy Economics*, vol. 32, no. 6, pp. 1520-1522, DOI 10.1016/j.eneco.2010.08.012

Aliu, F., Kucera, J. and Haskova, S. (2023). "Agricultural Commodities in the Context of the Russia-Ukraine War: Evidence from Corn, Wheat, Barley, and Sunflower Oil", *Forecasting*, vol. 5, no. 1, pp. 351-373, DOI 10.3390/forecast5010019

Bekkers, E., Brockmeier, M., Francois, J. and Yang, F. (2017). "Local Food Prices and International Price Transmission", *World Development*, vol. 96, pp. 216-230, DOI 10.1016/j.worlddev.2017.03.008

Chocholac, J. (2017). "A comparative analysis of direct marketing strategies used by retail chains in the Pardubice region", *Proceedings of 5th International Conference Innovation Management, Entrepreneurship and Sustainability (IMES)*, Prague, pp. 93-102, ISBN 978-80-245-2216-6

CZSO, Czech Statistical Office, Public Database, Prague, (2023). [Online], Available: <https://vdb.czso.cz/vdbvo2/faces/cs/index.jsf?page=uziv-dotaz#>, [Accessed: 15 Apr. 2023]

Devereux, S. (2007). "The impact of droughts and floods on food security and policy options to alleviate negative effects", *Agricultural Economics*, vol. 37, pp. 47-58, DOI 10.1111/j.1574-0862.2007.00234.x

Eurostat, European Statistical Office, Database, Luxembourg, (2023). [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/PRC_FSC_IDX/default/table, [Accessed: 15 Apr. 2023]

Hamilton, S. F, Liaukonyte, J. and Richards, T. (2020). "Pricing Strategies of Food Retailers", *Annual Review of Resource Economics*, vol. 12, pp. 87-110, DOI 10.1146/annurev-resource-101619-094219

Jarzebowski, S. (2017). "Models and development directions of food supply chains", *Proceedings of International Scientific Conference on Strategies for the Agri-Food Sector and Rural Areas - Dilemmas of Development*, Stary Lichen, Poland, pp. 136-146, ISBN 978-83-7658-690-8

Kucerova, V. and Zeman, J. (2018). "Methodology for planning a successful store flyer campaign based on a case study from a Czech retail market", *Oeconomia Copernicana*, vol. 9, no. 4, pp. 755-779, DOI 10.24136/oc.2018.037

Lu, J., Wu, L., Wang, S. and Xu, L. (2016). "Consumer preference and demand for traceable food attributes", *British Food Journal*, vol. 118, no. 9, pp. 2140-2156, DOI 10.1108/BFJ-12-2015-0461

Malakhov, S. (2021). "Force of Invisible Hand, Labor, and Just Price: Basic Principles of Sorting and Matching Under Wage and Price Dispersion", *Journal of Institutional Studies*, vol. 13, no. 1, pp. 37-59, DOI 10.17835/2076-6297.2021.13.1.037-059

Peersman, G. (2022). "International Food Commodity Prices and Missing (Dis)Inflation in the Euro Area", *Review of Economics and Statistics*, vol. 104, no. 1, pp. 85-100, DOI 10.1162/rest_a_00939

Shemyakina, O. (2022). "War, Conflict, and Food Insecurity", *Annual Review of Resource Economics*, vol. 14, pp. 313-332, DOI 10.1146/annurev-resource-111920-021918

Zubikova, A. and Smolak, P. (2022). "Macroeconomic Impacts of the COVID-19 Pandemic in the Czech Republic in the Period of 2020-2021", *International Journal of Economic Sciences*, vol. 11, no. 1, pp. 117-145, eISSN 1804-9796

DOMAIN-FOCUSED DATA MODELS TO SUPPORT THE OPEN SCIENCE INITIATIVE AND THE FAIR PRINCIPLES

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Annotation: The main objective of this paper is to evaluate available data model tools for sharing scientific data from selected areas of agricultural research and rural development. This contribution evaluates the application of the MIAPPE (Minimum Information About a Plant Phenotyping Experiment) and BrAPI (Breeding API) standards in facilitating FAIR (Findable, Accessible, Interoperable, and Reusable) principles-based data sharing in the field of plant phenotyping. Plant phenotyping plays a crucial role in agricultural research, and effective data management is essential for advancing scientific discoveries. The evaluation assesses the contributions and effectiveness of MIAPPE and BrAPI in enhancing data accessibility, discoverability, interoperability, and collaboration within the plant phenotyping community, aligning with the FAIR data principles. The findings provide valuable insights into the adoption and impact of these standards, enabling researchers to leverage standardized approaches for improved data sharing, integration, and scientific advancements in agriculture.

Key words: Data models, data modeling, metadata, data sharing, Open Science, FAIR principles.

JEL classification: L86 Information and Internet Services, Computer Software; C88 Other Computer Software

1. Introduction

Data sharing has a significant impact on scientific research, particularly in the context of the FAIR principles. By making research data available for reuse, researchers can avoid duplicating efforts, build on existing knowledge, and accelerate scientific progress. Furthermore, data sharing can help to identify errors, biases, and gaps in scientific knowledge, leading to more robust and reliable scientific conclusions.

The FAIR principles emphasize the importance of data sharing by ensuring that research data is easily accessible, interoperable, and reusable. This framework promotes collaboration among researchers, leading to more efficient and effective research efforts. The principles also encourage the use of open access data repositories, allowing researchers to share and access data in a standardized and consistent manner. This helps to address the challenges of data heterogeneity, which can arise when data is stored in disparate formats and locations.

Moreover, data sharing can have broader societal impacts beyond the scientific community. By making research data available to policymakers, healthcare professionals, and the public, scientific knowledge can be translated into practical applications that benefit society.

In conclusion, data sharing has a significant impact on scientific research, particularly in the context of the FAIR principles. By making research data accessible, interoperable, and reusable, data sharing promotes collaboration, transparency, and reproducibility

in scientific research. The broader societal impacts of data sharing highlight its importance in advancing scientific knowledge and improving human health and well-being.

With the advent of new technologies, it is possible to share data via the Internet all over the world easily and at a reasonable cost. The sharing of data in machine-usable formats was started by the Open Data initiative (Stočes et al., 2018) (Maresová et al., 2019), which primarily aimed at publishing public sector data. The current trend is the concept of Open Science. The idea that scientific research should be free for all was popularized by Robert King Merton in the early 1940s. Data produced by research should be freely shared for the common good. (Merton et al., 1942) Open science has the potential to make the scientific process more transparent, inclusive and democratic, and is increasingly recognized as a critical accelerator for achieving the Sustainable Development Goals and a real game-changer in bridging gaps in science, technology and innovation and fulfilling human rights to science (Tzanova et al., 2020) (UNESCO, 2013).

To increase the reusability of scientific data, it is essential that the data is appropriately described by metadata and standardized. The FAIR principles initiative deals with this issue. In 2016, "The FAIR Guiding Principles for scientific data management and stewardship" was published in the journal *Scientific Data* (Wilkinson et al., 2016). The authors intended to provide guidelines for improving the discoverability, accessibility, interoperability, and reuse of digital assets. The principles emphasize machine action (i.e., the ability of computing systems to find, access, interoperate, and reuse data with little or no human intervention) as humans increasingly rely on computational support to work with data due to the increase in volume, complexity, and speed of data creation. This methodological set presents how to publish data, it is based on fifteen principles in four groups: Findability (to be Findable), Availability (to be Accessible), Interoperability (to be Interoperable) and Reusability (to be Reusable). FAIR principles are also reflected by providers of finance for science and research, e.g. Horizon Europe, TAČR and others (Prodan, 2022).

Data are stored and further provided using so-called data repositories. The current trend is to connect national, thematic and other repositories using metadata catalogs so that the data can be traced from one place (Thoegersen et al., 2021). The issue of data sharing and the creation of a repository at the national level or at the level of scientific societies is one of the research and innovation strategies of the European Commission. This strategy is presented under the term European Open Science Cloud (EOSC) (Burgelman et al., 2021).

The advent of innovative procedures and technologies for obtaining data in the field of biology has brought the problem of how to effectively deal with the obtained data. In various scientific fields, communities have begun to emerge that create standards, regulations, and ontologies for handling data. An example can be the MIAPPE community (Papoutsoglou et al., 2020), dealing with the issue of data standards designed to harmonize data from plant phenotyping experiments. Other initiatives address the issue of how to share data effectively. Here we can mention, for example, the project The Breeding API (BrAPI) (Selby et al., 2019), an ontology-driven information system designed for the plant phenomenology PHIS or the open source ISA framework.

ISA's open source framework and tools help manage an increasingly diverse set of biological, environmental, and biomedical experiments that use a single technology or combination of technologies. Built on the "Investigation" (project context), "Study" (research unit)

and "Assay" (analytical measurement) data model and serializations (tabular, JSON and RDF), the ISA framework helps you provide a rich description of experimental metadata (i.e. sample characteristics, measurement technologies and types, relationships between samples and data) so that the resulting data and discoveries are reproducible and reusable. (Sansone et al., 2012)

In Europe, activities dealing with data from the field of living nature are covered by the non-governmental structure ELIXIR (David et al., 2020). ELIXIR brings together biological data resources, these resources include databases, software tools, training materials, cloud storage and supercomputers. The goal of the ELIXIR structure is to coordinate these resources so that they form a single infrastructure. This infrastructure makes it easy for scientists to find and share data, exchange expertise and agree on best practices. Ultimately, this will help them gain new insights into how living organisms work.

The scientific community perceives the need to handle data in such a way that their reuse is possible. The problem is, on the one hand, the theoretical requirements arising from the FAIR principles and, on the other hand, the theoretical models and standards based on industry needs. According to a survey (Godem et al., 2022), 46% of biologists do not know how to organize data so that it can be further used.

The main objective of this paper is to evaluate available data model tools for sharing scientific data from selected areas of agricultural research and rural development.

2. Materials and Methods

In this paper, we focused on analyzing the shortcomings of branch-oriented data models, frameworks, and tools from the field of agricultural research and rural development, such as MIAPPE, BrAPI, and PHIS, with regard to the implementation of FAIR principles. To achieve this, we reviewed relevant literature, consulted with experts in the field, and conducted case studies using specific datasets from the plant production, hydrology, and economics domains.

We also collected requirements for the creation of a data repository and analytical tools that could facilitate working with data in a FAIR manner while mitigating the risk of misuse of shared data, such as intellectual property rights. To obtain these requirements, we conducted surveys and interviews with researchers, data managers, and other stakeholders involved in agricultural research and rural development.

We also performed risk analyses to identify potential risks associated with data sharing, such as the risk of data misuse or unauthorized access, and developed strategies to mitigate these risks.

We would like to note that as the authors, we had access to large and specific data sources obtained using the phenotyping platforms developed by PSI and Phenospex. These platforms are market leaders in working with 2D and 3D data, and their data allowed us to conduct in-depth case studies and analyses in the plant production domain.

These data from the phenotyping units were used for the analyses. The data was entered into a pilot repository based on the specification of the BrAPI standard.

To ensure that the datasets we used in this study and the requirements we collected could be shared in a FAIR manner, we deposited our processed data, along with all of our analysis

code, on a public repository. We also submitted our findings to relevant repositories, databases, and communities of practice, with complete metadata to ensure that the data could be easily found, accessed, and reused by other researchers.

3. Results and Discussion

Sharing Biological Data According to FAIR Principles. The FAIR principles (Findable, Accessible, Interoperable, and Reusable) are a set of guidelines for making data more accessible, reusable, and interoperable. In the context of biological data, adhering to these principles can help to ensure that research outputs are maximally impactful, by allowing other researchers to easily locate and reuse the data generated by a particular study.

To achieve this, there are several important things that are necessary to ensure that biological data can be shared according to FAIR principles. These include:

Standardization of data collection and curation: Data collection and curation should follow standard procedures to ensure that the data is consistent, complete, and well-documented. In the agricultural research domain, initiatives like MIAPPE (Minimum Information About a Plant Phenotyping Experiment) and BrAPI (Breeding API) provide guidelines and tools for standardizing the collection and sharing of phenotyping and breeding data, respectively.

Use of controlled vocabularies and ontologies: The use of controlled vocabularies and ontologies can help to ensure that the data is findable and interoperable, by providing a standardized language for describing biological concepts and entities. For example, the Crop Ontology and the Phenotypic Quality Ontology are two examples of ontologies that can be used to standardize the description of agricultural data.

Use of common data formats and metadata standards: The use of common data formats and metadata standards can help to ensure that the data is accessible and reusable, by allowing other researchers to easily interpret and analyze the data. For example, the ISA-Tab format is a widely-used standard for representing metadata associated with biological data.

Use of open and interoperable data repositories: The use of open and interoperable data repositories can help to ensure that the data is accessible and reusable, by providing a centralized location for storing and sharing data. Repositories like Zenodo, Dryad, and Figshare provide options for sharing data in a FAIR manner, while domain-specific repositories like the Crop Research Informatics and PHIS (Plant Health Information System) provide more specialized options for sharing agricultural data.

Adoption of data access and usage policies: The adoption of data access and usage policies can help to ensure that the data is shared in a responsible and ethical manner, by specifying how the data can be accessed, used, and reused. Policies like the Creative Commons licenses and the General Data Protection Regulation (GDPR) provide options for specifying data usage restrictions and ensuring that the privacy and confidentiality of research participants are respected.

The ongoing evaluation of the pilot repository reveals that some important methods for adhering to FAIR principles in data sharing are currently missing. Preliminary results emphasize the significance of incorporating these methods to ensure compliance with FAIR principles and enhance data sharing practices within the scientific community. These missing

methods include standardized metadata schemas, robust data curation processes, data provenance information, persistent identifiers, and standardized data formats and protocols. Addressing these gaps is crucial for facilitating findability, accessibility, interoperability, and reusability of shared scientific data, fostering collaboration, transparency, and scientific advancements. Future efforts should prioritize the implementation of these missing methods to establish a solid foundation for FAIR data sharing.

4. Conclusion

In this paper, we have discussed the importance of sharing biological data according to FAIR principles, and outlined several important things necessary to ensure that biological data can be shared in a FAIR manner. We have also highlighted the role of initiatives like MIAPPE and BrAPI in standardizing the collection and sharing of agricultural data, and identified several open and interoperable data repositories that can be used for sharing data in a FAIR manner. By adhering to these guidelines, we can ensure that biological data is maximally impactful and contributes to the advancement of science and innovation in the agricultural research domain.

Adoption of MIAPPE and BRAPI, and other FAIR principles, can help ensure that agricultural research data is accessible, interoperable, and reusable. By following these guidelines, researchers can maximize the value of their data and facilitate scientific discovery and innovation. As more and more researchers embrace FAIR data sharing principles, the agricultural research community can expect to see increased collaboration, improved data sharing, and accelerated progress towards addressing important challenges such as food security, crop improvement, and environmental sustainability.

In conclusion, the paper highlights the importance of sharing scientific data and the need for appropriate metadata and standardization to increase data reusability. The FAIR principles and the European Open Science Cloud (EOSC) are initiatives that emphasize the importance of making scientific data more transparent, inclusive, and democratic. To effectively deal with the increasing volume and complexity of data, data repositories and metadata catalogs are used to connect national, thematic, and other repositories. The paper also focuses on the MIAPPE community and the Breeding API (BrAPI) project, which address the issue of data standards and effective data sharing in the field of biology. The ISA framework is also useful for managing diverse biological, environmental, and biomedical experiments. Finally, the paper evaluates available data model tools for sharing scientific data from selected areas of agricultural research and rural development, highlighting the need for more effective data organization and sharing in the field.

Researchers should adhere to FAIR principles and utilize standards like MIAPPE and BrAPI to enhance data sharing, maximize data impact, and drive scientific innovation in agricultural research.

Adoption of MIAPPE, BrAPI, and other FAIR principles ensures accessible, interoperable, and reusable agricultural research data, promoting collaboration and addressing key challenges such as food security and environmental sustainability.

Repositories should prioritize open and interoperable platforms that align with FAIR principles, facilitating easy data access and reuse for researchers.

The FAIR principles and initiatives like the European Open Science Cloud (EOSC) promote transparency and inclusivity in scientific data sharing, empowering researchers and advancing knowledge in the field.

Effective data organization, metadata standardization, and utilization of data model tools are essential for sharing scientific data in agriculture and rural development, enabling efficient data management and collaboration within the research community.

Acknowledgements

The results and knowledge included herein have been obtained owing to support from the following institutional grant. Internal grant agency of the Faculty of Economics and Management, Czech University of Life Sciences Prague, grant no. 2023B0020 Domain-focused data models to support the Open Science initiative and the FAIR principles.

References

Burgelman, J.-C. (2021). "Politics and Open Science: How the European Open Science Cloud Became Reality (the Untold Story)", *Data Intelligence*, vol. 3, no. 1, pp. 5-19, ISSN 2641-435X, DOI 10.1162/dint_a_00069

David, A. et al. (2020). "Annotation and curation of human genomic variations: an ELIXIR Implementation Study", *F1000Research*, vol. 9. ISSN 2046-1402, DOI 10.12688/f1000research.24427.1

Gomes, D.G. et al. (2022). "Why don't we share data and code? perceived barriers and benefits to public archiving practices," *Proceedings of the Royal Society B: Biological Sciences*, vol. 289, no. 1987, ISSN 0962-8452, DOI doi.org/10.1098/rspb.2022.1113

Implementation of the UNESCO Recommendation on Open Science. [Online], Available: <https://www.unesco.org/en/open-science/implementation>, [Accessed: 20 Apr. 2023]

Novotný, J. (2019). "Open science, open research data and some open questions," *Hradec Economic Days*, pp. 174-181, DOI <https://doi.org/10.36689/uhk/hed/2019-02-017>

Merton, R. K. (1973) [1942]. The Normative Structure of Science, in: Norman W. Storer (Ed.) *The Sociology of Science: Theoretical and Empirical Investigations*, 267–278. Chicago: University of Chicago Press.

Papoutsoglou, E. A. et al. (2020). "Enabling reusability of plant phenomic datasets with Miappe 1.1," *New Phytologist*, vol. 227, no. 1, pp. 260–273, ISSN 0028-646X, DOI 10.1111/nph.16544

Prodan, R. et al. (2022). "Towards extreme and sustainable graph processing for urgent societal challenges in Europe," *2022 IEEE Cloud Summit*, pp 23-30, ISBN 978-1-6654-5113-0, DOI doi.org/10.1109/cloudsummit54781.2022.00010

Sansone, S.-A. et al. (2012). "Toward interoperable bioscience data," *Nature Genetics*, vol. 44, no. 2, pp. 121–126, ISSN 1061-4036, DOI org/10.1038/ng.1054

Selby, P. et al. (2019). "BrAPI—an application programming interface for Plant Breeding Applications," *Bioinformatics*, vol. 35, no. 20, pp. 4147–4155, ISSN 1367-4803, DOI <https://doi.org/10.1093/bioinformatics/btz190>

Stočes, M. et al. (2018). "Možnosti využití otevřených dat v sektoru cukr – cukrová řepa". *Listy cukrovarnické a řepářské*, vol. 134, no. 3, pp. 117-121. ISSN 1210-3306

Thoegersen, J. L. and Borlund, P. (2021). “*Researcher attitudes toward data sharing in public data repositories: A Meta-evaluation of studies on researcher data sharing,*” *Journal of Documentation*, vol. 78, no. 7, pp. 1–17, ISSN 0022-0418, DOI doi.org/10.1108/jd-01-2021-0015

Tzanova, S. et al. (2020). “*Changes in academic libraries in the era of Open science,*” *Education for Information*, vol. 36, no. 3, pp. 281–299, ISSN 01678329, DOI doi.org/10.3233/efi-190259

Wilkinson, M. D. et al. (2016). “*The Fair Guiding Principles for Scientific Data Management and Stewardship,*” *Scientific Data*, col. 3, no. 10, ISSN 2052-4463, DOI doi.org/10.1038/sdata.2016.18

Upper Secondary Agricultural Education as a Key Source of Skilled Labour Force for Czech Agriculture

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Annotation: The paper aims to analyse the supply and demand of agricultural labour force in the Czech Republic (CR), with a particular focus on upper secondary agricultural education. While the number of applicants for agricultural studies has been relatively stable, agricultural enterprises have been struggling to secure qualified workforce in the long term. This is despite the relatively even distribution of agricultural fields of studies throughout the country and the apparent sufficiency of agricultural graduates in relation to the labour force in agriculture. The paper examines the main agricultural specializations within upper secondary educational fields of study (programmes ending with a “maturita” examination and an apprenticeship certificate). It compares the ability of schools to generate enough graduates with the requirements of agricultural practice. This analysis will shed light on the extent to which the education system is meeting the needs of the Czech agricultural sector. The study uses a combination of secondary statistical data sources. The data sources include the Czech Statistical Office (CZSO) for data on the agricultural workforce and its socio-demographic characteristics, the Ministry of Labour and Social Affairs of the CR (MLSA CR) for data on labour demand and foreign workers in the agricultural sector, and the National Pedagogical Institute of the CR (NPI CR) for data on the number of agricultural secondary school graduates from 2014–2021.

Key words: agriculture, labour force, agricultural education, vocational school, Czech Republic

JEL Classification: J23, J24, J43

1. Introduction

“Current labour markets demonstrate a significant level of dynamism that affects the general and specific qualification requirements for workers and their skills” (Sirovátka, 2009). However, this characteristic is only applicable to a limited extent in rural or agricultural labour markets, where workers often have significant ties to the land and rural life. As Shortall, McKee and Sutherland (2020) note, in numerous regions across Europe farming is fundamentally a closed occupation, accessible solely to individuals who inherit agricultural resources. While some authors in the past referred to agricultural workers as the “social class of the past” (Vonderach, 1997) or as a type of outsiders due to the localization of their work in rural areas and lower incomes (Berger and Piore, 1980), the work of these individuals, who are slowly declining, remains one of the fundamental means of ensuring food security.

Although there has been a gradual reduction in the number of workers in the agricultural sector for various reasons, the need to ensure an adequate number of skilled workers for agricultural enterprises has been a persistent issue in the CR, as well as in many other EU countries. Attention is frequently directed towards the scarcity of youthful agricultural laborers and the issue of intergenerational transition within family-owned farming operations (Zagata and Sutherland, 2015, Rovný, 2016, Coopmans et al., 2021, Šimpachová Pechrová et al., 2018, Sutherland, 2023).

In the context of the CR, where a large portion of the land is managed by large enterprises with a low proportion of family farms⁵, graduates of secondary agricultural education can be considered a main and very important source of workers for Czech agriculture (Slavík, 2004). Therefore, this paper aims to describe the situation in Czech secondary agricultural schools (technical and vocational) in terms of the number of applicants and graduates in key agricultural programmes for agricultural production, with a closer examination of the match between the supply and demand for labour in the Czech agricultural labour market. While there are numerous topics related to the study of the linkages between the needs of agricultural practice and education, which mainly relate to the quality of education and its adaptation to the changing conditions of agricultural practice, this paper focuses primarily on the quantitative aspect of the process of preparing graduates with agricultural education.

Considering the characteristics of Czech farms, which are predominantly comprised of a high proportion of employees and relatively few family-owned businesses, as well as the focus of our discussion on skilled labour, the inclusion of part-time workers is not considered in our deliberations. However, it is worth noting that recent research, such as that conducted by Augère-Granier (2021), has specifically addressed the importance of this type of employment.

In the realm of agricultural employment, the CR exhibits trends common to many other European countries, namely a gradual decline in the number of farmers. Currently, there are about 97 thousand workers in Czech agriculture (Green Report, 2022), the share of all workers is very low (1.9% in 2021). Additionally, the Czech agricultural workforce is characterized by an unfavourable age distribution across all occupational categories, including managers. Over the long term, wage disparities exist between Czech agriculture and the broader economy, as well as with respect to the industrial sector. The unfavourable wage ratio has contributed to an increasing reliance on foreign workers in the Czech agricultural sector, a trend that has slowly but steadily been on the rise lately. The wage gap is exacerbated by the fact that workers in the agricultural sector, regardless of gender, traditionally have the longest time paid hours per month compared to all other sectors (TREXIMA, 2018).

With regards to agricultural labour, the CR in comparison to other European countries has some unique characteristics that deserve special attention. These include a significantly different size distribution of agricultural holdings⁶, a higher-than-average share of employees within the agricultural workforce⁷, a lower representation of workers aged under 25⁸,

⁵ Family workers are significantly underrepresented in the agricultural labour force, with only 37.2% of workers being family members, compared to 89.5% in the EU-28 (EUROSTAT, FSS 2016).

⁶ The majority of employment is concentrated within corporate enterprises, with partnerships outnumbering cooperatives. These corporate entities hold a significant proportion of agricultural land ownership and management. This leads to a phenomenon known as dual farming, where a small number of entities cultivate a large portion of the land. The CR has the highest average area of agricultural land per entity (130.2 ha) compared to the EU-28 average of 16.6 ha (FSS 2016).

⁷ Based on the available data on labour input within the agriculture sector in 2022, it can be observed that 70.2% of the agricultural work unit (AWU) was attributed to wage labour, while the remaining 29.8% was categorized as unpaid labour (mostly family workers) (Green Report, 2022).

⁸ In 2021, the Czech Republic had a lower share of agricultural workers under 25 compared to the European Union (EU-27) average. In particular, the share of workers under 25 in the Czech Republic was 5.9%, compared

and a higher proportion of workers with agricultural vocational education⁹. The latter reflects both the skill requirements of certain occupations on larger farms and the long tradition of agricultural education in Czech secondary schools. When compared to EU countries, the CR has a lower percentage of highly educated individuals (less than 12% in 2021) in the agricultural sector. However, it has by far the highest percentage of workers with secondary education (with or without graduation - 82%) and the lowest percentage of workers with only basic education (6.8%). Czech agricultural managers are among the most highly educated in their field. After Luxembourg, the Czech Republic has the highest proportion of agricultural managers with at least a high school diploma (38.7% compared to less than 9% in the EU-27, EUROSTAT, 2022).

Unlike educational structures, the age distribution of the Czech agricultural workforce is a frequently discussed socio-demographic issue (Spěšná et al. 2009; Spěšná et al. 2019; Delín and Spěšná, 2020; Conference on agricultural education at Czech University of Life Sciences Prague in 2022), despite not being among the most unfavourable in Europe. Specifically, the average age of farmers in the Czech Republic in 2021 was 46.4 years old, which is roughly three years older than the average age of Czech employees (CZSO, 2022).

The generational transition of agricultural workers has been challenging due to the low popularity of agricultural education (Procházka, Smutka, and Steininger, 2011) and low interest of agricultural graduates in agricultural work, as noted by Spěšná et al. (2019), Tomšíková, Hudečková and Tomšík (2019) and Delín (2022). This lack of interest is likely due to the gradual decline in agricultural employment, wage disparity and the generally low prestige associated with agricultural professions among the Czech public. The notion that agriculture is a financially undervalued occupation associated with physical labour is in Czechia quite widespread (Svobodová, 2022), which not only influences adolescents in their career decision-making but also the generation of their parents, who may thus influence their children in choosing an educational path and profession. In the long run, the gradual estrangement of individuals from the natural milieu, the waning of scientific and agricultural proficiency, and even the surging phobia towards flora and fauna among younger generations (Jančaříková, 2016; Vácha, Ryplová and Valvodová, 2021), all have a negative impact on young people's interest in pursuing agricultural careers.

Changing the societal perception of farmers constitutes a task of substantial duration (Slavík, 2014, Shortall and Marangudakis, 2022), it becomes imperative to consider not only educational institutions, particularly teachers who serve as disseminators of agricultural knowledge, but also agricultural enterprises or their affiliated organizations (Oppeltová, Navrátilová, and Marešová, 2019). With regard to the ongoing decline in agricultural literacy observed over the past decades (Frick et al., 1991, Jeong and Choi, 2020), it is certainly not a simple process.

The potential threat of absence of young people in the agricultural sector and the consequent lack of generational renewal within farming can result adverse effects. These effects may include the disappearance of family farms without a secure successor and a reduction of labour-intensive agricultural production. These impacts can further result in adverse

to 6.7% in the EU-27. The share of workers under 25 in the agrarian population was lower in Spain, Poland, Italy, Greece, Bulgaria, Croatia, Lithuania, Latvia, Slovenia, Cyprus and Portugal (EUROSTAT 2022).

economic, social, and environmental consequences, such as a decline in food self-sufficiency for key commodities, a reduction in livestock production with a subsequent decrease in fertilizer volumes. Furthermore, this trend may lead to a reduction in the social function of agriculture and a loss of know-how, among other issues. The absence of younger generations in the farming community may hinder the development of the sector in areas such as Agriculture 4.0 and new methods of environmental protection. This is particularly concerning as younger generations tend to be more receptive to modern technologies and innovative approaches. Their lack of presence on farms and in agricultural schools may, therefore, impede the advancement of the agricultural sector in these crucial areas.

2. Materials and methods

To evaluate the ability of Czech secondary agricultural education to generate an adequate number of graduates for Czech agricultural enterprises, we primarily rely on officially published information regarding the agricultural workforce, obtained from the Czech Statistical Office – CZSO (mainly data of the Farm structure survey – FSS), as well as labour demand data, sourced from the Ministry of Labour and Social Affairs (MLSA CR). Information on agricultural graduates comes from the National Pedagogical Institute of the Czech Republic (NPI CR), these data are not available to the public in a detailed breakdown based on specific fields of agricultural education. To evaluate the real benefit of agricultural schools in the field of preparing qualified workers we utilize primary data from the previous research of the Institute of Agricultural Economics and Information (IAEI) conducted by Spěšná et al. (2017, 2018, 2019) who specifically examined the farms' experiences in hiring recent graduates and the graduates' willingness to pursue careers in agriculture.

There are three main types of secondary schools in the Czech Republic: in addition to grammar schools (general schools that do not offer vocational education), there are *secondary technical schools* (in Czech „střední odborná škola“ – SOŠ) and *secondary vocational schools* („střední odborné učiliště“ – SOU). These two types of schools offer secondary agricultural education. The technical schools most often provide comprehensive vocational education through four-year programmes with a matura examination, vocational schools primarily focus on providing training programmes that lead to an apprenticeship certificate (a VET certificate, in Czech “výuční list”).

Czech upper secondary agricultural education has a long tradition and offers many diverse specializations (programmes) in comparison to other fields of study (Chomová, 2014). Agricultural programmes offered at secondary schools can be divided into several categories of education (these categories are equivalent to ISCED level 3 and the levels of the European Qualifications Framework, as demonstrated in Table 1). It is designed typically for students between the ages of 15 and 19 years. It includes programmes whose code in the national *Classification of Educational Programme Types* (in Czech „Klasifikace kmenových oborů vzdělávání“ – KKO) starts with the number 41.

Table 1. Upper secondary agricultural education by categories in the Czech Republic

KKOV	Description of the Category	Length of the Programme in Years	Conclusion Output (final certificate)	European Qualifications Framework (EQF)
E	Ordinary upper secondary	2-3	certificate of apprenticeship	2
H	Upper secondary with an apprenticeship certificate	3	certificate of apprenticeship	3
L	Vocational education with "Maturita" examination	2	certificate of apprenticeship + maturita certificate	4
M	Upper secondary with "Maturita" examination	4	maturita certificate	4
N	Tertiary professional schools	3	Absolutorium (vocational examination)	6

Notes: E category – Agricultural programmes within this category of education are aimed above all at very practically oriented pupils whose success in basic schooling is limited.

H – Programmes are vocational and prepare the students for direct entry into the labour market. Programmes for a qualification with apprenticeship certificate end with a final examination in which students demonstrate that they are prepared for relevant work activities.

M – Individuals who have completed these programmes may be eligible to pursue further studies at a tertiary institution, they are equipped with the necessary skills and knowledge to enter the workforce directly.

L – Programmes (shortened courses) are designed for students who have undergone an apprenticeship to obtain maturita examination.

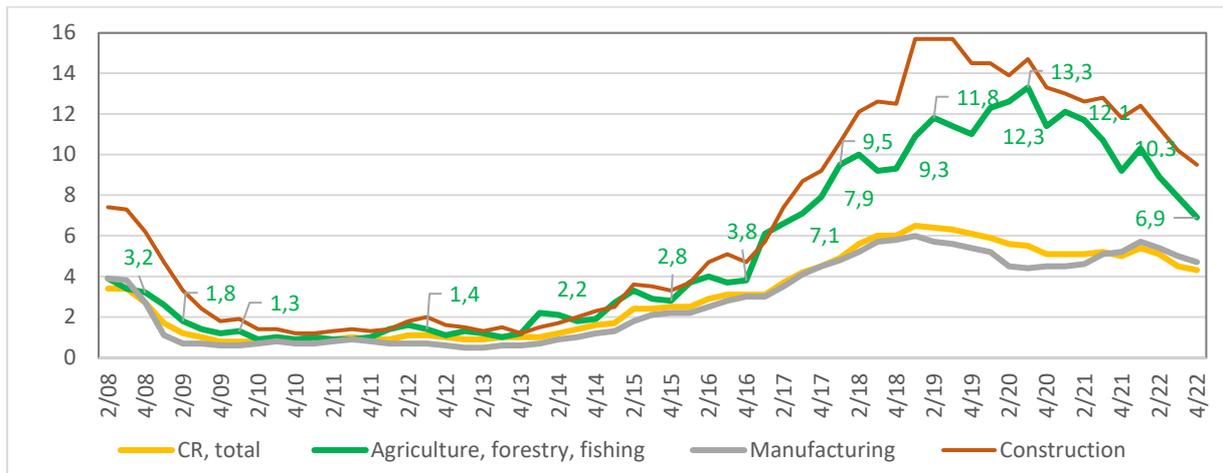
N – Programmes offer education of higher level.

Further information about the Czech education system can be found in CEDEFOP (2022).

Source: The KKOV (Classification of Educational Programme Types); Czech National Agency for International Education and Research, Ministry of Education, Youth and Sports; European Qualifications Framework (EQF)

In this paper, we present two indicators of upper secondary agricultural education. The first indicator pertains to the number of students enrolled in agricultural studies during their first year, while the second indicator focuses on the number of graduates who have completed such studies in specific years. The data on the number of first year students and graduates are based on their respective counts in September of the relevant year. Moreover, the data on graduate unemployment reflects the situation as of April of the given year but pertains to the graduates from the previous September. It is important to note that the data on graduates include all types of study programmes (i.e., full-time and combined) without any distinction, while the data on unemployment solely encompasses full-time graduates. In the paper, we mainly focus on vocational and secondary school programmes in categories H and M, which form the backbone of secondary agricultural education (see Figure 5). Figure 1 displays a dense network of secondary agricultural schools in the CR, which are represented in all regions.

Figure 2. Job Vacancy Rate on a Quarterly Basis in the Czech Republic from 2008 to 2022 (%)



Source: CZSO, 2023

Note: Job Vacancy Rate is calculated as the number of job vacancies divided by the sum of the number of job vacancies and occupied posts

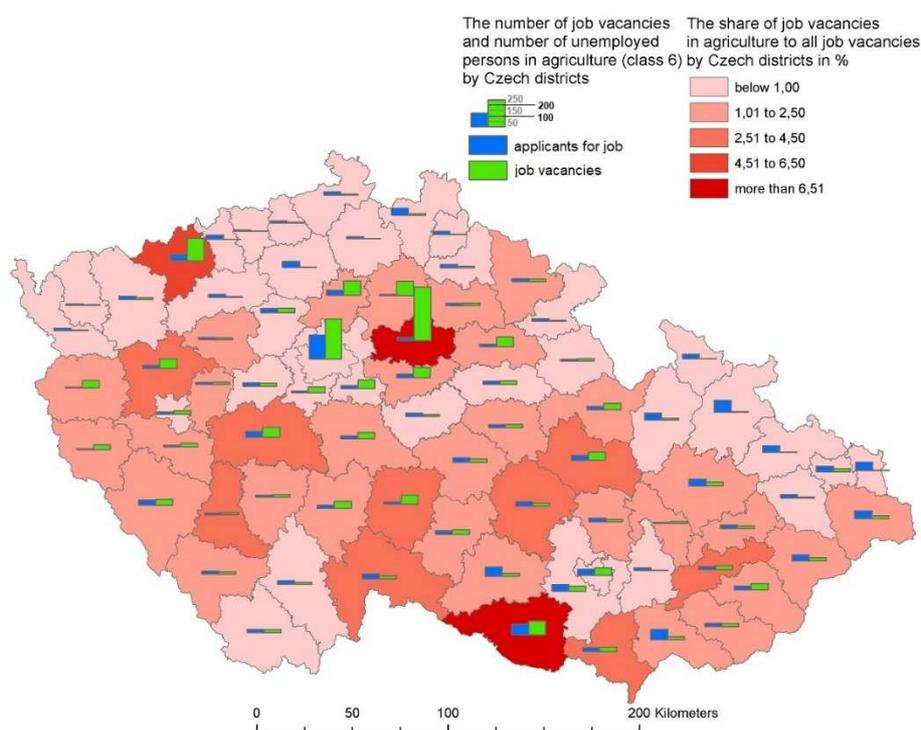
Based on vacancy rates it is possible to estimate how many employees the sector needs to recruit. In Czech agriculture sector, this would be almost 8 thousand people in mid-2022 (a decrease of about 3 thousand compared to the same period of the previous year). Underemployment in agriculture is a major problem "operationally", as it is absolutely necessary to ensure proper daily care of the animals kept (which of course is also fully valid in times of pandemics, etc.) and to carry out at least basic agrotechnical interventions on all cultivated agricultural land within the relevant agrotechnical deadlines (otherwise, among other things, subsidies – direct payments – would be cut, or in more serious cases, fines from municipal authorities, etc.). It is clear from the information on the situation on some farms (which in some cases was also reported in the media) that the amount of labour input in agriculture in recent years has been lower than what was actually needed – some labour tasks were not carried out in full (e.g. in hop growing, apple harvesting, etc.), which, of course, had a negative impact on the quantity and quality of production, and consequently on the lower revenues of the farms.

The demand for labour force can also be inferred from the data of the MLSA CR. Out of the total number of 343 thousand vacancies offered at Czech labour offices at the end of 2021, the agricultural sector (group A according to CZ-NACE) accounted for 7,436 vacancies (2.2% of total in the CR). However, since a large part of all registered vacancies (193.8 thousand) remains unclassified or unspecified in terms of individual sectors or fields of activity and the obligation for employers to report vacancies to the labour offices has passed, the actual demand for filling jobs in the agricultural sector could thus be higher.

Data on the number of available job applicants across the entire agricultural sector in the Czech Republic are not available. Therefore, only the comparison between job offers and available job seekers in occupational class 6 CZ ISCO, which includes qualified agricultural workers (often livestock caretakers and qualified workers in plant production), can be made separately. As of June 30, 2022, a total of 1,798 job seekers (nearly 60% of whom were women) were registered in this category in the Czech Republic, while the number of job openings amounted to 4,018. On average, there were less than

0.5 available candidates per one vacant job position in this group of workers, with significant differences across Czech regional labour markets (ranging from 0.2 available candidates in the Central Bohemia to 2.3 in the Liberec region). The latest data on demand for jobs in occupational category 6 is shown in Figure 3, revealing significant differences between individual regions and a high concentration of job opportunities in the Central Bohemian region.

Figure 3. Applicants for Jobs and Vacant Positions in occupational category 6 CZ ISCO in the Czech Republic in March 2023



Source: MLSA, 2023

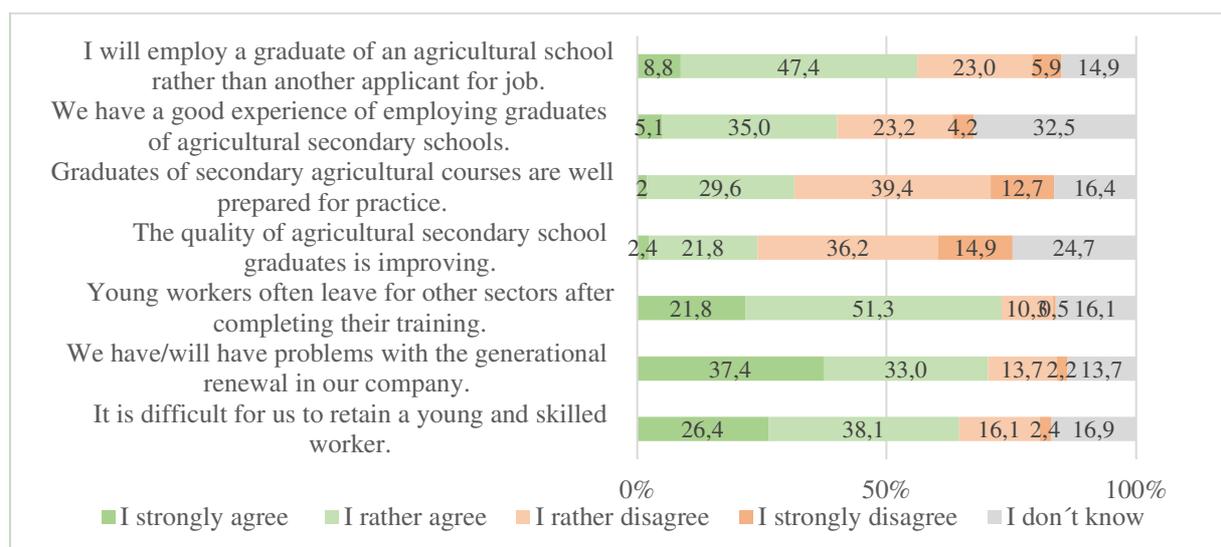
Upon comparing our results with the earlier study conducted by Nohel et al. (2011), which examined the regional supply and demand for agricultural workers in the CR, it becomes apparent that despite the volatility in the labour market and the option of commuting for work (which, in the case of agriculture, is typically deterred by lower wages), certain regions persistently exhibit a surplus of unfilled agricultural positions. Specifically, areas such as Central Bohemia located in the vicinity of Prague, and Znojmo neighbouring Austria, have a higher demand for agricultural workers than the supply available, while regions with elevated unemployment suffer from an oversupply of job seekers in agriculture relative to the number of vacant positions (typical for the Moravian-Silesian, Liberec, and Ústí nad Labem regions).

The difficult situation of Czech agricultural businesses to obtain workers, or the inability to ensure an adequate number of workers from domestic sources, is indirectly demonstrated by the trend of increasing numbers of foreign workers (however, the extent to which these non-Czech employees are full-time workers (AWUs), permanent or seasonal workers, repeat registrants, unfortunately cannot be determined without proper research). According to the CZSO (2023), as of December 31, 2022, there were 23,000 foreign workers (2.9% of the total workforce) registered by labour offices in these industries. This is an increase

of 1,000 from the previous year. The largest group of foreign workers came from Ukraine (9.2 thousand), followed by citizens of EU member states (10.8 thousand in total) and Slovak citizens (4.4 thousand).

Furthermore, aside from statistical sources, empirical research conducted by the Institute of Agricultural Economics and Information can provide data on the demand for agricultural workers. The most recent research was conducted by Spěšná et al. (2018). During that time, the Czech economy was doing well. A significant portion of the agricultural entities surveyed acknowledged problems with the generational turnover of their workers (70% of the 409 companies surveyed), and nearly 64% of the agricultural firms surveyed considered a shortage of workers in the labour market to be an obstacle to further development. Based on the experiences of more than 80% of the managers surveyed, it became clear that finding qualified workers was increasingly difficult for them. For most agricultural companies, it was not only difficult to find workers, but also to retain them in the company. Relatively frequently, agricultural enterprises also engaged in "poaching" qualified workers, as confirmed by a slight majority of agricultural managers in the survey (58.2%). Without hiring new employees for the period 2018–2022, only a negligible proportion of these companies (approximately 1%) would have managed. The average need for worker replenishment amounted to between 4-5% of their workforce annually. The research by Spěšná et al. (2018) further showed that a large portion of businesses were interested in hiring fresh agricultural graduates and would even prefer them over other job applicants, despite frequent doubts about their professional readiness for practical work. However, a large portion of these businesses had no prior experience with them, graduates had not applied for jobs in their companies in the past. The experience of managers regarding the employment of recent agricultural graduates is shown in Figure 4.

Figure 4. Experience of agricultural managers with agricultural graduates in 2018 (%)



Source: Spěšná et al., 2018

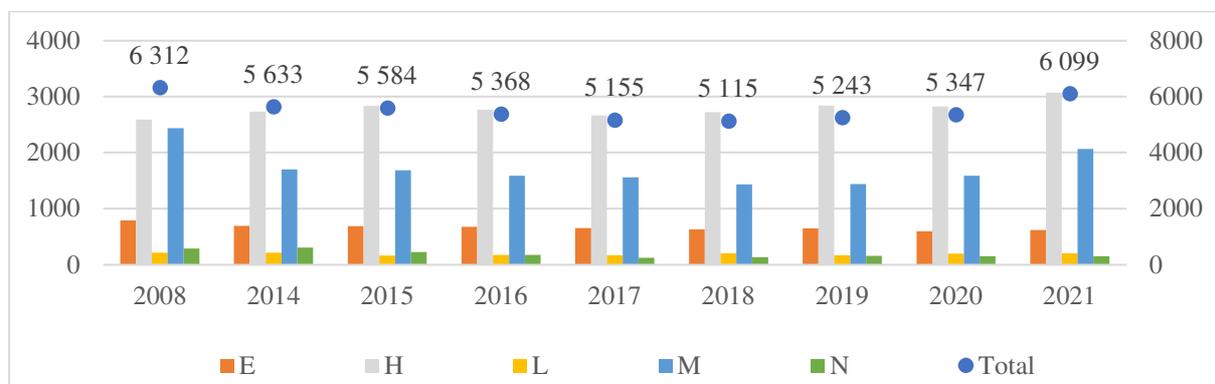
Note: An empirical survey conducted in 2018 by the IAEI at 409 agricultural companies in the Czech Republic

Let us focus on the situation from the perspective of the number of students studying agricultural disciplines. The development of the absolute number of first year students

in agricultural fields of secondary schools in 2008 and the range of years 2014–2021 is presented in Figure 5. We can see that in recent years there has been an increase in their number, but this trend needs to be put into context with the increasing birth rate after 2000, resulting in stronger cohorts in secondary schools in recent years, rather than with a growth in interest in these fields.

On the other hand, the numbers of students entering agricultural programmes were slightly higher than the average for all fields of study in the Czech Republic, and the proportion of students in the first year of agricultural programmes among all students enrolled in the first year of secondary schools in the Czech Republic has remained relatively stable for a long time, hovering around 5% (5.4% in 2021 according to NPI CR).

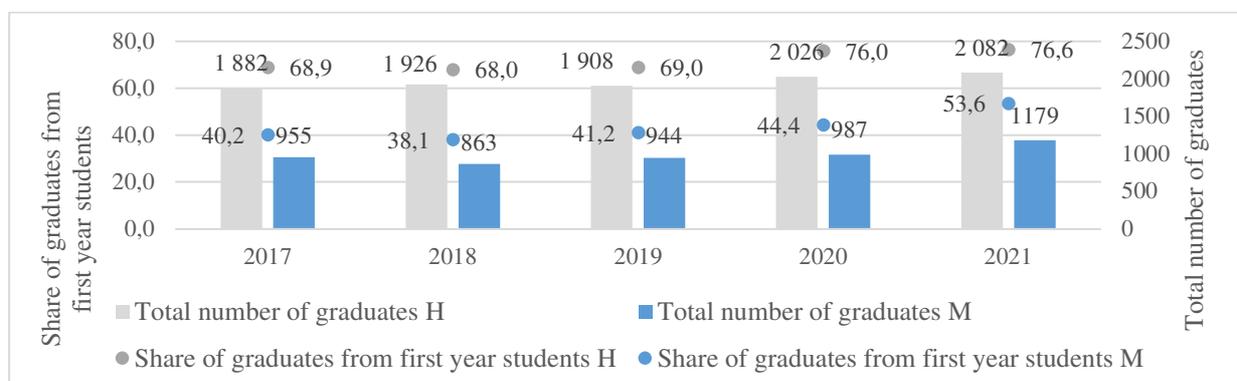
Figure 5. Numbers of first year students in agricultural programmes of Czech secondary schools by educational category in 2008, 2014–2021



Source: Database NPI CR

From the perspective of preparing professional workers, it is necessary to draw attention to the still relatively low effectiveness of the educational process regarding frequent premature termination of studies in secondary agricultural programmes. In Figure 6, we show the proportion of students who complete their studies in the fields of education category H and M. Although the situation has been improving in recent years, unfortunately, the proportion of agricultural graduates in vocational programmes is still very low compared to the number of students who originally started their studies.

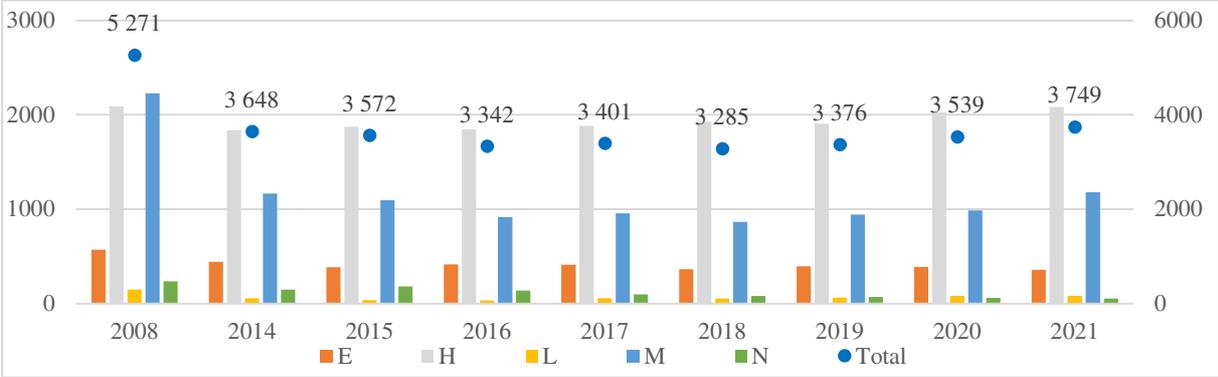
Figure 6. Number of graduates in agricultural programmes of categories H and M (abs.) and the proportion of graduates among new students between 2017–2021 (%)



Source: Database NPI CR, calculations of IA EI

Let us now turn attention to the number of students who successfully graduate from secondary agricultural schools in the Czech Republic and proceed to practical training or further studies. The Figure 7 illustrates the overall numbers of graduates from all categories of secondary education, while the following images (Figures 8, 9) display the structure of the two most significant groups of high school fields sorted by individual specializations.

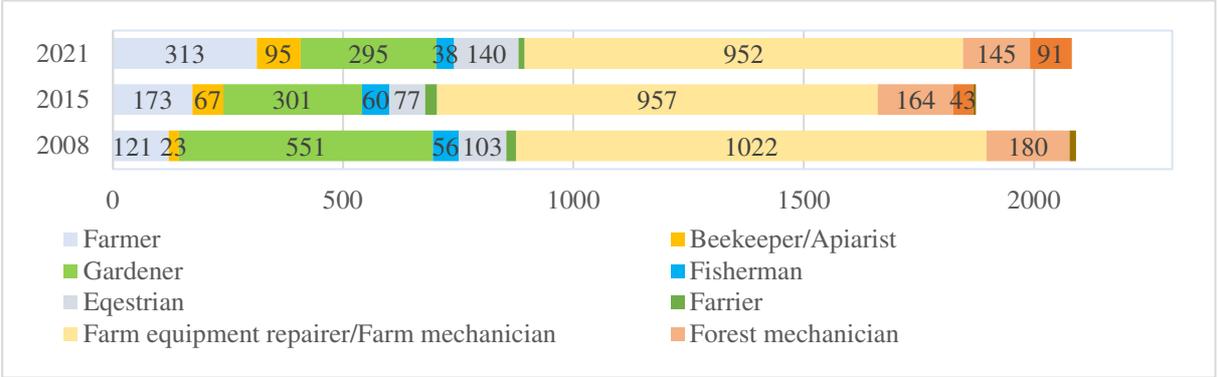
Figure 7. Number of graduates in secondary agricultural programmes in the years 2008, 2014–2021



Source: Database of NPI CR, calculations of IAEI

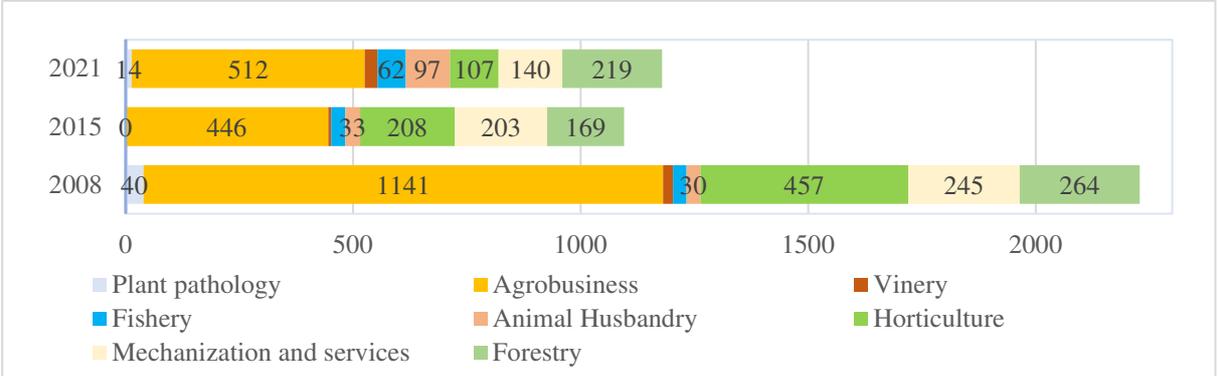
Note: Graduates of all education categories (E, H, L, M, N). Data on graduates include all forms of study (day and combined) without distinction

Figure 8. Number of Agricultural Graduates with an Apprenticeship (category H) in the Czech Republic in 2008, 2015 and 2021



Source: Database NPI CR, calculations of IAEI

Figure 9. Number of Agricultural Graduates with a matura examination (category M) in the Czech Republic in 2008, 2015 and 2021

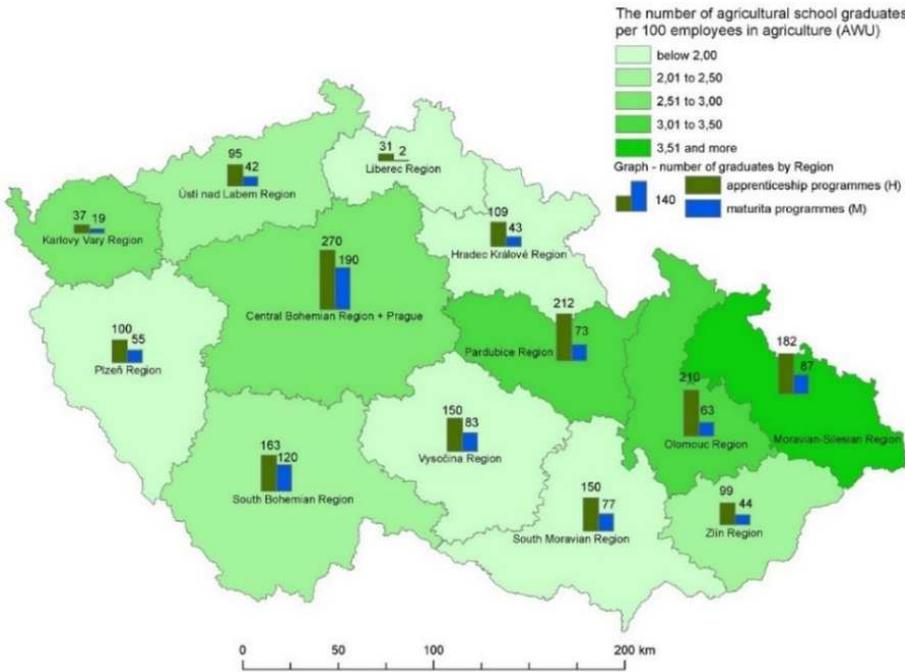


Source: Database NPI CR, calculations of IAEI

The numbers of graduates in agricultural fields serve primarily as a signalling indicator, denoting a potential source for replenishing the workforce in the agrarian sector. However, it should be noted that an increase in the number of graduates is not necessarily indicative of a smooth generational turnover in the agrarian sector (as will be discussed below).

According to data from the CZSO and the NPI CR, the average number of graduates in Czech agriculture was 3.02 (across all programmes) and 2.18 (specifically for programmes H and M, excluding Forestry and Fishery programmes) per 100 full-time workers. As shown in Figure 10, in some regions, the number of agricultural graduates compared to the number of workers is extremely low (below 2; often, these are rural regions with a significant agrarian employment). On the other hand, regions such as the Moravian-Silesian region, which do not belong to typical agricultural areas, have higher values of this indicator.

Figure 10. Number of secondary agricultural school graduates per 100 employees in Czech agriculture (AWU)



Source: The Integrated Farm Survey 2020, CZSO 2022. Database of NPI CR

Note: The data pertaining to agricultural graduates comprises graduates of vocational education programmes falling under the H and M categories, except for those in forestry and fishery programmes, as the latter predominantly pursue education that does not lead to a career in agriculture

To evaluate the success of agricultural graduates in the labour market, it is necessary to examine statistical data regarding their employment outcomes. Furthermore, it is important to investigate to what extent their actual work corresponds or deviates from the specialization they studied.

One possible approach to looking at the success of employment in the job market is to examine the percentage of graduates who become unemployed after successfully completing their studies. This approach allows for the exclusion of graduates who continue their education at a university or higher vocational school. However, it does not consider whether the graduates sought employment in their field of study, such as agriculture

or a related industry (for example, graduates of agricultural machinery repair programmes may find work relatively easily in the transportation or automotive industry).

Data on the unemployment of recent agricultural graduates indicate a relatively good prospect for graduates from three-year vocational programmes (H). In the years 2017-2021, the unemployment rate of their graduates was lower than the overall vocational programmes (in 2021, 6.5% compared to 9%). The situation is less favourable in agricultural programmes within M category of education. Here, the unemployment rate of agricultural graduates often slightly exceeds the level of the entire group of secondary school programs (in 2021, 6.7% compared to 6.2%).

Table 2. The Unemployment Rate of Graduates in Agricultural Fields of Upper Secondary Schools and in Upper Secondary School Fields Overall

Study programme (KKOV category)	Unemployment rate of graduates (%)					Number of unemployed graduates				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Agricultural programmes (H)	5,9	3,3	2,8	5,5	6,5	104	58	51	100	125
All H programmes	6,2	4,4	3,7	5,9	9,0	1174	829	671	1025	1726
Agricultural programmes (M)	5,8	5,0	3,2	5,2	6,7	50	48	26	49	65
All M programmes	5,2	3,7	3,8	4,7	6,2	1437	1015	1039	1340	1913

Source: *infoabsolvent.cz*

Another indicator that we can use in connection with the potential renewal of the workforce in the sector is the (mis)match between the education received and the job performed. Doležalová (2020) shows that there is less „agreement“ between the education received and the job performed among graduates of agricultural fields of study. Among those trained in agriculture, there are significantly more who do not work in the field they studied shortly after completing their studies. Although the relatively frequent mismatch between the field of study and the profession pursued by graduates of agricultural fields of study may indicate a discrepancy between the educational system, students' interests, their preparation, and the demands of the labour market, it also signals a certain adaptability of the agricultural graduates who successfully apply themselves in fields outside of agriculture.

Previous research by IAEI on the professional orientation of agricultural graduates also often pointed to the fact that graduates very often direct their careers outside the agriculture sector (Spěšná et al., 2017, 2018, and 2019). The employability of agricultural graduates in agricultural practice, aside from the labour market situation, significantly depends on the personal preferences of the students. According to research conducted by IAEI among students and teachers at upper secondary schools, as reported by Spěšná et al. (2018, 2019), it has been shown that many pupils do not consider a career in agriculture when choosing a secondary school. These students choose to pursue agricultural studies due to the perception of convenience in obtaining certifications such as an apprenticeship certificate or matura, a driving license, a welder's license, or other related courses that are offered by the schools. Additionally, the proximity of the agricultural school to their place of residence is also a determining factor in their decision. Based on these studies, it can be estimated that at most around half of all agricultural secondary school graduates pursue a career in agricultural practice. These studies further indicated significant differences in the number of students

pursuing agriculture among different agricultural fields and among different schools. It was found that a significant number of students from agricultural families plan to pursue agriculture. Students without an agricultural family background and without prior interest in agriculture find it difficult to enter the field.

4. Conclusion

To conclude, we will consider the perspective of Czech agricultural enterprises in terms of securing their workforce. Is it realistic for Czech agricultural companies to obtain qualified workers from domestic sources with the current number of high school graduates?

Based on data on the number of farmers and findings from previous empirical research, it can be inferred that there is a theoretical demand for approximately 4,000 new workers annually in Czech agriculture. This estimate is derived from the average rate of worker turnover in agricultural enterprises surveyed, which was approximately 4% per year. Despite differences in specific conditions among individual companies, this figure serves as a valuable reference point for understanding the overarching demand for fresh labour in Czech agriculture.

In the case of considering solely the replacement of retiring workers, it would be necessary to hire at least 2,500 new workers annually in Czech agriculture, given the absolute number of workers (approximately 100,000) and their theoretical even distribution across different age groups and their regular retirement. This estimate assumes that an employee can work in agriculture for 40 years (i.e., the entire working life) without changing jobs. However, given that a higher percentage of older individuals work in agriculture and not only retiring workers require replacement, this estimate represents an absolute minimum.

Acknowledging that not only fresh graduates from secondary agricultural schools enter the industry, that not only graduates from agricultural schools work in Czech agriculture, and that a certain proportion of unskilled workers also work and will continue to work in the industry, the last numbers of around 3.5 thousand secondary school graduates per year may seem sufficient (the number of graduates related directly to the number of Czech agricultural workers is about 3 per 100). However, given that some agricultural programmes (forestry, fishery, horticulture) do not prepare workers directly for agricultural production, and that approximately half of graduates according to earlier IAEI research planned to pursue a career outside the sector and did not plan to work in agriculture even after further education, it can be expected that agricultural companies will continue to face serious problems in securing the necessary qualified workforce.

The number of secondary school graduates who enter the agricultural sector (it can be assumed that it has been about half of the approximately 3,500 graduates in recent years) thus falls below the absolute minimum threshold necessary for the generational renewal of Czech agriculture (previously mentioned 2,500 employees required to replace those retiring, under ideal (yet unrealistic) conditions of zero employee turnover).

The demand for workers in the current labour market, which has fluctuated between 6,000 and 11,000 employees in recent years (numbers vary depending on seasonality and market conditions), and the high numbers of foreign workers (over 20,000) indicate that Czech secondary agricultural education has been failing in the long term (despite stable numbers of students, graduates, and an increasing share of those who complete their studies) to prepare the workforce for Czech agriculture. If the proportion of agricultural graduates willing

to work in agriculture does not increase, Czech agricultural companies will continue to be forced to use workers with qualifications other than agricultural. Successfully managing generational renewal thus remains a challenging task for Czech agricultural companies in the long run.

Acknowledgements

This paper was created within the project of the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0923, Internal Research Project no. 1272/2023.

References

- Agricultural Association of the Czech Republic, (2022). “Conference on Agricultural Education at Czech University of Life Sciences Prague”, [Online], Available: <https://www.odbory.info/obsah/5/videozaznam-z-konference-zemedelske-skolstvi/332095>, [Accessed: 25. Apr. 2023]
- Augère-Granier, M.- L. (2021). “Migrant Seasonal Workers in the European Agricultural Sector“, EPRS European Parliamentary Research Service (Eds.): *Migrant seasonal workers in the European agricultural sector*, Brüssel, European Parliament
- Berger, S. and Piore, M., J. (1980). “*Dualism and Discontinuity in Modern Societies*“, Cambridge, Cambridge University Press, ISBN 978-05-2123-134-3
- CEDEFOP, European Centre for the Development of Vocational Training, Vocational education and training in Czechia: short description., 2022. [Online], Available: <http://data.europa.eu/doi/10.2801/163428>, [Accessed: 3. Apr. 2023]
- Chomová, P. (2014). “*Absolventi škol a trh práce*”. *Odvětví: Zemědělství*, Prague, National Institute of Education (In Czech)
- Coopmans, I., Dessein, J., Accatino, F., Antonioli, F., Bertolozzi-Cared Petitt, A., Urquhart, J. and Wauters, E. (2021). “Understanding farm generational renewal and its influencing factors in Europe”, *Journal of Rural Studies*, vol. 86, pp. 398-409, ISSN 0743-0167
- CZSO, Czech Statistical Office, The Integrated Farm Survey, 2020. [Online], Available: <https://www.czso.cz/csu/czso/integrated-farm-survey-2020>, [Accessed: 3. Apr. 2023] (In Czech)
- CZSO, Czech Statistical Office, Struktura mezd zaměstnanců, 2022. [Online], Available: <https://www.czso.cz/csu/czso/struktura-mezd-zamestnancu-2021>, [Accessed: 30. March 2023] (In Czech)
- CZSO, Czech Statistical Office, Cizinci v ČR, 2023. [Online], Available: <https://www.czso.cz/csu/cizinci/cizinci-pocet-cizincu>, [Accessed: 18. Apr. 2023] (In Czech)
- CZSO, Czech Statistical Office, Ukazatele sociálního a hospodářského vývoje ČR od roku 1990 do konce 4. Čtvrtletí 2022, [Online], Available: <https://vdb.czso.cz/vdbvo2/faces/cs/index.jsf?page=vystupobjekt&pvo=ZAMDUSHV04-Q&z=T&f=TABULKA&skupId=3348&katalog=32855&pvo=ZAMDUSHV04-Q>, [Accessed: 31. March 2023] (In Czech)
- Delín, M. (2022). “*Agrární trh práce. Tematický úkol ÚZEI pro MZe ČR. č. 5/4215*“, Prague, IAEI (In Czech)

- Delín, M. and Spěšná, D. (2020). “Střední zemědělské školství jako jeden ze zdrojů pracovních sil v zemědělství ČR”, *Evropské a české zemědělství před novými výzvami: sborník příspěvků z on-line ekonomické konference*, Prague, Profi Press s. r. o., pp. 64-74, ISBN 978-80-7271-244-1 (In Czech)
- Doležalová, G. (2020). “*Shoda dosaženého vzdělání a vykonávaného zaměstnání – 2019*”, Prague, National Pedagogical Institute of the Czech Republic (In Czech)
- EQF, European Qualifications Framework, 2023. [Online], Available: <http://archiv-nuv.npi.cz/eqf.html>, [Accessed: 13. Apr. 2023]
- EUROSTAT, Employment by sex, age and economic activity, 2021. [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/LFSA_EGAN22D__custom_5858998/default/table?lang=en, [Accessed: 14. Apr. 2023]
- Frick, M. J., Kahler, A. A. and Miller, W. W. (1991). "Agricultural Literacy: A Framework for Communicating to the Public Sector," *Journal of Applied Communications*, vol. 75, issue 2, DOI: 10.4148/1051-0834.1501
- Green Report, (2022). “*Zpráva o stavu zemědělství ČR za rok 2022*”, (1. version for review procedure), internal material issued by IAEI (In Czech)
- Jančaříková, K. (2016). “Problémy generace Z a alfa spojené s fenoménem odcizování člověka přírodě”, *Speciální pedagogika, stati didaktické a metodické*, vol. 26, no. 3, pp. 131-144, ISSN: 1211-2720 (In Czech)
- Jeong, S. I. and Choi S. J. (2020). “Agricultural literacy in the context of agricultural education in South Korea: using hierarchical linear modeling“, *The Journal of Agricultural Education and Extension*, 26:4, pp. 401-419, DOI: 10.1080/1389224X.2020.1748670
- MLSA, Ministry of Labour and Social Affairs, Monthly statistics on the structure of applicants and vacancies, 2023. [Online], Available: <https://www.mpsv.cz/web/cz/struktura-uchazecu>, [Accessed: 17. Apr. 2023]
- Nohel, F., Spěšná, D. and Pospěch, P. (2011). “Regional markets with agricultural workforce based on labour offices data”, *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Brno, Mendelova univerzita, vol. 59, no. 4, pp. 177-186, ISSN 1211-8516
- NPI CR, National Pedagogical Institute of the Czech Republic, Data on the number of first-year students and the number of graduates of secondary schools in the Czech Republic, 2022, non-public database
- Oppeltová, P., Navrátilová, M., and Marešová, P. (2019), “Environmental education at farms” *Conference on Public Recreation and Landscape Protection – With Sense Hand in Hand*, May 13-15, 2019, Křtiny, Czech Republic, pp. 141-144, WOS: 000484833100028
- Procházka, P., Smutka, L. and Steininger, M. (2011). “Analysis of Diversification Efforts in Agricultural Education”, *Journal on Efficiency and Responsibility in Education and Science*, vol. 4, no. 3, pp. 116–128
- Rovný, P. (2016).” The Analysis of Farm Population with Respect to Young Farmers in the European Union”, *Procedia - Social and Behavioral Sciences*, vol. 220, pp. 391–398. ISSN 1877-0428. DOI 10.1016/j.sbspro.2016.05.513

- Shortall, S., McKee, A. and Sutherland, L. - A. (2020). "The performance of occupational closure: the case of agriculture and gender", *Sociol Rural* 60:40–57, DOI: 10.1186/s40100-023-00244-z
- Shortall, S. and Marangudakis, V. (2022). "Is agriculture an occupation or a sector? Gender inequalities in a European context", *Sociologia Ruralis*, vol. 62, pp. 746-762, DOI: 10.1111/soru.12400
- Slavík, M. (2004). "Changes and trends in secondary agricultural education in the Czech Republic", *International Journal of Educational Development*, vol. 24, issue 5, pp. 539-545, DOI: 10.1016/S0738-0593(03)00041-5
- Spěšná D., Pospěch, P., Nohel, F., Drlík, J. and Delín, M. (2009). "Aging of the Agricultural Workforce in Relation to the Agricultural Labour Market", *Agricultural Economics (AGRICECON)* 55(9), pp. 424-435, DOI:10.17221/20/2009
- Spěšná, D., Delín, M., Doležalová, L., Drlík, J., Karas, J., Svobodová, I. and Tuzová, M. (2017). "Analýza vzdělávacích potřeb rezortu s důrazem na střední odborné školství. Tematický úkol pro MZe ČR. č. 39/4217.", Prague, IAEI (In Czech)
- Spěšná, D., Delín, M., Doležalová, L., Drlík, J., Karas, J., Svobodová, I. and Tuzová, M. (2018). "Analýza vzdělávacích potřeb rezortu s důrazem na střední odborné školství. Tematický úkol pro MZe ČR. č. 39.", Prague, IAEI (In Czech)
- Spěšná, D., Delín, M., Doležalová, L., Drlík, J., Karas, J., Svobodová, I. and Tuzová, M. (2019). "Analýza vzdělávacích potřeb rezortu s důrazem na střední odborné školství". Tematický úkol pro MZe ČR. č. 25.", Prague, IAEI (In Czech)
- Svobodová, I. (2022). "Obraz zemědělství u české veřejnosti: Český agrární sektor v měnícím se ekonomickém prostředí", Collection of papers from conference Zemědělec roku, Prague, pp. 28-39, Profi Press s. r. o, ISBN 978-80-7271-253-3. (In Czech)
- Sirovátka, T. (2009). "Dualizace na trhu práce a strategie „outsiderů“, *Nejistoty na trhu práce*, Brno, ALBERT, pp. 9-38, ISBN 978-80-7326-172-6 (In Czech)
- Sutherland, L. - A. (2023). "Who do we want our 'new generation' of farmers to be? The need for demographic reform in European agriculture", *Agricultural and Food Economics*, 11:3 (2023), DOI: 10.1186/s40100-023-00244-z
- Šimpachová Pechrová, M., Šimpach, O., Medonos, T., Spěšná, D. and Delín, M. (2018). "What Are the Motivation and Barriers of Young Farmers to Enter the Sector? ", *AGRIS online Papers in Economics and Informatics*, vol. 10, No. 4, pp. 79-87. ISSN 1804-1930. DOI: 10.7160/aol.2018.100409
- Tomšíková, K., Hudečková, H., and Tomšík, K. (2019), "Enhancing Attractiveness of Secondary Agricultural Education in the Czech Republic", *Journal on Efficiency and Responsibility in Education and Science*, vol. 12, no. 4, pp. 135-145, DOI: 10.7160/eriesj.2019.120404
- TREXIMA, Trexima, spol. s.r.o., Vliv digitalizace a robotizace na charakter práce a roli sociálního dialogu v zemědělství, 2018. [Online], Available: https://www.zscr.cz/media/upload/1527066127_agrodialog-ii-studie-final-20180430.pdf [Accessed: 31. March 2023] (In Czech)

Vácha, Z., Ryplová, R. and Valvodová, E. (2021). “Pěstitelská gramotnost - sonda znalostí u žáků na druhém stupni základních škol”, *Envigogika*, vol. 16, no. 1, pp. 1-19, DOI: 10.14712/18023061.615 (In Czech)

Vonderach, G. (1997). “*Landarbeiter im alten Deutschland: Zur Sozialforschung und Sozialgeschichte einer vergangenen Gesellschaftsklasse*”, Münster, Literatur-Verlag, ISBN 978-38-2582-890-5

Zagata, L. and Sutherland, L.-A. (2015). “Deconstructing the ‘young farmer problem in Europe: Towards a research agenda”, *Journal of Rural Studies*, vol. 38, pp. 39-51, ISSN 0743-0167, DOI: 10.1016/j.jrurstud.2015.01.003

RELATION OF LARGE AGRICULTURAL HOLDINGS TOWARDS THEIR EMPLOYEES

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Annotation: The number of agricultural workers in the Czech Republic has been decreasing due to increased productivity and partly perceived unattractiveness of the sector. Besides, the workforce in the agricultural sector is ageing and most agricultural businesses are struggling to recruit workers, especially large agricultural holdings. Hence, attracting new people or retaining of employees is important. This can be done by both financial and non-financial incentives. Relation towards the employees is a part of Corporate Social Responsibility (CSR) concept and stakeholder theory as workers are important internal group that is influenced by the company and at the same time influence the company. Therefore, the aim of the paper is to examine the relation of the large agricultural holdings in the Czech Republic towards their employees.

The article is based on the data from the survey mapping the socially responsible behaviour of large agricultural holdings in the Czech Republic with 133 representatives of the farms. The data was collected in October 2018. Almost all respondents acknowledged the importance of their employees. They communicated with them their decisions (mostly at the meetings) and provided them benefits to increase their satisfaction. The feedback was gained mostly by informal meetings. Considering the difficult situation on the labour force market, it was surprising that majority of agricultural holdings did not have elaborated strategy on attracting young people. The answers did not depend on the size of the farm which implicated that social responsibility towards the employees was very important for all of agricultural holdings for many reasons. Employees are understood not only as a production factor, but also represent important stakeholder from social point of view, because over half of companies stated that they employ some local people in agriculture also for the social reasons.

Key words: agricultural holding, corporate social responsibility, employees, relation, recruiting

JEL classification: Q19, J43, J24

1. Introduction

Czech farms belong to the one of the largest in the European Union. According to Eurostat (2022) farms over 100 ha cultivate 86.4% of the agricultural land. They breed almost 70% (68.3%) of livestock and employ around 2/3 (66.5%) of all farm labour force.

The number of agricultural workers has been decreasing due to increased productivity and because of the unattractiveness of the sector. Between 2016 to 2018, the number oscillated around 100 thousand, but decreased to 98,8 thousand in 2020. (MoA, 2021). Share on the total employment in the Czech economy is still low (1.9% in 2020). According to CZSO (2022), in comparison with year 2000, in year 2020 the share of large farms over 100 ha on employment decreased from 63.7% to 60.0% but is still very high.

The workers in age between 45–59 years had the highest share on the total employment in agriculture. Despite that the share of workers aged 45 years and more decreased to 40.0% in 2020, it is still higher than in national economy. (MoA, 2021). This causes problems

with generational renewal of agricultural labour force together with low share of young workers in the sector. Although, the the workforce in the agricultural sector is aging most agricultural businesses are struggling to recruit new workers. (Vodičková, 2021). The conditions in the sector are not motivational for many young people. Average wages in agriculture, including forestry and fishing, have long remained below the level of wages in industry and in the national economy as a whole. It was on 80.3% level in 2020. (MoA, 2021). The difficulties of agricultural firms in recruiting workers continued to worsen in 2020, as evidenced by 11.4% vacancy rate in the sector. (MoA, 2021). Hence, employees' retention is important. According to the Agrarian Chamber of the Czech Republic (2021) ninety percent of agricultural enterprises experience a shortage of workers, with most facing this problem year-round. Especially in larger agricultural holdings there is a problem with recruitment labour force which can be solved by both financial and non-financial incentives. "Socially responsible actions towards employees constitute an important theoretical component and a manifestation of the implementation of the CSR concept in business practice." (Matejun and Ratajczak, 2019)

Relation towards the employees is a part of Corporate Social Responsibility (CSR) concept that was elaborated by Carroll (1991) as workers are important stakeholders in the company. The pyramid of CSR expresses that the economic responsibility of the firm is the base. Then there are legal, ethical and philanthropic responsibilities. CSR concept can be linked to the stakeholder's theory (Windsdor, 2001). Freeman and McVea (2001) define the stakeholders as "any group or individual who is affected by or can affect the achievement of an organization's objectives". Stakeholders in a narrow sense are groups of people that are crucial for the achievement of corporate objectives. (Friedman and Miles, 2006). The key relationships for a business go far beyond the relations with its customers and include the relationships with its employees, suppliers and partners, investors and market analysts, government regulators, trade associations and others that influence the business climate. (Susniene and Sargunas, 2009).

According to Ali, Khan and Rehman (2013) employees' engagement is critical to organizational success as engaged employees are more productive and help organization in achieving its corporate goals. Employees expect from the organization that they get paid for their work and they aim on maximization of their wages. Besides, they expect long term perspective in their jobs. On the other hand, companies suppose that employees will do their job well.

The effect of CSR on employees was examined e.g. by Zhu and Yong (2013) who found out positive influence – the higher the level of social responsibility of the firm, the higher the level of employee performance. Factors influencing the safety of the employees were examined by Koo and Ki (2020) in Korea. They used regression analysis where CSR was and explained variable and number of workplace injuries was explanatory. The results show that higher CSR scores are associated with fewer working days lost due to the workplace injuries. Importance of employee-oriented CSR was stressed by Adamek and Bernatik (2014). Their findings show that managers of small and medium enterprises, who view their employees as legitimate stakeholders of the firm, will introduce employee-oriented CSR out of their sense of moral responsibility towards their employees bringing positive effect in entrepreneurial area as well as on employee's commitment. (Adamek and Bernatik, 2014). Tsourvakas and Yfantidou (2018) reached similar conclusion. According to them,

the employees are proud to identify themselves with companies that have a caring image and that they feel engaged, satisfied and motivated when their works contributes to the society. Matejun and Ratajczak (2019) found out that involvement of the agricultural companies in socially responsible actions towards employees were a source of specific economic and social benefits.

Světlíková, Korcová and Falteisková (2016) conducted guided interviews with the chief accountant and economist of medium sized agricultural holding in the Czech Republic and asked about the personnel composition of staff and the possibilities of attracting new workforce. We focus also on the Czech Republic and to larger agricultural holding, but the focus is on the point of view of the managers on the relation with the employees.

2. Materials and Methods

The aim of the paper is to examine the relation of the large agricultural holdings in the Czech Republic towards their employees. The data is a part of broader survey which examined the socially responsible behaviour of large agricultural holdings. The survey took place in October 2018 mainly by face-to-face interviews. When F2F CAPI was not possible, phone interviews (CATI) were done. External contractor asked managers or other higher management representatives of agricultural holdings that farm in municipalities with less than 2000 inhabitants.

133 representatives of the farms were surveyed, among them 82.0% were men. Age was mainly between 41 to 60 years (63.9%). 2/3 had university degree and 1/3 high school degree. The agricultural holdings employed 48 employees on average and farmed on 1282 ha of arable land and 1565 ha of all agricultural land on average. Majority of holdings were joint-stock companies (42.9%) or cooperatives (37.6%); the rest were limited liability companies. The most of agricultural holdings farmed in Středočeský, Jihočeský (both 16.5%) and Vysočina regions (15.0%) which corresponds to the structure of farms in the CR where the most farms are in Středočeský, Jihočeský and Jihomoravský region (there is the most of farms – 19.9%, contrast to 9.0 % in our sample).

Data gained by survey were statistically described. Then the hypotheses were tested in contingency tables by χ^2 test. Null hypothesis of this test states that the qualitative variables are independent. Alternative hypothesis reads that the variables are dependent. χ^2 test than compares empirical frequencies with theoretical values that are calculated as (1):

$$n'_{ij} = \frac{n_{i*} n_{*j}}{n} \quad (1)$$

where n'_{ij} are theoretical frequencies, n is number of observations and n_{i*} and n_{*j} are relevant marginal frequencies (sums of columns and rows). Then the test criterion G is calculated as (2):

$$G = \sum_{i=1}^r \sum_{j=1}^c \frac{(n_{ij} - n'_{ij})^2}{n'_{ij}} \quad (2)$$

where n_{ij} are empirical frequencies, r stays for row and c for column. G statistics approximately follows χ^2 distribution and when its value is higher than critical value ($\chi^2_{[r-1, c-1]}$) the null hypothesis is rejected. Similarly, when the p-value of the test is lower than

the level of significance (0.05 in our case), the null hypothesis is rejected in favour of an alternative hypothesis.

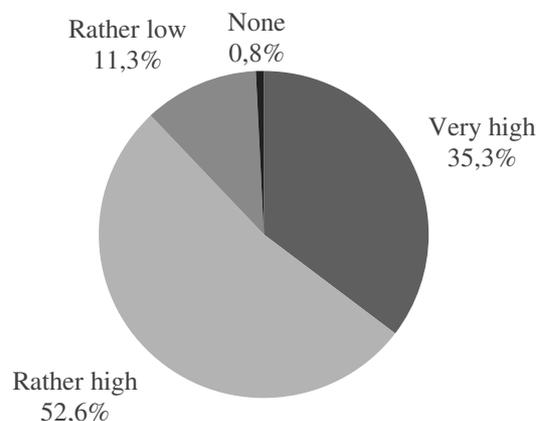
We tested whether the relation of agricultural holdings towards the employees depends on the size of agricultural holding. We divided the firms to 3 groups: 1000 ha or below (27.8% of the sample), from 1001 ha to 2000 ha (52.6%), from 2001 ha to 3000 ha (10.5%) and over 3000 ha (9.0%).

3. Results and Discussion

Relation towards the employees is a part of CSR as workers are important stakeholder of in the company. The representatives of agricultural holding acknowledged that communication with stakeholders was very important (64.7%) and rather important (34.6%) for them. Others stated that this was rather unimportant. Čotura, Čolak and Kožul (2022) found out that communication with stakeholders is important and that even the managers of small and medium enterprises provide a significant level of strategic approach to communication with stakeholders.

This is not surprising, because the managers acknowledge the influence of employees on the functioning of agricultural holding (see Figure 1). Majority of them thinks that their business is influenced by their employees. Only 11.3% view the employees' impact as rather low and 0.8% – 1 company – view as none). The dependence of the opinion on the size of the firm was tested in contingency table. The results are summarized in table 1. The opinion was the same across differed sizes of firms, because the view on the influence of employees on the functioning of agricultural holding did not depend on the size of the company. P-value was 0.185, so the null hypothesis could not have been rejected.

Figure 1. The influence of employees on the functioning of agricultural holding



Source: own elaboration, 2023, based on own survey, 2018

In 2/3 of cases (67.4%) the representatives of agricultural holdings also communicated or consulted with this stakeholder the decisions regarding the operation of the company. As Figure 2 suggests that this is the second most consulted group by the managers. At the first places, 87.8% of representatives of agricultural holdings consult their decisions with shareholders, investors and owners. This highlights their importance.

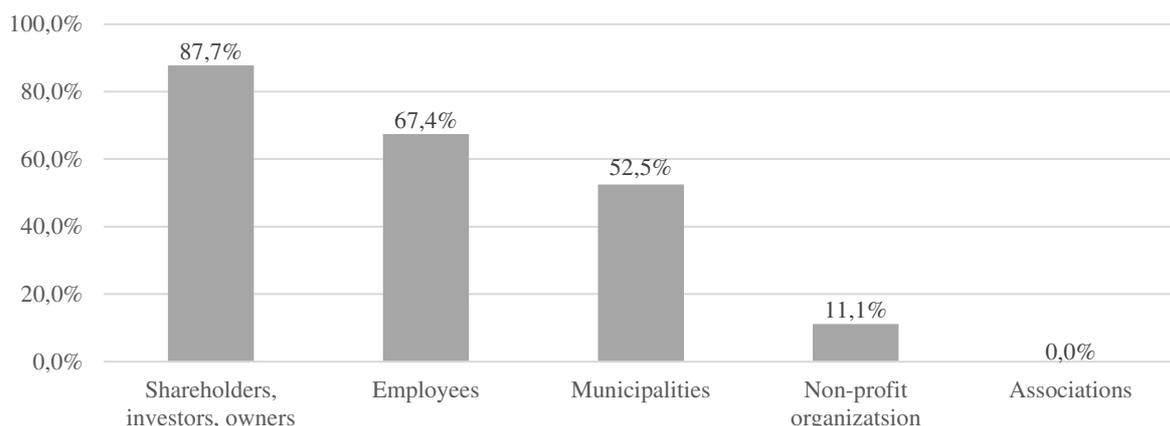
Similarly, as in previous case, whether the representatives of agricultural holdings consult the decision with the employees or not does not depend on the size of the farm (see Table 1).

P-value was 0.559 that is much higher than 0.05 level of significance. It can be interpreted that the involvement of employees in the decision-making process is deemed necessary by companies of all sizes. It is in line with the conclusions of Laur and Danilovic (2020) who examined the influence of the stakeholders on the change in organization and found out that internal stakeholders were actively engaged in the process of the change, while external stakeholders were included only to a limited extent. Similarly, Čotura, Čolak and Kožul (2022) found a correlation between managers' commitment to communication to stakeholders and the perceived power of stakeholders to influence the company.

When the companies consult the decision with the employees it is only during personal meetings. Other ways of communications were not mentioned. However, the level of formalization of those meetings is not known, because the question did not distinguish the formal meetings (consultations) from informal meetings.

As a follow up questions, the managers were to sort the stakeholders according to their importance for functioning of the company. Most respondents put shareholders / investors / owners and employees in the first two places. Municipalities were most often mentioned in third place. On the contrary, trade unions and associations were almost not included in the selection (only once in 2nd and once in 3rd place). The most common combination was that employees were put first, then shareholders / investors / owners and finally the municipality. Also, in terms of importance, the same combination was mentioned very often, only with the first two places swapped. Over half of agricultural enterprises (54.1%) considered employees to be the most important for the operation of the enterprise from a social and economic point of view. It is good that the feedback is gained because "Organization-stakeholder relations lead to new ideas about the responsibilities of organizations, the role of managers, and the most appropriate management style." (Susniene and Sargunas, 2009).

Figure 2. Communication with stakeholders about decisions regarding the operation of the agricultural holding



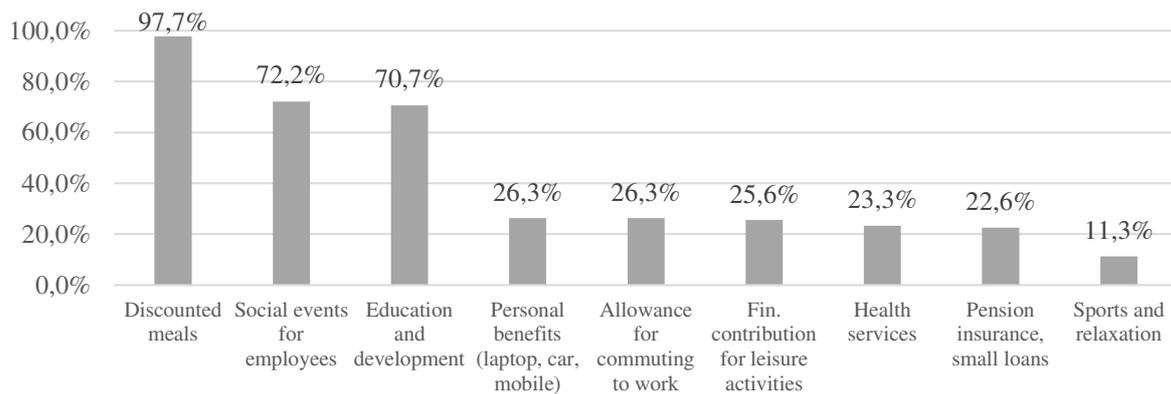
Source: own elaboration, 2023, based on own survey, 2018

One of the manifestations of the importance of the employees was that the benefits of a non-financial nature were offered to the them. From Figure 3 can be seen that almost all firms offered discounted meals (97.7%). Companies also organized social events for employees (72.2%) and provided further education for the development of the employees (70.7%). However, only 9.0% had system that ensured the professional development of employees

(career development plans). Other benefits were provided only in around ¼ of companies. The least offered benefits were sports and relaxation activities.

Hypothesis testing which results are displayed in Table 1 revealed that almost all of the benefits were independent on the company size. In all cases with the exception of allowance for commuting to work, the p-values were higher than 0.05 level of significance. Smaller or larger holdings offered various benefits in the similar volume and structure. The only difference is provision of the allowance for commuting.

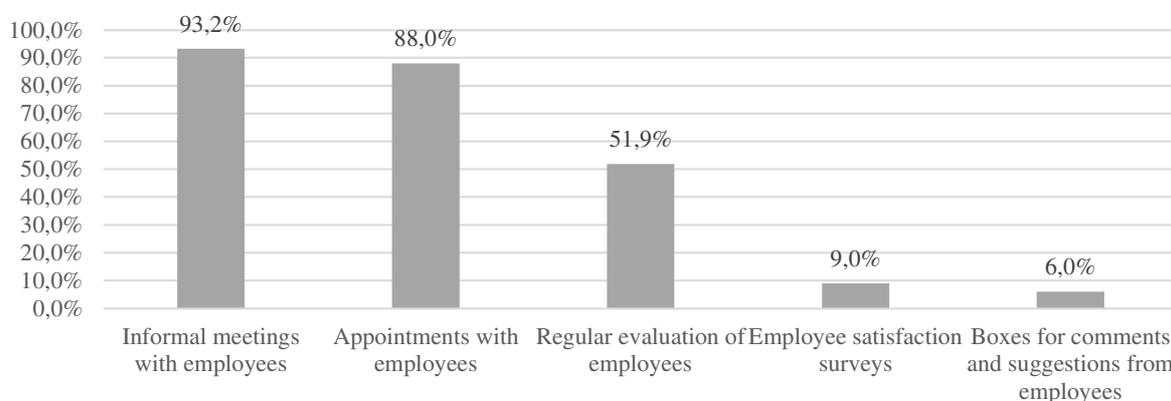
Figure 3. Employee benefits of a non-financial nature provided to the employees



Source: own elaboration, 2023, based on own survey, 2018

The feedback from the employees should be collected to examine their job satisfaction. Matejun and Ratajczak (2019) even found out in their survey that employee satisfaction surveys and data protection and protection of employee privacy were key socially responsible actions towards employees. All feedback possibilities from the questionnaire are displayed at Figure 4. The employers observed the employees' satisfaction to get feedback mostly by informal meetings (93.2%) or formal appointments (88.0%). Again, the independence was found by the tests in contingency tables (see Table 1). As in previous cases, the type of the feedback did depend on the size of the company.

Figure 4. Means of employee satisfaction survey

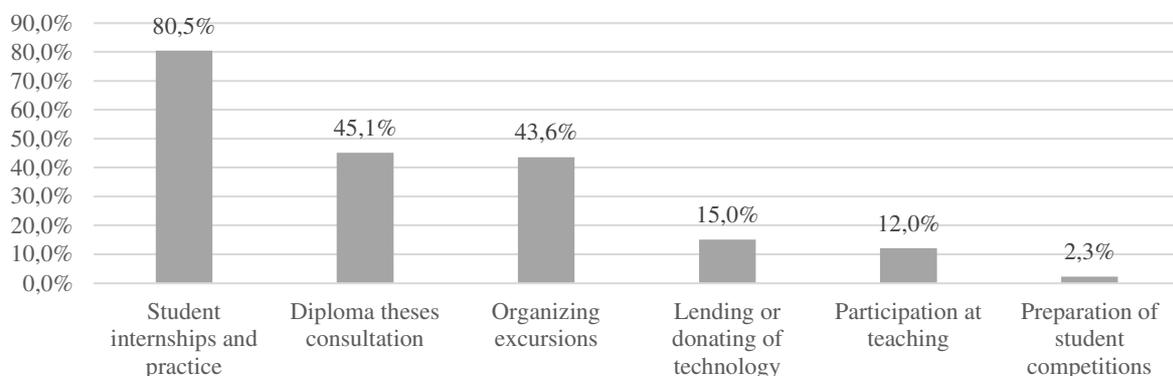


Source: own elaboration, 2023, based on own survey, 2018

Considering the difficult situation on the agricultural labour force market, it is surprising that only 18.0% of agricultural holdings had strategy on attracting young people. On the other

hand, regarding the cooperation with schools, most of the companies provided student internships (80.5%). Over 40.0% of companies also consulted diploma thesis or organized excursions. (see Figure 5).

Figure 5. Cooperation with all types of schools



Source: own elaboration, 2023, based on own survey, 2018

Table 1. Results of dependency testing in contingency tables

Null hypothesis H ₀ :	d. f.	Pearson χ^2 test criterion	P-value of χ^2 test
Opinion on the influence of employees on the functioning of agri-holding does not depend on size	9	12.5283	0.185
Whether the representatives of agri-holdings consult the decision with the employees does not depend on size	3	2.0660	0.559
Whether the agri-holding offers discounted meals for employees does not depend on size	3	5.6139	0.132
Whether the agri-holding does social events for employees does not depend on size	3	0.7406	0.864
Whether the agri-holding provides education and development does not depend on size	3	1.9581	0.581
Whether the agri-holding provides personal benefits does not depend on size	3	5.2765	0.153
Whether the agri-holding provides allowance for commuting to work does not depend on size	3	7.9449	0.047
Whether the agri-holding provides contribution for leisure activities does not depend on size	3	4.2950	0.231
Whether the agri-holding provides health services does not depend on size	3	0.6094	0.894
Whether the agri-holding provides pension insurance or small loans does not depend on size	3	2.6855	0.443
Whether the agri-holding provides sports or relaxation does not depend on size	-	too few observations	-
Whether the agri-holding does informal meetings with employees does not depend on size	3	1.1506	0.765
Whether the agri-holding does appointments with employees does not depend on size	3	2.7685	0.429
Whether the agri-holding regularly evaluate the employees does not depend on size	3	1.5174	0.678
Whether the agri-holding does employees' satisfaction surveys does not depend on size	3	1.9561	0.582
Whether the agri-holding has boxes for comments and suggestions does not depend on size	-	too few observations	-

Source: own elaboration, 2023, based on own survey, 2018; Note: d. f. = degrees of freedom

Over half of companies (55.6%) stated that they employ local people in agriculture also for the social reasons. And what is more, agricultural holdings with non-agricultural activities (35.0% of all cases), in 30.0% of cases (14 agricultural holdings) employ local people in order to retain employment in the municipality.

It can be seen that also social aspect of employing people is important for certain companies. Despite the fact that employees are “classified” in the economic area of CSR as stakeholders in our contribution, their importance goes beyond this category. It is a matter of fact that employees are important resource for economic prosperity and performance. For example, Dumitrascu and Simionescu (2015) proved by OLS regression that higher level of social responsibility towards employees influence positively economic situation (particularly indicators ROE and ROA) of the firms (listed companies in Romania between years 2009–2013). However, this is only one dimension that they are often seen as production factor only. Matejun and Ratajczak (2019) show on the example of Polish farm, that if a company undertakes socially responsible activities towards its employees, it has a number of specific economic and social benefits. Not only that financial performance of the company improves, but also image of the company increases which leads to higher trust from the stakeholders.

Indeed, in certain cases they also employ agricultural workers for “social reasons”. It is therefore possible to think about some fluidity of the position of employees in agriculture. On one hand, the company understands employees as a “production factor”, that is why they are building relations with, communicated with, benefits are granted to them, etc. But on the other hand, employing elderly or disadvantaged people, etc., is not entirely economically rational. Regarding the reasons why agricultural companies do that, in addition to the social awareness of the managers, the reason for employing these people may also be that they are local and available (because agricultural holdings cannot find young people). The main activity of attracting young people that is done from the side of agricultural holdings is providing internships to young students. However, they are probably not doing enough for the economic area of social responsibility as the average age of employees in agricultural companies is still increasing.

4. Conclusion

The focus of the article was on big farms because Czech farms belong to the largest in the EU in terms of their acreage. The aim of the paper was to examine the relation of the large agricultural holdings in the Czech Republic towards their employees. We built on the theory of Corporate social responsibility and stakeholder theory. The employees were understood by surveyed farm management mainly as a production factor (a part of economic dimension of CSR pyramid), but also as one of the important internal stakeholders.

A primary survey was conducted in 2018, which asked 133 representatives of agricultural holdings. Almost all respondents acknowledged the importance of their employees. They tried to communicate with them their decisions (mostly at the meetings). Also, benefits were provided to increase their satisfaction. The feedback was gained mostly by informal meetings. Considering the difficult situation on the labour force market, it was surprising that only few agricultural holdings had elaborated strategy on attracting young people. On the other hand, majority of them provided students internships and practice. The answers did not depend on the size of the farm which has implication that social responsibility towards the employees

was very important for agricultural holdings of all sizes for many reasons. Employees were not always understood from economical point of view as production factor only, but also represent important stakeholder from social point of view. Over half of companies stated that they employed some local people also for the social reasons.

Acknowledgements

This paper was created within the project of the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0923, Internal Research Project no. 1117/2023.

References

- Adamek, P. and Bernatik, W. (2014). “Employee Perception of Corporate Social Responsibility”, *Crafting Global Competitive Economies: 2020 Vision Strategic Planning & Smart Implementation*, vol. I-IV, pp. 966–974, doi.org/10.3389/fpsyg.2022.948363
- Agrarian Chamber of the Czech Republic, Průzkum: Zemědělským podnikům chybí až pětina lidí, 2021. [Online], Available: <https://www.businessinfo.cz/clanky/pruzkum-zemedelskym-podnikum-chybi-az-petina-lidi/> [Accessed: 03 Mar. 2023] (In Czech)
- Ali, I., Khan, S. U. R. and Rehman, I. U. (2013). “How Corporate Social Responsibility and Corporate Reputation Influence Employee Engagement?” *Transformations in Business & Economics*, vol. 12, no. 1A, pp. 354–364
- Carroll, A. B. (1991). “The pyramid of corporate social responsibility: Toward the moral management of organizational stakeholders”, *Business Horizons*, vol. 34, no. 4, pp. 39–48, ISSN 1873-6068, DOI 10.1016/0007-6813(91)90005-G
- Čutura, M., Čolak, A. and Kožul, I. (2022). “Communication Commitments and Stakeholder Power: Case of Business Sector in the Federation of Bosnia and Herzegovina”, *Proceedings of the 11th International Scientific Symposium on Region, Entrepreneurship, Development*, Osijek, Croatia, pp. 113–125, ISSN 1848-9559
- CZSO, Czech Statistical Office, Integrované šetření v zemědělství - analytické vyhodnocení – 2020, 2022. [Online], Available: <https://www.czso.cz/csu/czso/prilohy-k-casti-ii-t2swyh392b> [Accessed: 28 Feb. 2023] (In Czech)
- Eurostat, European Statistical Office, Farms and farmland in the European Union – statistics. Brussels, 2022. ISSN 2443-8219, [Online], Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#Farms_in_2020 [Accessed: 28 Feb. 2023]
- Freeman, R. E. and McVea, J. (2001). “A Stakeholder Approach to Strategic Management”, Oxford, Blackwell Publishing, DOI 10.2139/ssrn.263511
- Friedman, A. L. and Samantha Miles, S. (2006). “Stakeholders: Theory and Practice”, Oxford, Oxford University Press, ISBN 0-19-926986-6
- Koo, J.E., and Ki, E.S. (2020). “Corporate Social Responsibility and Employee Safety: Evidence from Korea”, *Sustainability*, vol. 12, no. 7, Article Number 2649, DOI 10.3390/su12072649
- Laur, I. and Danilovic, M. (2020). “Enabling change within new forms of organisations: an empirical investigation of change patterns and stakeholder influence on core intermediary

activities”, *Journal of Organizational Change Management*, vo. 33, no. 6, pp. 1041–1070, DOI 10.1108/JOCM-01-2020-0026

Matejun, M. and Ratajczak, M. (2019). “Economic and social benefits of socially responsible actions towards employees in agribusiness enterprises”, *Management*, vol. 23, no. 2., pp. 49–63, ISSN 1429-9321, DOI 10.2478/manment-2019-0018

MoA, Ministry of Agriculture of the Czech Republic, Zpráva o stavu českého zemědělství v roce 2021, 2022. [Online], Available: <https://eagri.cz/public/web/mze/ministerstvo-zemedelstvi/vyrocnni-a-hodnotici-zpravy/zpravy-o-stavu-zemedelstvi/> [Accessed: 24 Apr. 2023] (In Czech)

Susniene, D. and Sargunas, G. (2009). “Prerequisites of Stakeholder Management in an Organization”, *Inzinerine Ekonomika – Engineering Economics*, vol. 61, no. 1, pp. 58–64, ISSN 2029-5839

Světlíková, D., Korcová, R. and Falteisková, S. (2016). “Active Employment Policy Instruments in Environment of Agricultural Company”, *Proceedings of the Political Sciences, Law, Finance, Economics and Tourism Conference*, vol. II, Albena, Bulgaria, pp. 517–524, ISBN 978-619-7105-73-5

Tsourvakas, G. and Yfantidou, I. (2018). “Corporate social responsibility influences employee engagement”, *Social Responsibility Journal*, vol. 14, no. 1, pp. 123–137, DOI 10.1108/SRJ-09-2016-0153

Vodičková, R. (2021). “Práce v zemědělství mladé lidi příliš neláká.”, *Statistika&My*, vol. 11, no. 11–12, pp. 36–37, ISSN 1804-7149, [Online], Available: <https://www.statistikaamy.cz/2021/12/15/prace-v-zemedelstvi-mlade-lidi-prilis-nelaka> [Accessed: 03 Mar. 2023] (In Czech)

Windsor, D. (2001). “The future of corporate social responsibility”, *International Journal of Organizational Analysis*, vol. 9, no. 3. pp. 225–256, ISSN 1934-8835

Zhu, L.Y. and Yong, S.H. (2013). “The Effect of Corporate Social Responsibility on Employees”, *Proceedings of the International Conference on Information Management Innovation Management and Industrial Engineering*, Xian, China, pp. 268–271, ISSN 9781479902439, DOI 10.1109/ICIII31646.2013

THE INFLUENCE OF EDUCATION ON THE CONSCIOUS PURCHASE AND CONSUMPTION OF FOOD

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Annotation: A part of negative impact of climate change mitigation process is the reduction of greenhouse gas emissions, to which population can contribute through individual behavior (e. g. consumption habits, shopping scenarios, sustainability of travel ways and types, type of products used, etc.). The way people eat affects all areas of their lives; it became a sign of their lifestyle. Nutrition type is one of the most important main externalities influencing health status of everyone as well as the entire population. The main goal of this paper is through statistical analysis and testing to formulate influence intensity of selected factor "education" on ecological behavior of Czech population during purchase and consumption of food. Education is closely related to lifestyle as one of the most decision-making factors including food price shaping the way of eating. A subset of consumption behavior is the customer's purchasing behavior. A more detailed analysis from the perspective of sociodemographic characteristics has shown some differences in attitudes and purchasing or consumer behavior. In terms of age, there is a certain generational divide, particularly in items related to purchasing behavior and food preparation. In case of education, the analysis has focused on the dimensions of purchasing behavior and the environment. It has been shown that education is one of the factors that influences the importance of main factors when purchasing food and the value which consumers attach to environmental aspects. People with higher education levels engage more frequently in activities that are beneficial for the environment and related to the purchase and consumption of food. Similarly, the importance of reasons for reducing food waste is linked to education. People with higher education levels are more likely to see "food waste as a major problem".

Key words: ecological behaviour, food habits, shopping preferences, education, public opinion research, time serie.

JEL classification: D12, C83, C22, I25

1. Introduction

Humankind should now more than ever be interested in and concerned about the environment, climate, restoration, equality, and overall sustainability (Rep, 2021). Across all areas and industries, there is an increasing emphasis on environmental aspects and sustainability (Pindešová et al., 2022). In recent decades, we have witnessed globalization that directly impacts changes in agricultural production and also affects food consumption (Steininger and Smutka, 2022). Responsible shopping and consumption behavior can be explained as consumers' interest in ethical, environmental, and ecological aspects, including the social impacts of their decision-making (Musová et al., 2018). People's dependence on processed foods and dietary habits based on high meat consumption potentially results to negative consequences for personal health as well as environmental sustainability (Cullen et al., 2015, Slater et al., 2018, Thomas et al., 2019). The amount of food waste and waste generated from ready meals and packaged food production worsen environmental pollution (Melikoglu et al., 2013, Zhang et al., 2021). Food consumption is associated with various environmental impacts, and therefore, the consumers food choice represents an important environmental decision (Tobler et al., 2011).

Current food consumption patterns are considered to be the main barriers to responsible shopping and dietary behavior, such as consuming fresh and healthy foods, purchasing locally produced foodstuff, reducing meat consumption, and limiting food waste (Monroe et al., 2015). In the future, changes in consumer behaviour can be expected. The growing concern for reducing the ecological impact of food production, in accordance with sustainable development, could be a significant turning point in the consumption patterns of Czech people. One possible solution to reducing the negative impacts of nutrition on the environment is consumer food literacy. Food literacy is comprehensively defined as “the scaffolding that empowers individuals, households, communities or nations to protect diet quality through change and strengthen dietary resilience over time” (Thompson et al., 2021). Stinson (2010) described food literacy as "the ability to deeply understand the complex environmental and social factors of food in everyday life." Cullen et al. (2015) described it as "the ability to develop a positive relationship with food and individual skills and behaviors in the context of a complex food system" and "the ability to make sustainable and proper decisions with respect to various factors of the food system." According to current studies, the concept of food literacy has expanded from knowledge of nutrition and health information to ethical and environmental aspects (Vidgen and Gallegos, 2014; Ronto et al., 2016). The main reasons why people practice ecological dietary behavior are not only to protect their own health and safe food systems, but ultimately to achieve global sustainability goals for the needs of future generations (Osbaldiston and Schott, 2012; Wang, 2016). The term ecological dietary behavior is therefore often compatible with pro-environmental or sustainable food consumption and has become a significant topic since people realized that environmental issues are directly related to survival of humankind (Guyonard et al., 2021). It has been confirmed that people who achieve a high level of food literacy strive to develop healthy dietary habits and apply ecological dietary behavior in their everyday lives (Rosas et al., 2022; Poelman et al., 2018; Meyer et al., 2021).

Due to the easy availability of food, a wide range of products, and massive food production, food waste has become one of the major sustainability issues today. It is expected that by 2050, the amount of food waste will be more than double compared to the present (Hic et al., 2016). Food surplus and waste are key problems affecting economic and environmental sustainability (Richards and Hamilton, 2018). The global food system consumes enormous resources to satisfy consumers' demand for food, significantly contributing to environmental impacts (Springmann et al., 2018, Willet et al., 2019). Higher food quality is associated with greater food waste, resulting in significant amounts of wasted resources and greenhouse gas emissions (Conrad and Blackstone, 2021). Food waste has made it difficult to align sustainable social development and environmental sustainability with economic principles. This is the reason why the sharing economy will play a crucial role in achieving food sector sustainability and is considered as a fundamental approach promoting environmental sustainability and economic conditions effective way in (Morone et al., 2017).

The thematic of responsible decision-making in food purchases and responsible nutrition is currently a significant societal topic. Therefore, the aim of this article is to evaluate and verify the impact of "education" on selected aspects of responsible behavior of Czech consumers in food purchase and consumption.

2. Materials and Methods

In the article, ecological behavior in food purchase and consumption is evaluated based on a statistical analysis of a data matrix ($n = 821$) from the most recent quota sample survey on Food from 2022 conducted by the Public Opinion Research Centre (2022), Institute of Sociology of the Czech Academy of Sciences. Comparison of trends and attitudes over time was made based on survey from the previous year 2020 ($n = 979$). The surveys represent the population of the Czech Republic aged 15 and over. Questions and statements were categorized into the following five dimensions: ethical, environmental, purchasing and consumption behavior, food preparation, and the impact of expiration date. The article focuses on selected aspects of the purchasing behavior dimensions and the environmental dimension in relation to the respondents' education. The data collection method used was a standardized interview. The data collection was conducted by trained interviewers from the the Public Opinion Research Centre interview network. Respondents were selected using a quota sampling method to ensure representativeness. According to Reichel (2009), quota sampling is a typical non-probability sampling method and is commonly used in public opinion surveys. Its principle guarantees the necessary representativeness of the sample. The quota characteristics of the respondents were gender, age, and education. The quotas were set based on data from the Czech Statistical Office (2023a).

The survey results were presented by relative frequencies of responses to selected questions and visualized by graphs of interactions between frequencies. The Pearson's χ^2 -test (chi-squared) test was used to verify the influence of the "education" factor on conscious shopping, opinions, and attitudes of Czech consumers.

$$\chi^2 = \frac{n(ad-bc)^2}{(a+b)(a+c)(b+d)(c+d)}, \text{ resp. } \chi^2 = \sum_{i=1}^r \sum_{j=1}^s \frac{(n_{ij}-n_{oj})^2}{n_{oj}} \quad (1)$$

The level of correlation was assessed based on the coefficient of association:

$$|V| = \sqrt{\frac{\chi^2}{n}} \quad (2)$$

and Cramer V:

$$V = \sqrt{\frac{\chi^2}{n(h-1)}} \quad \text{pro } h = \min(r, s) \quad (3)$$

To assess the impact of university education, in selected cases, the odds ratio was used to summarize the relationships between associated frequencies.

$$OR = \frac{ad}{bc} \quad (4)$$

TIBCO Statistica 14.0.0.15 software for Windows was used for statistical analysis. The significance level was set to 0.05.

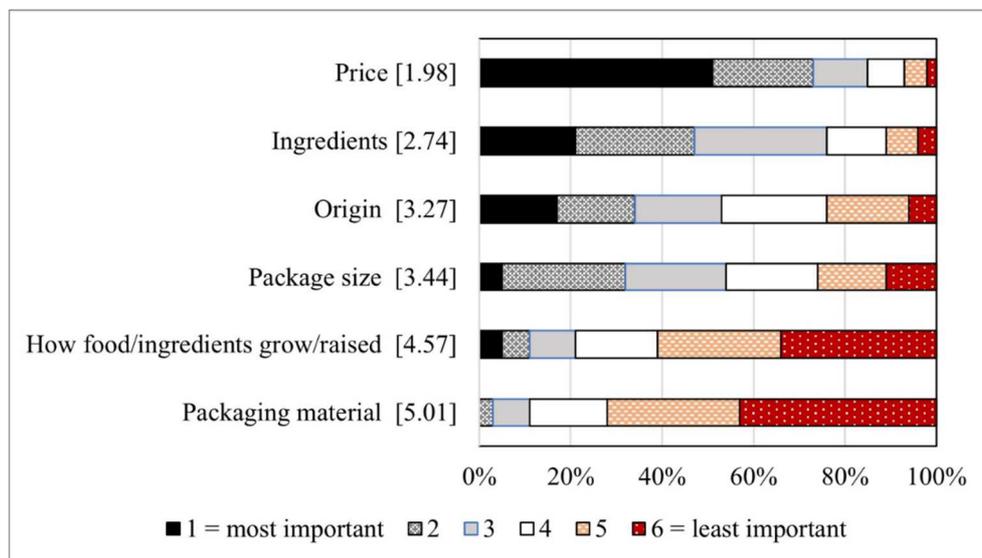
3. Results and Discussion

Purchasing food is a significant item in the budget of Czech households. According to the Czech Statistical Office (2023b), in 2021, expenses on food (excluding restaurants and alcoholic beverages) represented more than one-fifth of all consumer expenditures of households; in households with pensioners without working members, it was nearly one-fourth.

Based on the analysis of data obtained through surveys conducted by the Public Opinion Research Centre (2022), it is emerged that for respondents, and consequently for the Czech public, the most important aspect when buying food is unquestionably its price (see Figure 1), identified as the key decision making factor indicated by more than half (51%) of respondents.

About one-fifth (21%) of respondents consider the composition of the food to be the most important factor when shopping for groceries. Respondents chose the origin of the food as the third most important factor, followed by package size with an average value of 3.44 (on a scale of 1 to 6, where 1 is the most important and 6 is the least important). People do not attach much importance to the remaining two factors - the method of animal husbandry/cultivation of food or its raw materials, and packaging material. This is especially valid for packaging material, which was identified as the "least important" factor by 43% of respondents.

Figure 1. Importance of main factors when buying food in 2022 - distribution of responses; n = 705 (only those respondents who buy food)



Source: own processing; data - Public Opinion Research Centre (2022), Institute of Sociology, Czech Academy of Sciences, 'Food' 2022; respondents over the age of 15; face-to-face interviews
 Pozn.: V závorce uvedeno průměrné pořadí (viz hodnocení na škále 1 až 6)

The comparison over time shows the ranking of factors importance when shopping for food between 2020 (Public Opinion Research Centre, 2020) and 2022 (Public Opinion Research Centre, 2022) has not changed, however, there is a slight increase or decrease in their importance year-on-year. Compared to the results from the previous survey, there has been an increase in the importance of price (average score of the importance of price in 2021 = 2.31), which may be related to the current economic situation (inflation, energy crisis). For other factors, the shifts were not as significant.

An influence of education on the importance of price, composition, and package size was demonstrated (see Table 1). The relationship can be considered statistically significant and weak with 95% reliability. Dimitri and Dettmann (2021) confirmed that education has a strong impact on the likelihood of purchasing organic food, which can be considered a category of products with a responsible approach.

Across educational categories (basic and secondary education without graduation; secondary education with graduation, tertiary education), no difference in the assessment of the importance of these factors has been demonstrated: origin; how food/ingredients are grown/raised and packaging material. This can be explained, for example, by the fact that the place of production origin is equally significant for all groups of shoppers in the case of food, and similarly, how food/ingredients are grown/raised and packaging material. The research by Walaszczyk and Galińska (2020) also arrived at the same result of negligible impact of education on the influence of product origin and production method. The study by Stávková et al. (2007) also demonstrated a low or negligible impact of packaging. Furthermore, people in the Czech Republic generally do not attach great importance to these aspects when purchasing food (see Figure 1 and Table 1).

Table 1. The results of dependence test related to importance of different shopping factors on education level (n = 705, only those respondents who buy food)

Various factors people take into consideration when shopping for food	χ^2	DF	p-value	Cramér's V
Price	31.4425	12	0.0017	0.1484
Ingredients	35.6909	12	0.0004	0.1581
Origin	13.1871	12	0.3556	-
Package size	27.4511	12	0.0067	0.1387
How food/ingredients grow/raised	17.8509	12	0.1203	-
Packaging material	9.6054	12	0.6505	-

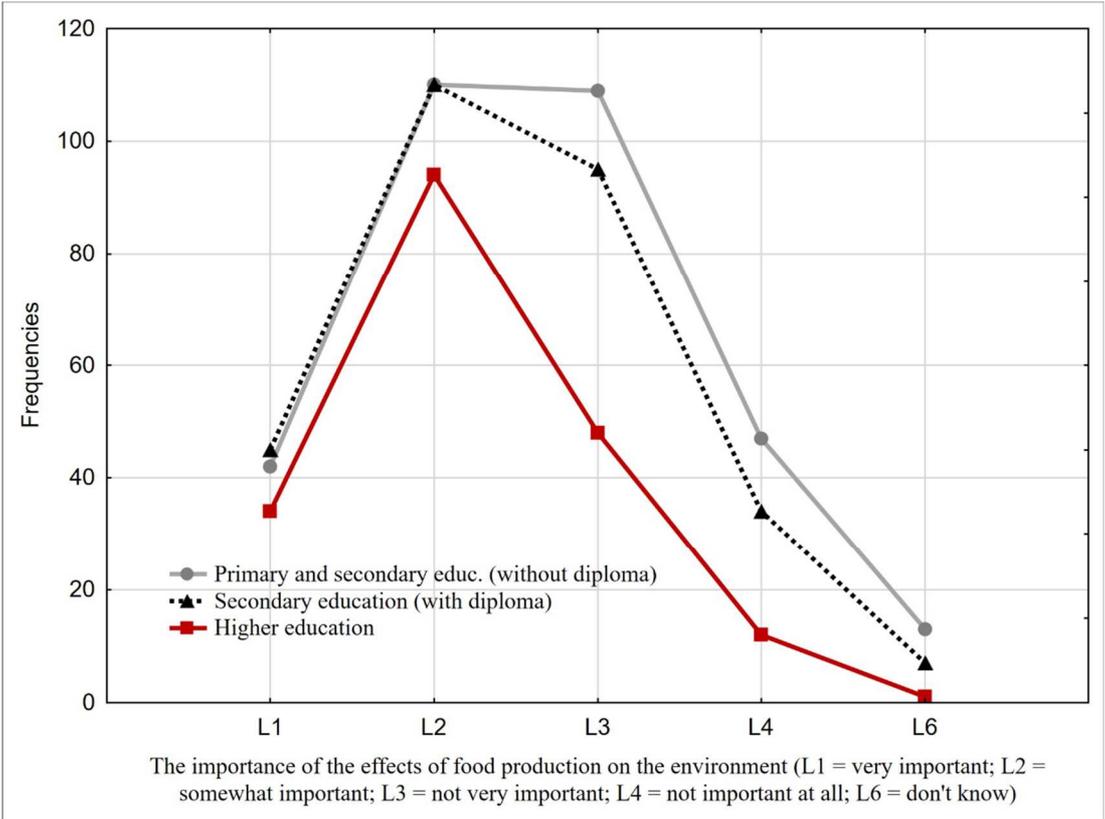
Source: own processing; data - Public Opinion Research Centre (2022), Institute of Sociology, Czech Academy of Sciences, 'Food' 2022; respondents over the age of 15; face-to-face interviews

Furthermore, as indicated by the analysis of data obtained through surveys conducted by the Public Opinion Research Centre (2022), Czechs mostly buy food (regularly or occasionally) at hypermarkets/supermarkets (97%), smaller shops (92%), or specialized stores such as butchers or bakeries (86%). Other options are less common, as only half, or fewer respondents regularly shop there. Half (50%) of those surveyed regularly or occasionally go to the regular market, 42% to a farm shop or healthy food store, and 42% to a farmers' market. A third (33%) of people also occasionally buy directly from growers and breeders. 20% of respondents stated that they regularly or occasionally use online shopping (an increase of 5% compared to 2020). Only 15% of people occasionally shop in a packaging-free store.

Moreover, the findings from the 2022 public opinion survey (Public Opinion Research Centre, 2022) further indicated, that for over half of the respondents (51%), the impact of food production on the environment is important when buying food, while for 47% it is not important. According to Smith and Paldino's findings (2010), concerns about the environment lead to positive attitudes towards sustainable food. The remaining 2% of respondents were unable to answer and chose the option "don't know". The importance attached to the impact of food production on the environment when purchasing food has not changed in recent years. Statistical analysis of the data also showed that respondents have a clear opinion (agree or disagree) on all statements related to environmentally friendly behaviour when buying and consuming food. A relatively small proportion of respondents always chose the neutral option ("neither agree nor disagree").

Further testing has shown a statistically significant relationship between attitudes towards the importance of the environmental impact of food production and the education level of respondents ($\chi^2 = 25.1505$; $DF = 8$; $p = 0.0015$; $V = 0.1253$), as shown in Figure 2. The largest difference between education categories was in the frequency of choosing the answer "not very important". As the level of education increases, the proportion of respondents for whom the environmental impact of food production is “definitely” and “rather important” when shopping for food increases. As indicated by the odds ratio value - $OR = 2.0847$, highly educated individuals consider the impact of food production on the environment twice as important when shopping for food as those with lower levels of education.

Figure 2. Interaction plot - Dependence of the environmental impact of food production importance on the education level of respondents - distribution of answers; $n = 705$ (only those respondents who buy food)



Source: own processing; data - Public Opinion Research Centre (2022), Institute of Sociology, Czech Academy of Sciences, 'Food' 2022; respondents over the age of 15; face-to-face interviews

The Public Opinion Survey Research Centre (2022) conducted in 2022 further revealed, that as beneficial activity with positive impact on environment can be considered fact, that Czechs mostly bring their own bags when shopping (at least occasionally 91 %). This means that a large portion of shoppers are aware that one way how to contribute to the environment friendly behaviour is to manage packaging and try to regularly use their own bags for shopping. These results correspond with a study (Tobler et al., 2011), which also found that consumers believe that the strongest impact on the environment is avoiding excessive packaging. 84% of respondents prefer food locally produced in the Czech Republic. The relationship between knowledge of food origin and ecological dietary behaviour was confirmed by Perry et al. (2017).

The data from the Public Opinion Research Centre (2022) show, that about 70% of respondents at least occasionally avoid single-use plastic packages and use their own reusable bottles for drinking. Just under three-fifths of respondents said they at least occasionally prepare food in their own boxes (58%). A third (33%) of respondents at least occasionally buy fruits and vegetables in so-called "endless bags". All environmentally friendly activities related to the purchase and consumption of food are more commonly performed by women and mostly by people with higher education levels. The finding of a higher level of food literacy among women compared to men is confirmed by Sponselee et al. (2021). Krause et al. (2018) argues that food literacy is also related to higher education levels.

Regarding the time comparison (see Table 2), there has been a shift in most items compared to the 2020 survey of the Public Opinion Research Centre (2020), particularly observed is an increase in the proportion of those who engage in these activities at least occasionally. The highest increase (by 21%) was observed in the use of their own reusable bottles for drinking, while the proportion of those who prefer food produced in the Czech Republic increased by 7%, as did the proportion of those who prepare their own food in their own boxes.

Table 2. Changes in environmentally beneficial activities related to food purchase and consumption. in ČR 2020 – 2022

Environmentally friendly household behaviours	2020 [%]	2022 [%]	Difference
I use own bag for shopping	85	91	+6
I prefer food locally produced in ČR	77	84	+7
I avoid single-use plastic packages	65	71	+6
I prefer use of own reusable bottle for drinking	48	69	+21
I prepare my own food in own boxes	51	58	+7
I buy fruits and vegetables in so-called "endless bags"	38	33	-5

Source: own processing; data - Public Opinion Research Centre (2020, 2022), Institute of Sociology, Czech Academy of Sciences, 'Food' 2020 and 2022; respondents over the age of 15; face-to-face interviews
Note: The values in the table represent the sum of responses "always" + "often" + "sometimes". The calculation to reach 100% includes responses "rarely", "never" and "don't know".

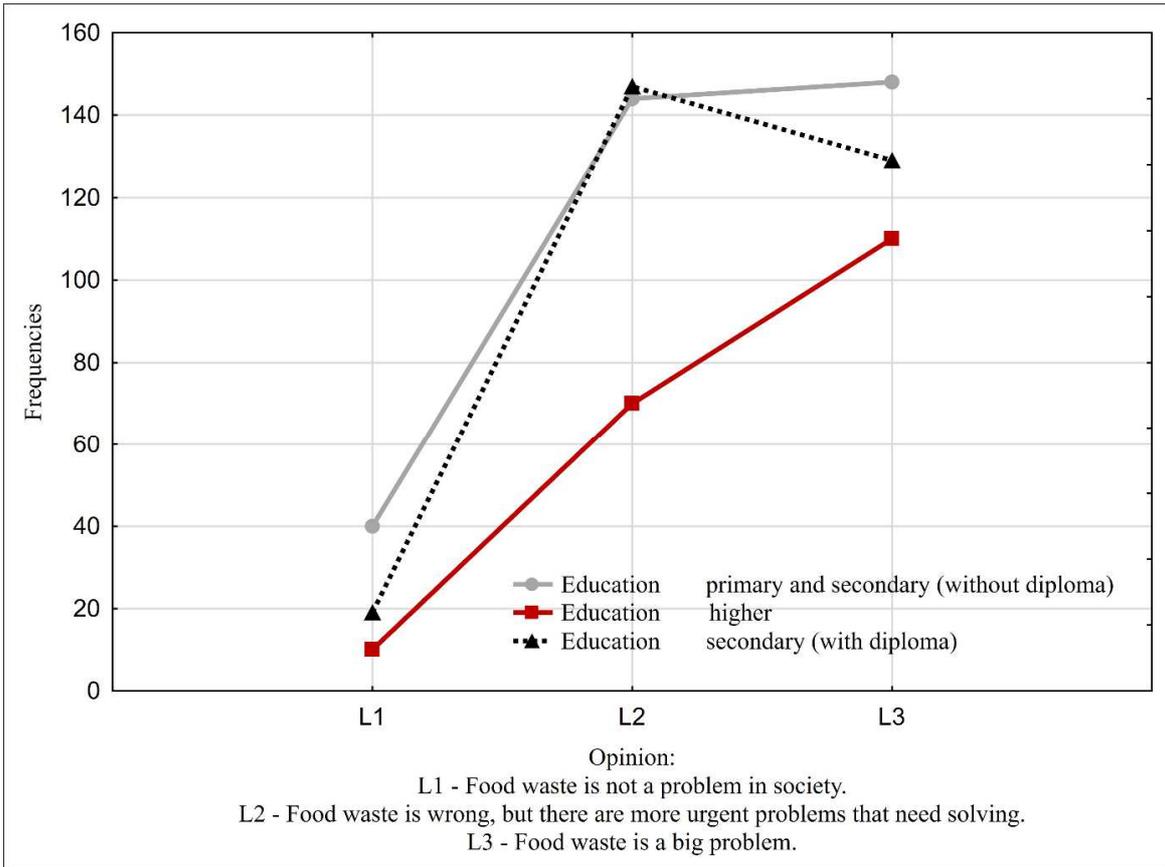
The Conscious food purchasing, and consumption is closely related to food waste. Currently, it represents a significant global challenge with has environmental, economic, and social impacts (Sujita et al., 2023; Some et al., 2022). The topic is transformed to one of the United Nations Sustainable Development Goals - to halve per capita global food waste at the retail and consumer levels and reduce food losses throughout the entire production and supply chain, including post-harvest losses, by 2030 (FAO, 2011).

Furthermore, as indicated by the analysis of data obtained through surveys conducted by the Public Opinion Research Centre (2022) revealed that, nearly half (47%) of the respondents consider food waste to be a major problem, according to another 44%, food waste is not right, but there are more pressing issues that need to be addressed, and only less than a tenth (9%) of the Czech public does not see food waste as a societal problem. Compared to the survey from 2020 of the Public Opinion Research Centre (2020), there has been a slight increase (5%) in the proportion of those who consider food waste to be a major

problem, and conversely, a decrease (5%) in the proportion of those who do not consider food waste to be a societal problem.

Attitude towards food waste is related to the shopping location. The data from the Public Opinion Research Centre (2022) show, that the respondents who regularly shop at farmers' markets, farm stores, directly from growers or breeders, or at zero-waste stores were more likely to lean towards the opinion that "food waste is a big problem." The same opinion was also more often expressed by women (56%; men 37%), people over 55, and people with university education (58%). The results of previous studies show that age (Janssen, 2018), gender (Budhathoki and Pandey, 2021), and education (Teng et al., 2011) are directly related to consumers' attitudes towards food handling. The dependence of the attitude towards food waste on education is, based on the Public Opinion Research Centre (2022), statistically significant ($\chi^2 = 19.0954$; $DF = 4$; $p = 0.0008$; $V = 0.1081$). The largest difference between educational categories of respondents was in the frequency of choosing the answer "Food waste is wrong, but there are more urgent problems that need solving," as shown in Figure 3. The proportion of respondents who consider food waste a big problem increases with the level of education.

Figure 3. Interaction plot – Dependence of attitudes towards food waste on respondents' education level – distribution of answer; n = 817

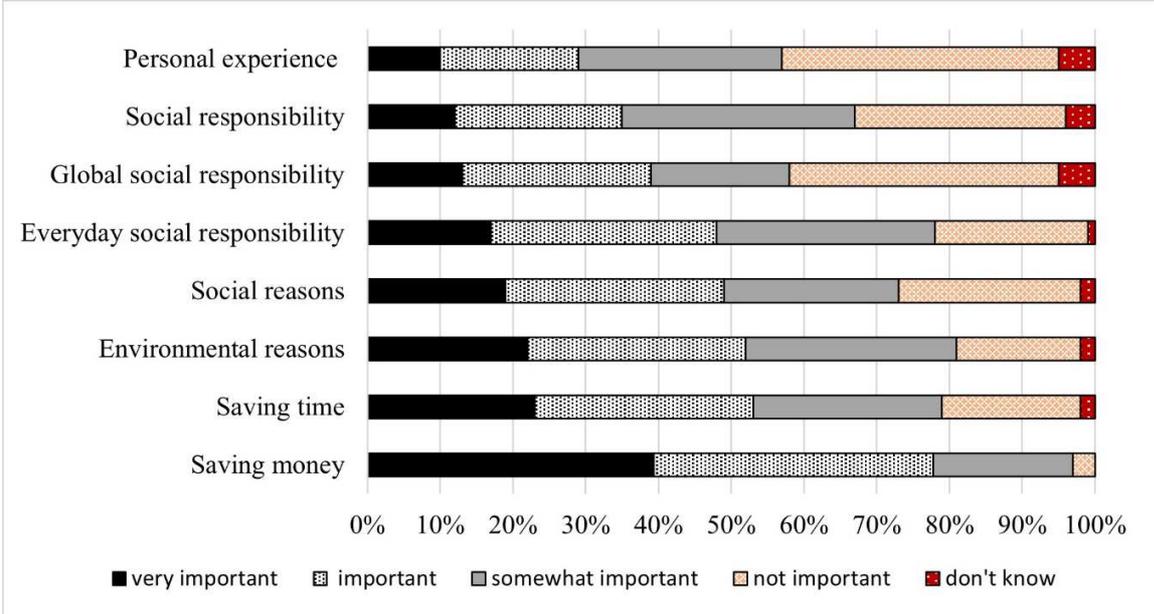


Source: own processing; data - Public Opinion Research Centre (2022), Institute of Sociology, Czech Academy of Sciences, 'Food' 2022; respondents over the age of 15; face-to-face interviews
 Note.: No answer „don't know“ = 4 respondents

While evaluating specific reasons of reducing food waste, respondents of the Public Opinion Research Centre (2022), value household financial savings as the most important

(77% of respondents). More than half (53%) of those surveyed consider time savings, which would have been spent on food preparation or shopping, to be important. Additionally, 52% see reducing food waste as beneficial for the environment (the main reasons are summarized in Figure 4).

Figure 4. Importance of main reasons of reducing food waste in 2022 (Distribution of answers); n = 821



Source: own processing; data - Public Opinion Research Centre (2022), Institute of Sociology, Czech Academy of Sciences, 'Food' 2022; respondents over the age of 15; face-to-face interviews

The importance of reasons for reducing food waste is associated with education, as shown in the results of the dependency testing in Table 3. In the case of the highest level of education achieved, there were no differences except university educated individuals more often agree with the statements "I think throwing food away is not environmentally friendly" and "I feel guilty about waste production in general."

Table 3. Results of testing the dependence of reasons for reducing food waste on education (n = 821)

Reasons for limiting food waste	χ^2	DF	p-value	Cramér's V
Saving money: it's possible to save money	12.4107	8	0.1338	-
Saving time: not spending time preparing wasted food	9.9734	8	0.2669	-
Environmental reasons: food waste is bad for the environment	21.9054	8	0.0051	0.1157
Social reasons: there are people who have nothing to eat	7.4306	8	0.4910	-
Everyday social responsibility: set an example for others	11.3574	8	0.1823	-
Global social responsibility: our role in producing waste	26.7403	8	0.0008	0.1279
Social responsibility: a chance to influence society	10.5274	8	0.2299	-
Personal experience: have personally experienced having not enough food	13.2292	8	0.1042	-

Source: own processing; data - Public Opinion Research Centre, Institute of Sociology, Czech Academy of Sciences, 'Food' 2022; respondents over the age of 15; face-to-face interviews

Most of the respondents, based on the Public Opinion Research Centre (2022), specifically more than four-fifths, agreed with the statement "when I prepare food, I make sure to use

everything that can be used." Approximately two-thirds of surveyed consider "packaging of food as bigger problem for the environment than wasting food." Approximately three-fifths of respondents are aligned with statements such as "I feel guilty when I waste food" and "the amount of food wasted concerns me because it requires a lot of resources for its production, processing, packaging, and transportation."

In the case of the highest achieved education level, there were no differences recorded, except agreement of university educated individuals with statements such as "I feel guilty when I waste food" and "I am concerned about the expenses for food that I throw away", while they more often disagree with two items related to the environmental dimension, namely "when wasting food, I don't think about its impact on the environment" and "food waste is not a problem for the environment because it is biodegradable".

It is possible to state that education is a statistically significant factor of on ecological eating behaviour. The importance of environmental education towards environmentally conscious food purchasing and consumption behaviour has been also documented by Alam et al. (2023). Studies such as Rowat et al., 2021 and Slining et al., 2013 confirm that the approach to food consumption in terms of its environmental impact is closely correlated with the level of education achieved. Food literacy is a fundamental element in addressing issues related to eco-friendly purchasing behaviour and its impact on food consumption (Rowat et al., 2021).

4. Conclusion

The study focused on the evaluation of the Czech population's food purchasing and consumption behaviour. Some aspects beneficial for the environment and related to food purchase and consumption were evaluated in relation to the level of education.

The results of a conducted study show that for Czech consumers, economic aspects (price is the key decision making factor indicated by more than half (51%) of respondents) and qualitative aspects (about one-fifth (21%) of respondents consider the composition of the food to be the most important factor when shopping, origin of the food was the third most important factor) play a major role when purchasing food. Ethical and environmental aspects are less important and the Czechs rank them 4-5th in the order of importance. At the same time, for a majority of respondents, it is important to consider the environmental impact of the food they purchase (51% respondents) . As the level of education increases, the proportion of respondents who consider the environmental impact of food production as definitely or rather important during food shopping also rises. Highly educated individuals consider the impact of food production on the environment twice as important when shopping for food as those with lower levels of education. Detailed analysis further reveals that environmentally beneficial activities related to food purchasing and consumption are more frequently undertaken by women and individuals with higher education levels.

Nearly half of the surveyed Czechs (47%) view food waste as a serious issue. It has been demonstrated that attitudes towards food waste are influenced by shopping preferences. Respondents who frequently visit farmers' markets, farm stores, purchase directly from growers or breeders, or shop in packaging-free stores were more inclined to perceive "food waste as a major problem." Similarly, women (56%) and individuals with higher levels of education (58% people with university education) expressed this point of view and approach more frequently. More than half (52%) of surveyed considersee reducing food

waste as beneficial for the environment. The importance of reasons for reducing food waste is significantly associated with education - university educated individuals more often agree with the statements "I think throwing food away is not environmentally friendly" and "I feel guilty about waste production in general."

It is possible to state that education has a significant influence on some aspects of food purchase and ecological eating behaviour of the Czech population.

References

- Alam, S. S., Wang, C. K., Masukujjaman, M., Ahmad, I., Lin, C. Y. and Ho, Y. H. (2023). "Buying Behaviour towards Eco-Labelled Food Products: Mediation Moderation Analysis", *Sustainability*, vol. 15, no. 3, DOI 10.3390/su15032474
- Budhathoki, M. and Pandey, S. (2021). "Intake of Animal-Based Foods and Consumer Behaviour towards Organic Food: The Case of Nepal", *Sustainability*, vol. 13: 12795, DOI 10.3390/su132212795
- Conrad, Z. and Blackstone, N. T. (2021). "Identifying the links between consumer food waste, nutrition, and environmental sustainability: a narrative review", *Nutrition Reviews*, vol. 79, no. 3, pp. 301–314, DOI 10.1093/nutrit/nuaa035
- Cullen, T., Hatch, J., Martin, W., Higgins, J. W. and Shepard, R. (2015). "Food literacy: Definition and framework for action", *Canadian Journal of Dietetic Practice and Research*, vol. 76, pp. 140–145, DOI 10.3148/cjdpr-2015-010
- Czech Statistical Office, Veřejná databáze SLDB 2021, Praha, 2023a. [Online], Available: <https://vdb.czso.cz/vdbvo2/faces/cs/index.jsf?page=profil-uzemi>, [Accessed: 11 Jan. 2023] (In Czech)
- Czech Statistical Office, Spotřební výdaje domácností – 2021, Praha, 2023b. [Online], Available: <https://www.czso.cz/csu/czso/spotrebni-vydaje-domacnosti-2021>, [Accessed: 13 Jan. 2023] (In Czech)
- Dimitri, C. and Dettmann, R. L. (2012). "Organic food consumers: what do we really know about them?", *British Food Journal*, vol.114, no. 8-9, pp.1157-1183, DOI: 10.1108/00070701211252101
- FAO. Global food losses and food waste – Extent, causes and prevention. Rome. 2011. [Online], Available: <http://www.fao.org/docrep/014/mb060e/mb060e.pdf>, [Accessed: 05 Dec. 2022]
- Guyonard, H., Bouamra-Mechemache, Z., Chatellier, V., Delaby, L., Detang-Dessendre, C., Peyraud, J. L. and Requillart, V. (2021). "Why and how to regulate animal production and consumption: The case of the European Union", *Animal*, vol.15, no. 1, 100283, DOI 10.1016/j.animal.2021.100283
- Hic, C., Pradhan, P., Rybski, D. and Kropp, J. P. (2016). "Food surplus and its climate burdens", *Environmental Science & Technology*, vol. 50, no. 8, pp. 4269–4277, DOI 10.1021/acs.est.5b05088
- Janssen, M. (2018). "Determinants of organic food purchases: Evidence from household panel data". *Food Quality and Preference*, vol. 68, pp. 19–28, DOI 10.1016/j.foodqual.2018.02.002

- Krause, C. G., Beer-Borst, S., Sommerhalder, K., Hayoz, S. and Abel, T. (2017). “A short food literacy questionnaire (SFLQ) for adults: Findings from a Swiss validation study“, *Appetite*, vol. 120, pp. 275–280, DOI 10.1016/j.appet.2017.08.039
- Melikoglu, M., Lin, C. S. K. and Webb, C. (2013). “Analyzing global food waste problem: Pinpointing the facts and estimating the energy content“, *Central European Journal of Engineering*, vol. 3, no. 2, pp.157–164, DOI 10.2478/s13531-012-0058-5
- Meyer, N., Kluge, M. A., Svette, S., Shrader, A., Vanderwoude, A. and Frieler, B. (2021). “Food Next Door: From Food Literacy to Citizenship on a College Campus“, *International Journal of Environmental Research and Public Health*, vol. 18, no. 2, pp. 534, DOI 10.3390/ijerph18020534
- Monroe, J. T., Lofgren, I. E., Sartini, B. L. and Greene, G. W. (2015). “The Green Eating Project: Web-based intervention to promote environmentally conscious eating behaviours in US university students“, *Public Health and Nutrition*, vol. 18, no. 13, pp. 2368–2378, DOI 10.1017/S1368980015002396
- Morone, P., Papendiek, F. and Tartiu, V. E. (2017). “*Food Waste Reduction and Valorisation*“, Springer: Berlin, Germany, first edition, ISBN: 978-3-319-50088-1
- Musová, Z., Musa, H. and Ludhova, L. (2018). “Environmentally responsible purchasing in Slovakia“, *Economics and Sociology*, vol. 11, no. 4, pp. 289-305, DOI 10.14254/2071-789X.2018/11-4/19
- Osaldiston, R. and Schott, J. P. (2012). “Environmental sustainability and behavioral science: Meta-analysis of proenvironmental behavior experiments“, *Environmental Behavior*, vol. 44, no. 2, pp. 257–299, DOI 10.1177/0013916511402673
- Perry, E. A., Thomas, H., Samra, H. R., Edpmstpme, S., Davidson, L., Falulkner, A., Petermann, L., Manafò, E. and Kirkpatrick, S. I. (2017). “Identifying attributes of food literacy: A scoping review“, *Public Health Nutr.*, vol. 20, pp. 2406–2415
- Pindešová, D., Predanócyová, K., Lančarič, R. and Rábek, T. (2022). “Situation in the beer market and consumer attitudes towards craft beer consumption“, *Proceedings of the 31st International Scientific Conference Agrarian Perspectives XXXI. Green Deal – Future Perspectives*, Prague, pp. 188-203, ISBN 978-80-213-3211-9
- Poelman, M. P., Dijkstra, S. C., Sponselee, H., Kamphuis, C. B., Battjes-Fries, M. C., Gillebaart, M. and Seidell, J. C. (2018). “Towards the measurement of food literacy with respect to healthy eating: The development and validation of the self-perceived food literacy scale among an adult sample in the Netherlands“, *International Journal of Behavioral Nutrition and Physical Activity*, vol. 15, no. 1, pp. 54, DOI 10.1186/s12966-018-0687-z
- Public Opinion Research Centre, Institute of Sociology of the Czech Academy of Sciences, Food 2020 [data file], Praha, 2020. [Online], Available: <http://nesstar.soc.cas.cz/webview/>, DOI 10.14473/CSDA00293, [Accessed: 18 Apr. 2023]
- Public Opinion Research Centre, Institute of Sociology of the Czech Academy of Sciences, Food 2022 [data file], Praha, 2022. [Online], Available: <http://nesstar.soc.cas.cz/webview/>, DOI 10.14473/CSDA00303, [Accessed: 18 Apr. 2023]

- Reichel, J. (2009). “*Kapitoly metodologie sociálních výzkumů*”, Praha: Grada, Sociologie, pp. 192, ISBN 978-80-247-3006-6
- Rep, A. (2021). “The role of eu funds in the context of agricultural policy – additional resources in response to the covid-19 pandemic“, *Proceedings of the 30st International Scientific Conference Agrarian Perspectives XXX. Sources of Competitiveness under Pandemic and Environmental Shocks*, Prague, pp. 219–228, ISBN 978-80-213-3129-7
- Richards, T. J. and Hamilton, S. F. (2018). “Food waste in the sharing economy“, *Food Policy*, vol. 75, pp. 109–123, DOI 10.1016/j.foodpol.2018.01.008
- Ronto, R., Ball, L., Pendergast, D. and Harris, N. (2016). “Adolescents’ perspectives on food literacy and its impact on their dietary behaviours“, *Appetite*, vol. 107, pp. 549–557, DOI 10.1016/j.appet.2016.09.006
- Rosas, R., Pimenta, F., Leal, L. and Schwarzer, R. (2022). “FOODLIT-tool: Development and validation of the adaptable food literacy tool towards global sustainability within food systems“, *Appetite*, vol.168, pp.105-658, DOI 10.1016/j.appet.2021.105658
- Rowat, A. C., Soh, M., Malan, H., Jensen, L., Schmidt, L. and Slusser, W. (2021). “Promoting an interdisciplinary food literacy framework to cultivate critical citizenship“, *Journal of American Collage Health*, vol. 21, no. 4, pp. 459–462, DOI 10.1080/07448481.2019.1679149
- Slater, J., Falkenberg, T., Rutherford, J. and Colatruglio, S. (2018). “Food literacy competencies: A conceptual framework for youth transitioning to adulthood“, *International Journal of Consumer Studies*, vol. 42, no. 5, pp. 547–556, DOI 10.1111/ijcs.12471
- Slining, M. M., Mathias, K. C. and Popkin, B. M. (2013). “Trends in food and beverage sources among US children and adolescents: 1989–2010“, *Journal of the Academy Nutrotion and Dietetics*, vol. 113, no. 12, pp. 1683–1694, DOI 10.1016/j.jand.2013.06.001
- Smith, S. and Paldino, A. (2010). “Eating clean and green? Investigating consumer motivations towards the purchase of organic food“, *Australasian Marketing Journal*, vol.18, no. 2, pp. 93–104, DOI 10.1016/j.ausmj.2010.01.001
- Some, S., Roy, J., Chatterjee, J. S. and Butt, M. H. (2022). “Low demand mitigation options for achieving Sustainable Development Goals: Role of reduced food waste and sustainable dietary choice“, *Journal of Cleaner Production*, vol. 369, no. 2, 133432, DOI 10.1016/j.jclepro.2022.133432
- Sponselee, H., Kroeze, W., Poelman, M. P., Renders, C. M., Ball, K. and Steenhuis, I. H. (2021). “Food and health promotion literacy among employees with a low and medium level of education in the Netherlands“, *BMC Public Health*, vol. 21, no. 1, pp. 1273, DOI 10.1186/s12889-021-11322-6
- Springmann, M., Clark, M. and Mason-D’Croz, D. (2018). “Options for keeping the food system within environmental limits“, *Nature*, vol. 562, pp. 519–525, DOI 10.1038/s41586-018-0594-0

- Stávková, J., Prudilová, H., Toufarová, Z. and Nagyová, L. (2007). “Factors influencing the consumer behaviour when buying food“, *Agric. Econ. - Czech*, vol. 53, no. 6, pp. 276-284, DOI: 10.17221/983-AGRICECON
- Steininger, M. and Smutka, L. (2022). “Analysis of czech food retail prices“, *Proceedings of the 31st International Scientific Conference Agrarian Perspectives XXXI. Green Deal – Future Perspectives*, Prague, pp. 276–285, ISBN 978-80-213-3211-9
- Stinson, E. (2010). “Eating the World: Food Literacy and Its Place in Secondary School Classrooms, University of Victoria“, *Victoria, BC, Canada*
- Sujita, P., Budhathoki, M., Feng, K., Thomsen, M. and Reinbach, H. C. (2023). “Who Buys Surplus Meals? An Exploratory Survey in Danish Canteens “, *Foods*, vol. 12, no. 5, pp 1035. DOI 10.3390/foods12051035
- Teng, P. K., Rezai, G., Mohamed, Z. and Shamsudin, M. N. (2011). “Consumers’ intention to purchase green foods in Malaysia“, *International Conference on Innovation, Management and Service IPEDR*, vol. 14, no. 1, pp.112–118
- Thomas, H., Perry, E. A., Slack, J., Samra, H. R., Manowiec, E., Petermann, L., Manafò, E. and Kirkpatrick, S. I. (2019). “Complexities in Conceptualizing and Measuring Food Literacy“. *Journal of the Academy of Nutrition and Dietetics*, vol. 119, no. 4, pp. 563–573, DOI 10.1016/j.jand.2018.10.015
- Thompson, C., Adams, J. and Vidgen, H. A. (2021). “Are We Closer to International Consensus on the Term ‘Food Literacy’? A Systematic Scoping Review of Its Use in the Academic Literature (1998–2019)“, *Nutrients*, vol. 13, no. 6, DOI 10.3390/nu13062006
- Tobler, C., Visschers, V. H. M. and Siegrist, M. (2011). “Eating green. Consumers' willingness to adopt ecological food consumption behaviors, *Appetite*, vol. 57, no.3, pp. 674-682, ISSN: 0195-6663, DOI: 10.1016/j.appet.2011.08.010
- Vidgen, H. A. and Gallegos, D. (2014). “Defining food literacy and its components“, *Appetite*, vol.14, no.76, pp. 50–59, DOI 10.1016/j.appet.2014.01.010
- Walaszczyk, A. and Galińska, B. (2020). “Food Origin Traceability from a Consumer’s Perspective “, *Sustainability*, vol. 12, no. 5: 1872. DOI 10.3390/su12051872
- Wang, Y. F. (2016). “Development and validation of the green food and beverage literacy scale“, *Asia Pacific Journal of Tourism Research*, vol. 21, no. 8, pp. 20–56
- Zhang, J., Ye, H., Bhatt, S., Jeong, H., Deutsch, J., Ayaz, H. and Suri, R. (2021). “Addressing food waste: How to position upcycled foods to different generations“, *Journal of Consumer Behaviour*, vol. 20, pp. 242–250, DOI 10.1002/cb.1844

UX TESTING OF DIGITAL CAR INFOTAINMENT

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Annotation: Human capital is essential for the effective functioning of the economy. But it is directly influenced by the environment in which, or with which, a person interacts. This also applies to the operation of computers, machines, etc. The interface (HMI) of modern car infotainment is also a basic system that modern humans commonly operate. Particularly for professionals who spend thousands of hours on the road, clear, intuitive, and most importantly, safe operation of these elements is essential. With a poorly implemented HMI, the driver cannot concentrate on the activities associated with operating the equipment and cannot pay sufficient attention to driving. This can lead to distraction and a potential incident. In addition, interaction with a poorly designed environment leads to increased fatigue and, again, increased inattention.

The HMI design of digital car infotainment and its subsequent evaluation in terms of User Experience methods and safety in simulating vehicle operation on the highway was the subject of the study presented in this paper. In the evaluated infotainment prototypes, the results demonstrated that the graphic style and layout of the individual controls might negatively affect driver distraction from driving. Through user testing to verify user acceptance, several suitable control layout options were identified that can reduce driver distraction from driving the car. The general finding of this paper is the need to optimize and mutually balance user-friendliness, clarity, and efficiency of the HMI interface, especially concerning the safety of use. User-testing the prepared prototypes resulted in a specific infotainment design that achieved the best results in measuring driver distraction and the most positive user ratings.

In addition, laboratory testing in the environment of a personal car has shown the suitability of the applied method for the environment of professional drivers, e.g., truck drivers, messengers, delivery drivers, etc.

Key words: UX, infotainment, UI design, HMI, distraction, laboratory testing, user-testing

JEL classification: L62, O32, L86

1. Introduction

With the increasing technological development in the automotive industry, we can face the issue of compromise between the use of modern technologies and driver safety, where attention can be diverted from driving the car to controlling the touch screen located on the dashboard of the infotainment. The interface (HMI) of modern car infotainment is a basic system that modern humans commonly operate. Particularly for professionals, including agricultural drivers, who spend thousands of hours on the road, clear, intuitive, and most importantly, safe operation of these elements is essential. With a poorly implemented HMI, the driver cannot concentrate on the activities associated with operating the equipment and cannot pay sufficient attention to driving. This can lead to distraction and a potential incident. In addition, interaction with a poorly designed environment leads to increased fatigue and, again, increased inattention.

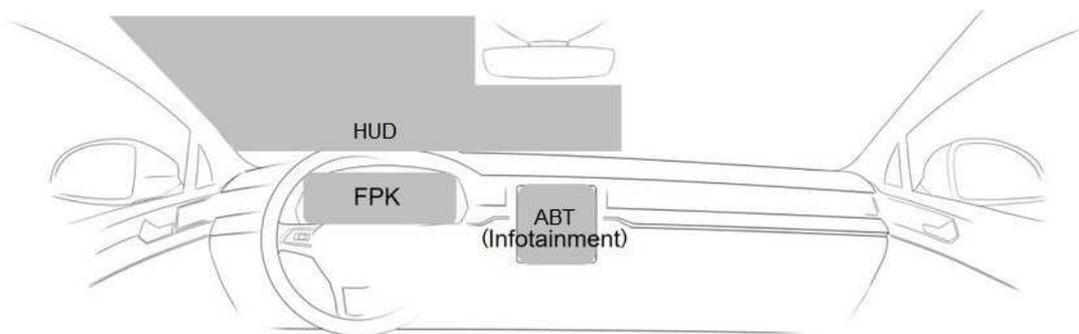
This paper presents the results of a study on road safety research. Specifically, it examines the distraction effects of personal vehicle drivers working with an infotainment car system

on the simulator and explores the possibilities for the eventual implementation of a new simulator with a focus on professional drivers. A partial objective of the study is also to determine whether it is appropriate to further develop the applied procedure to the field of agricultural machinery.

Infotainment is part of an automobile or any other vehicle (automotive) HMI (Human Machine Interface). HMI defines Stoufer et al. (2020) as "*The hardware or software through which an operator interacts with a controller. An HMI can range from a physical control panel with buttons and indicator lights to an industrial PC with a color graphics display running dedicated HMI software*". These solutions include navigation system touchscreens, voice-enabled vehicle infotainment clusters, the steering wheel, buttons, displays, and driving assistance tools that enable people to understand in-car technology, operate their vehicles safely, and feel comfortable and in control as self-driving becomes more widely available. Even autonomous and electric vehicles cannot achieve mass customer adoption unless OEMs get HMI development right (Debkaliuk, 2022).

The automotive HMI can include a front-facing display (FPK), a head-up display (HUD) and a central display (ABT), which is mainly known as infotainment (Bauerfeind et al., 2017; Meixner and Christian, 2017). The whole system can be extended using digital mirrors (Babu et al., 2022).

Figure 1: Automotive HMI layout



Source: own processing, (Bauerfeind et al., 2017)

The entire automotive HMI including infotainment system should therefore be designed with the principles of HCI (Human-centered design) in mind, which are defined by International Organization for Standardization (2019) as "*An approach to interactive systems development that aims to make systems usable and useful by focusing on users, their needs and requirements using human factors or ergonomics, knowledge and usability techniques*". The infotainment prototype we used in our research was also built on this principle, as will be apparent later in this paper.

Concerning the automotive HMI (HMI in cars), the European Union has developed its recommendations (European Union, 2008). This document is made up of three general design principles on the human-machine interaction and 32 principles that cover the areas of system installation, information presentation, interaction with screens and controls, system behavior

and information about the system focuses on safety aspects that must be considered for the design of HMI of car infotainment systems (Alarcón et al., 2022).

In many non-automotive industries, the user's primary role is interaction with computers or smartphones, respective to their UI. In these cases, users can devote their cognitive capacity entirely to interacting with the HMI resp. UI and focus less on their surroundings. As Debkaliuk (2022) Bauerfeind (2017) and Meixner (2017) concur compared to this way of interaction, in a typical automotive setting, users must simultaneously drive their car, stay in their lane of traffic, watch their speed or react to the current traffic situation while working with technology. Less attention can be given to selecting targets or changing radio stations. This is a fundamental difference of an automotive HMI from other HMIs that should be kept in mind during its development because the interaction with automotive HMI can result in distraction related to driving e.g., following a map on a GPS or in not related to driving e.g., changing radio volume (François et al., 2016).

Although it may seem that the concept of driver distraction is well established, this is not the case. The concept of driver distraction is not used identically in many studies. In the review article Regan, Hallett and Gordon (2011) focused on comparing these studies and proposed a summary definition in the form of: "*Insufficient or no attention to activities critical for safe driving*", which we also lean towards in our research. Moreover, this study (Regan, Hallett and Gordon, 2011) understands driver distraction as a specific part of inattention.

According to a study for the European Commission (2015), driver distraction plays a role in 10-30% of all accidents on European roads. According to NHTSA (2021), in 2019 alone, 3,000 people died and 424,000 were injured in distracted driving-related crashes (2021). One of the reported causes of distraction is interaction with infotainment systems. As a result, designing systems aimed at reducing driver distraction is crucial in the automotive context. The interaction design must be clear, reliable, and consistent, and the modalities must be appropriately chosen for the task and the user. The user must not have any doubts or questions about interacting with the system. These aspects become even more important with the increasing complexity and variety of automotive HMI functions.

In his book chapter Leplat (1981) points out that the quality of an automotive HMI design partly, but not insignificantly, determines the driver's ability to perform the primary driving task while using the in-vehicle devices. In general, various internal and external factors can affect the quality of driver interaction. Internal factors affecting driving are driver characteristics (e.g., experience level, motivation, age, emotional state, and time pressure). External factors include contextual features (e.g., level of emergency, consequences of the action performed, and lighting conditions), and then characteristics of the interface itself (e.g., ease of use, menus in the interface, the approach used, colors, and voice recognition).

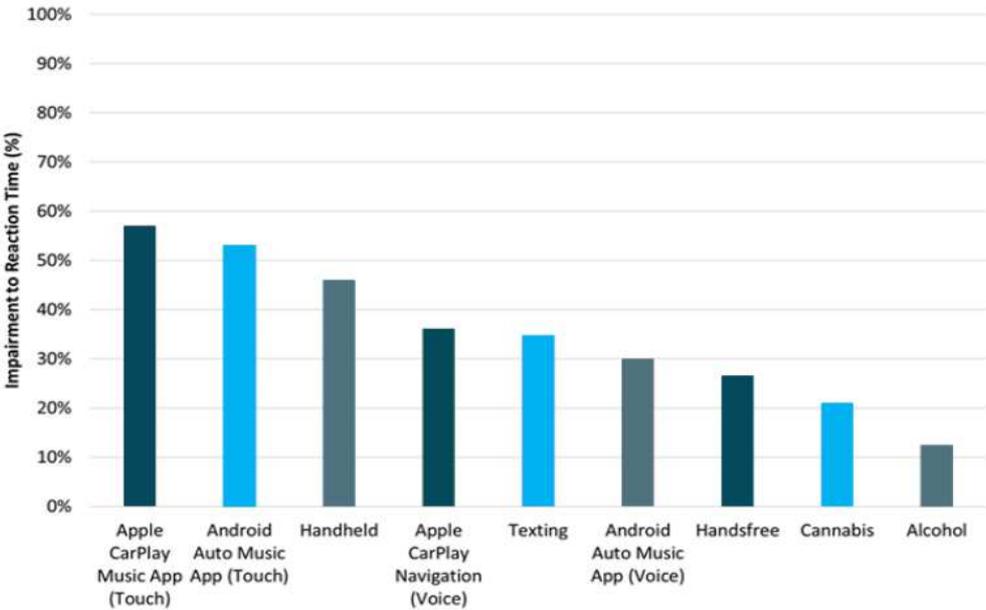
In terms of our study, it is also necessary to mention the term UX (User Experience). This concept is defined by ISO 9241-210:2010 (2019) as "person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service". User experience is a consequence of brand image, presentation, functionality, system performance, interactive

behavior and assistive capabilities of the interactive system, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use. Determining the level of UX and usability, defined by International Organization for Standardization (2018) is done using specific tests and measurements (Moran, 2019; Tullis & Albert, 2013), which we also used in our study.

2. Materials and Methods

The primary motivation for our research was the rather worrying results presented by IAM RoadSmart (Ramnath et al., 2020). This study sought to understand the impact of interaction with mobile infotainment systems on driver performance. It also compared the results with other forms of driver distraction. Two replicate measurements were conducted with Android Auto and Apple CarPlay to obtain data on driver performance. The results of their research show that the latest in-car infotainment systems are more distracting than texting, or even drinking alcohol, or consuming marijuana. The Figure 2 below shows the percentage change in reaction time for different driver distractions compared to the reaction time when driving without distractions. Compared to distraction-free driving, reaction times showed an average increase of 57% and 53% when playing music via Spotify using the touch function on Apple CarPlay and Android Auto, respectively. The results of their study show that working with the Spotify app has almost a quarter higher distraction effect for touch interface control - Android Auto Music (Voice), about 53% compared to voice control - Android Auto Music (Voice), about 30%, but this distraction is significant.

Figure 2. Comparison of changes in reaction time due to different driving



Source: Ramnath et al., 2020

Our study was conducted sequentially in two steps, and in this paper, we focus mainly on the second part, which involved testing in the laboratory. Nevertheless, we briefly outline below the process by which the testing infotainment layout was created.

The First step – infotainment design

The first step was to create an HMI, specifically an infotainment system using HCI methods and techniques as described in International Organization for Standardization (2019). We also focused on three basic criteria for automotive HMIs defined by François et al. (2016): usability, distraction and adoption. These three criteria cover the main general methods of measuring interface quality in the existing literature. While usability is the most widely used criterion for evaluating interfaces, driving safety and user acceptance may have critical implications for automotive HMIs due to the specific context of its use. Adopting HMIs is essential because accepted devices are more likely to be used by drivers. If interfaces do not match drivers' mental models and expectations, they can lead to misuse, potentially dangerous situations, and system rejection (Maltz, 2007). More detailed and specific models of the ergonomic quality of an automotive HMI exist in the literature - e.g., Harvey et al., (2010); Solman, (2002), but these can be subsumed into the three more general categories just mentioned (e.g., measured error rate, task length, or deviation from driving speed).

Based on the research of existing methods of creating digital dashboards and their UX characteristics, together with the definition of factors influencing the creation of HMIs, we created several variants of user-friendly HMIs. The design of the infotainment interface was inspired by solutions based on global automotive brands as well as companies that were impressed with their solutions presented in the Car HMI Europe Award, 2022.

In total, 5 different graphic designs were created. Each design is based on touchscreen designs already in use, but at the same time these designs are not an exact copy. It is clear, however, that each of the automotive brands based their concepts on some research and experience to satisfy most of their customers. So, designing an infotainment design from scratch would be counterproductive and very time-consuming. Although the designs differ mainly in the graphic style used, color palettes, icon sizes and font style, they all have a few common elements. Still, these may appear in different places and in various forms within a given concept.

Semi-functional prototypes were created from the graphical designs and tested online using a usability testing tool using the Click test method, which was evaluated based on a task in which the participant had to track the current consumption of the car. After filtering out incomplete or obviously erroneous interpretations, 71 participants took part in the testing. Alongside this testing, the testing participants also rated the level of design used on a scale of 1-10.

- Did you find the graphic style intuitive and logically organized?
- Did you find the graphic style clear and not confusing?
- Did you find this graphic style attractive? Did you like it?

For example, concept 1 was considered by respondents to be modern, visually friendly, and intuitive. Negative responses to this graphic style were minimal.

From the heat map of the click test answers, Figure 3, after filtering out the obvious wrong answers most respondents clicked in the right direction (left part of the concept), but at the same time, the time to find the function is quite large - 20 seconds. This suggests

that the concept is not very intuitive when searching for a particular function - this could be solved for example by icon labels.

Figure 3. Example of Click tracking Heat Map



Source: own processing

All 5 main graphic concepts were evaluated and tested in this way. Subsequently, the 3 concepts that achieved the best overall rating concerning both user preference and time taken to complete the task were selected. By the way, the concept with the best overall user rating was not identical to the concept with the shortest, so the best click test time score.

These 3 concepts were reworked into functional prototypes in terms of HMI. The primary objective was to allow the user, the participants of the testing, a more complex browsing experience so that the user would not have too simple tasks, but that a truly full-fledged HMI testing would occur. It was therefore necessary to also design the list contexts, the list items and the way to move between them. In total, we developed 23 different screens for each of the three concepts. In total, there are 69 contexts where the user can click during testing. To this must be added one menu design and 5 pop-ups that are common to all concepts.

The distribution of graphic elements according to were divided as follows:

- "Homescreen" context - 1 screen
- "Car" context - 3 screens
- "Connection" context (Appconnect/Smartconnect) - 5 screens + 1 pop-up
- "Settings" context - 4 screens + 1 pop-up
- "Media" context - 3 screens
- "Navigation" context - 4 screens + 1 pop-up
- "Charging" context - 3 screens + 2 pop-ups

During the transition between contexts, several interactions can be set up as to when and how a particular transition should occur.

There are several ways to trigger the transition:

- When you click on the desired element (On click).
- When dragging an element (On drag).
- While hovering over the element.
- While pressing the element, i.e., holding the click (While pressing).
- While pressing the keyboard (Key/Gamepad).

- While moving the mouse in different directions (Mouse enter/leave/down/up).

And how the actual transition is to take place were selected from the following:

- Navigate to - full transition, screen swapping.
- Change to - this transition is used when changing the variant of a component.
- Open/Swap/Close Overlay - this transition is often used for pop-ups when the original screen overlaps.
- Back - return to the previous screen.
- Move to (Scroll to) - for scrolling in the sheet.
- Open link - to move to another link.

For the transition animations themselves, we have set the transition property in addition to the duration and method of execution (linear, along different curves, etc.):

- Instant - virtually no visible transition is performed.
- Dissolve - simply "dissolve" one screen into another.
- Smart animate – used Figma software tool can identify common elements with another screen based on the screen structure and animate only those elements that are different. Or automatically evaluate which animation is best for a given element.
- Move in/out - move to or from a given screen. Different movement directions can be set.
- Push - push one screen out with another.
- Slide in/out - to slide out, for example, a pop-up window, also can be set in different directions.

After connecting all the screens and setting their transitions, it is necessary to set the starting point at which the user, the participant, will start after running the prototype created. Although there may be several of them, we set this entry point to the home screen for all participants.

The Second step – laboratory testing

These 3 described infotainment prototypes were subsequently tested from the usability point of view in the UX laboratory, using quantitative and qualitative methods, emphasizing measuring the driver's distraction when performing tasks on the touch screen while driving.

The Usability Laboratory testing with users was generally based on a usability evaluation. Specifically, we used two well-established methods. The primary method we used was User Task Scenarios as defined by Moran (2019). These scenarios were divided into several sub-steps, i.e. individual tasks. The second method used was the UX method Think-aloud. According to Prokop (2020) recommendation we specifically applied Retrospective think-aloud (RTA). This procedure avoided any contact between the researcher and the participant and possible interference with the driving. Therefore, this method was used immediately after the end of the test run in the simulator to verify the identified problems and the user's feelings. This method was supplemented by a guided interview with 20 set questions. Prior to the actual testing, participants completed an initial questionnaire focusing on participant identification, gender, driving license ownership, experience using touchscreens, relationship to technology, and a breakdown of preferred car features. After the interview, participants also completed a Final Questionnaire, where they rated the strength of preference for each concept using a Lickert scale (1 to 7). The questionnaire scales cover a comprehensive

impression of the user experience. Both classical usability aspects (efficiency, clarity, reliability) and user experience aspects (originality, stimulation) are measured. The result was a comprehensive database based on both quantitative and qualitative research.

As stated earlier, the primary motivation for undertaking this research was the IAM RoadSmart research report by Ramnath et al. (2020). Specifically, we were inspired by the analysis of deviation in lane position during driving when the participant performs assigned tasks by working with the infotainment. In their results, analysis of deviation in lane position showed large variations in lane position for the touch drive, compared with control, while performing the music, texting, and calling tasks using both infotainment systems. There was also a significant increase in deviation of lane position for the voice drive while performing the texting and calling tasks using Apple CarPlay. Controlling the vehicle's position in the lane and keeping a consistent headway to the vehicle in front suffered significantly when interacting with the systems, particularly when using touch control (Ramnath et al., 2020). How can a professional driver who clicks through a list of packages for the following address while driving be paying attention?

The usability testing took place in the UX laboratory of Digiteq Automotive s.r.o., which has been focusing on testing and developing electrical and software systems for cars since 2001.

The UX lab consists of a driving simulator, i.e., a seat, steering wheel, pedals and three connected screens on which the virtual environment is projected. The overall simulation runs on a total of three computers. One operates a virtual 3D highway environment created in the Unity engine. Then one computer for controlling and collecting data from the simulation and the last computer has the role of a server, which also operates a touch tablet for HMI designs and an FPK monitor for the dashboard display behind the steering wheel (displaying the current speed).

The 3D virtual environment consists of a model of a motorway with two lanes and one breakdown lane in each direction, with the two directions separated by barriers. Furthermore, the environment consists of a petrol station model, which acts as the start and end point of each journey. The entire virtual scene is complemented by trees around the road and road signs to simulate the real environment as much as possible. The driving takes place on a dynamically generated highway shaped like a sinusoid. So, it's not a straight road, but it is always slightly curved in or out. This is so that the user must correct the driving itself and pay close attention to the steering. This road is infinitely long; testing only ends when the user has tested all the necessary tasks. Only then is a model of a gas station generated at which the test respondent can stop.

Research and data collection

Seven tasks were prepared for testing, with varying difficulty and the number of clicks to complete. Respondents learn the testing task through an audio system where an audio was recorded with the wording of the task communicated by a female voice using artificial intelligence.

Figure 4. UX lab environment with a simulator



Source: own processing

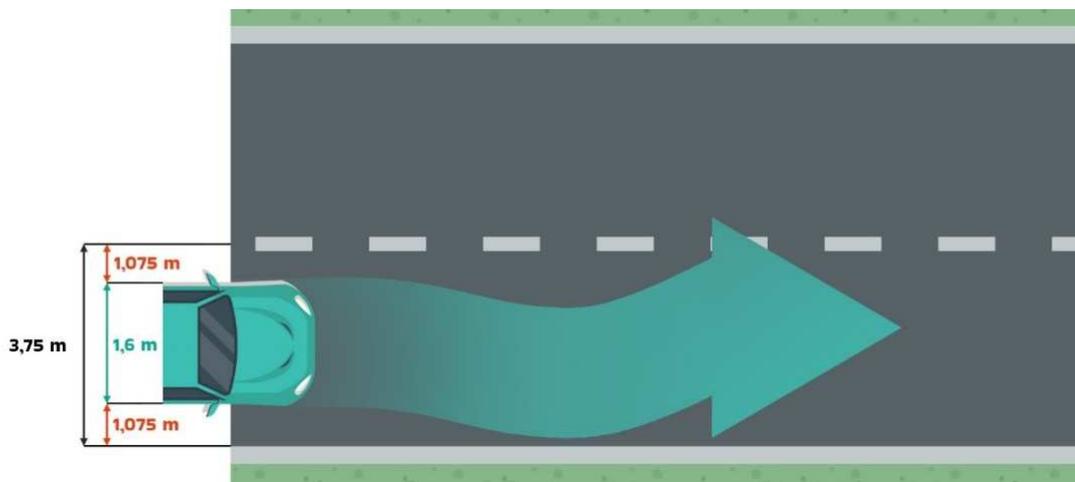
The tasks were as follows:

- Check the tire pressure.
- Increase the temperature on the driver's side by 1 degree.
- Go to Navigation and stop the current navigation. Set the new route to "Work".
- In the media, start listening to "Radio Brno".
- In the Android Auto Connection context, pair the device with your Samsung S31.
- In the Charging context, navigate to the nearest charging station.
- In Settings, change the language to German.

As in one of the lines of research conducted by Ramnath et al. (2020), we focused on evaluating the car's position in the lane.

Figure 5 describes how to read the generated driver distraction plots. The turquoise line shows the trajectory across the car's width during the task. The driving lane is 3.75 meters wide. The car is 1.6 meters wide. There is a space of 1.075 meters on each side to the edge of the lane.

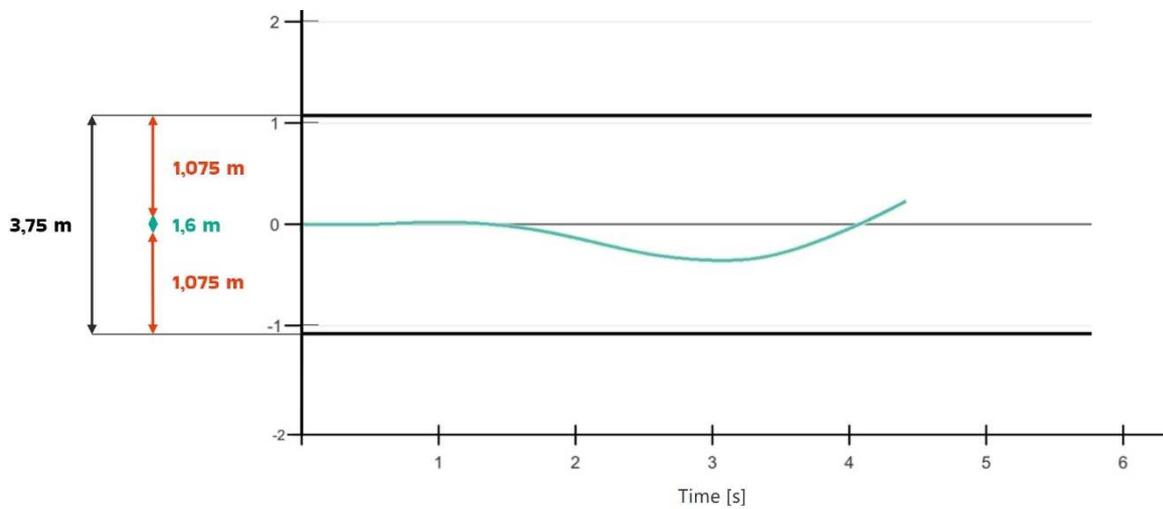
Figure 5. Principle of driver distraction measurement



Source: own processing

The example below shows, how the participant completed the task in 4.5 seconds and deviated by about 0.3 meters during the run.

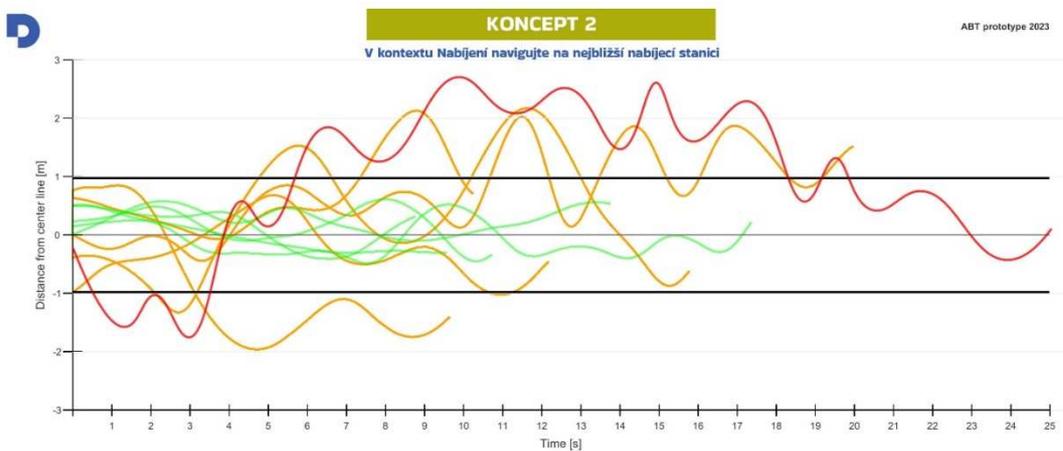
Figure 6. Example of a driver distraction measurement record



Source: own processing

- A green line means the participant has completed the task in the correct lane.
- The orange line shows cases where the participant has left the lane while performing the task.
- A red line shows failed attempts where the participant did not complete the task within the 25-second time limit.

Figure 7. Example of a diagram of a driver's journey while performing a task



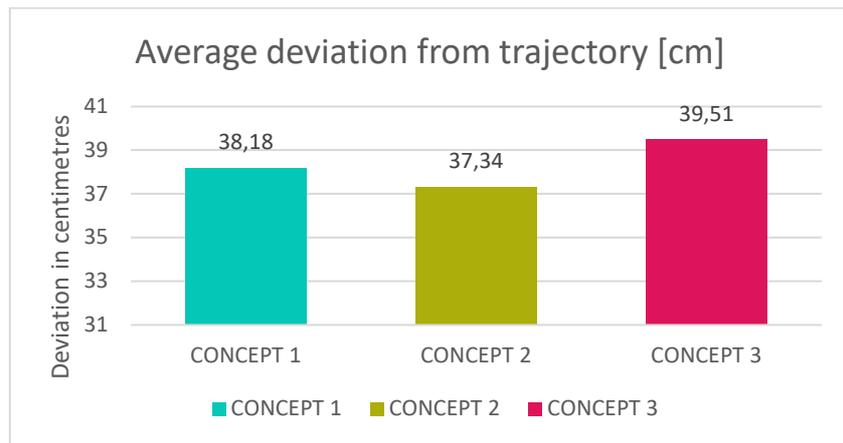
Source: own processing

Note: Task assignment - In the "Charging" menu, navigate to the nearest charging station.

3. Results and Discussion

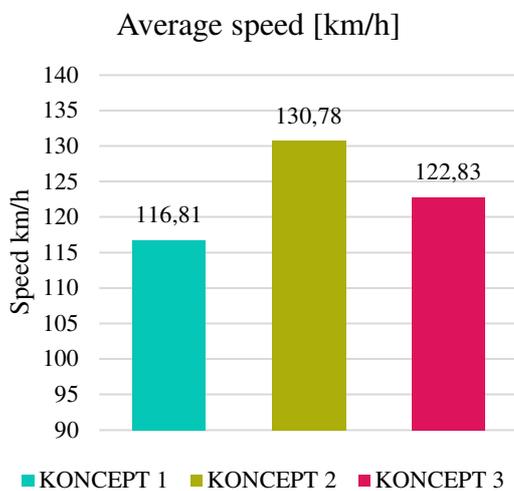
In the driver distraction test, Concept 2 scored the best rating. This concept dominated all the monitored statistics.

Figure 8. The average deviation from the trajectory



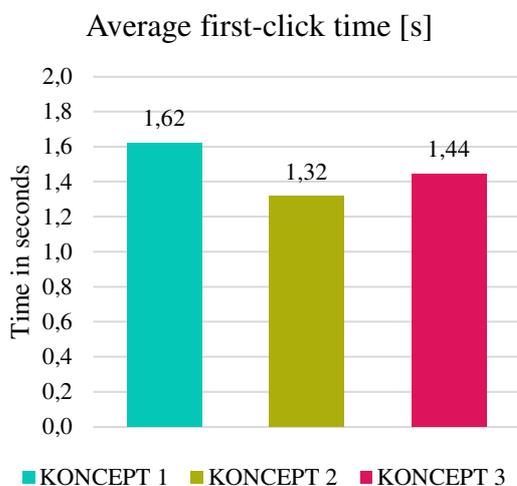
Source: own processing

Figure 9. Average speed



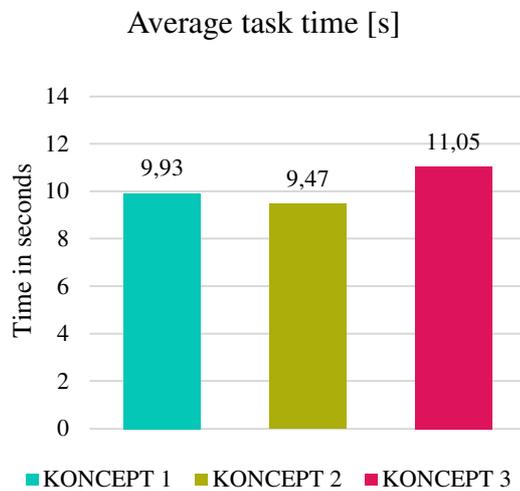
Source: own processing

Figure 11. Average first-click time



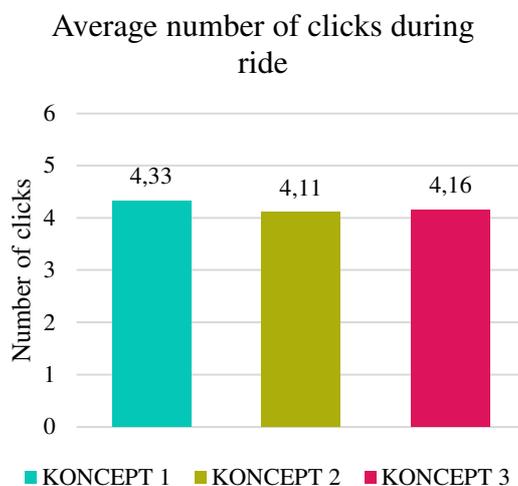
Source: own processing

Figure 10. Average task time



Source: own processing

Figure 12. The average number of clicks during the ride



Source: own processing

Reasons for the best overall rating for Concept 2:

- It has the smallest mean deviation from trajectory - 37.34 cm.
- It has the highest average cruising speed. This may indicate that users were more confident with the touchscreen controls and did not have to slow down as much when performing tasks.
- It has the lowest task execution time. Users performed tasks fastest in this concept.
- It has the lowest average first-click time. It was easy for users to quickly find the first button they had to press to complete a task.
- It has the lowest average number of clicks. This means that users had to click as little as possible to complete the tasks among all concepts.

Concept 2 also received the best overall user rating obtained through the qualitative part of the study. Respondents most appreciated its clarity, attractiveness, and efficiency of use.

One major criticism of Concept 1 by almost all participants was directed at the use of white as a complementary color. According to users, it is unsuitable due to its contrasting nature. A minor modification to the design was therefore made to replace this color with blue. At the same time, it would be possible to add the display of labels for icons to the design, for example, only when a finger approaches the icon (so-called proximity).

4. Conclusion

Based on the values obtained, we were able to create the final design of the prototype, which is intended for further testing.

Figure 13. Final HMI design



Source: own processing

Figure 14. Final HMI design - context with list items



Source: own processing

However, the primary outcome of this measurement is that the measurements made in this way make sense and can be applied in a specially adapted laboratory to professional drivers and drivers of heavy machinery including agriculture. For example, during harvest time, when drivers of agricultural machinery carrying grain are very tired during their work, the distraction of infotainment can be fatal. In contrast, a suitable interface can significantly reduce the potential risks. In contrast to web interface design, for example, other criteria specific to this segment must be considered when creating HMI concepts in the automotive environment. While usability is the most widely used criterion for evaluating interfaces, driver distraction and user acceptance can have critical implications due to the specific context of use. The study confirmed that it is appropriate to extend this topic further to the area of agricultural machinery drivers, especially with regard to traffic on ordinary roads, such as trucks or tractors carrying out specific activities.

The human capital of drivers will therefore be put to even better use. In addition, in the HUBRU (Human Behavior Research Unit) laboratory within the FEM CULS Prague, we can test extended possibilities of controlling and interacting with the system by voice or other modern HCI methods.

Acknowledgements

The results and knowledge included herein have been obtained owing to support from the following grant – Internal grant agency of the Faculty of Economics and Management, Czech University of Life Sciences Prague, grant no. 2020A0007 – “Using virtual reality tools for decision support and minimizing knowledge gaps of users in questionnaire surveys”.

The research was partly carried out in the UX laboratories of FEM CZU, Prague and also in the laboratories of Digiteq Automotive s.r.o.

References

Alarcón, J., Balcázar, I., Collazos, C. A., Luna, H., and Moreira, F. (2022). “User Interface Design Patterns for Infotainment Systems Based on Driver Distraction: A Colombian Case Study”, *Sustainability* 2022, vol. 14, no. 13, p. 8186, <https://doi.org/10.3390/SU14138186>

- Babu, S. S., Povýšil, J., Hruška, M., Vaculík, P., Benda, P., Zifia, A. M. and Fűs, M. (2022). “Assessment of the New Digital Side Mirror Technology from Driver’s Subjective Point of View Considering Traffic Safety”, *Acta Technologica Agriculturae*, vol. 25, no. 3, pp. 122–130. <https://doi.org/10.2478/ATA-2022-0019>
- Bauerfeind, K., Stephan, A., Hartwich, F., Othersen, I., Hinzmann, S. and Bendewald, L. (2017). “Analysis of potentials of an HMI-concept concerning conditional automated driving for system-inexperienced vs. system-experienced users”, *Proceedings of the Human Factors and Ergonomics Society Europe Chapter. Annual Conference*, Rome, Italy, pp. 67 - 77
- Debkaliuk, A. (2022). “The biggest automotive HMI design challenges and how to solve them”, *Automotive & Mobility*. [Online], Available: <https://star.global/posts/automotive-hmi-design/>, [Accessed: 25 Jan. 2023]
- European Commission, Rapp Trans, TNO and TRL (2015). “Study on good practices for reducing road safety risks caused by road user distractions: final report”, EU Publications Office. [Online], Available: <https://data.europa.eu/doi/10.2832/88265>, [Accessed: 22 Jan. 2023]
- European Union. (2008). “Commission recommendation of 26 May 2008 on safe and efficient in-vehicle information and communication systems: update of the European Statement of Principles on human machine interface”, Publications Office of the European Union, [Online], Available: <https://op.europa.eu/en/publication-detail/-/publication/f38d533a-33ff-4a96-b5dc-3ee4a591cba6/languageen/format-PDF/source-search>, [Accessed: 2 Feb. 2023]
- François, M., Osiurak, F., Fort, A., Crave, P. and Navarro, J. (2016). “Automotive HMI design and participatory user involvement: review and perspectives”, *Ergonomics*, vol. 60, no. 4, pp. 541–552. <https://doi.org/10.1080/00140139.2016.1188218>
- Harvey, C., Stanton, N. A., Pickering, C. A., McDonald, M. and Zheng, P. (2010). “Context of use as a factor in determining the usability of in-vehicle devices”, *Theoretical Issues in Ergonomics Science*, vol. 12, no. 4, pp. 318–338. <https://doi.org/10.1080/14639221003717024>
- International Organization for Standardization. (2018). “ISO 9241-11:2018 - Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts”, [Online], Available: <https://www.iso.org/standard/63500.html>, [Accessed: 20 Jan. 2023]
- International Organization for Standardization. (2019), “ISO 9241-210:2019 - Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems”, [Online], Available: <https://www.iso.org/standard/77520.html>, [Accessed: 20 Jan. 2023]
- Leplat, J. (1981). “Task Analysis and Activity Analysis in Situations of Field Diagnosis. Human Detection and Diagnosis of System Failures”, pp. 287–300. https://doi.org/10.1007/978-1-4615-9230-3_19
- Maltz, M. and Shinar, D. (2007), “Imperfect in-vehicle collision avoidance warning systems can aid distracted drivers”, *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 10, pp. 345-357, doi 10.1016/J.TRF.2007.01.002
- Meixner, G. and Christian, M. (2017). “*Automotive User Interfaces: Creating Interactive Experiences in the Car*”, *Automotive User Interfaces: Creating Interactive Experiences in the Car*, ISBN 978-3-319-49448-7

- Moran, K. (2019). "Usability Testing 101", Nielsen Norman Group. [Online], Available: <https://www.nngroup.com/articles/usability-testing-101/>, [Accessed: 2 Feb. 2023]
- NHTSA. (2021). "Distracted Driving 2019", *National Highway Traffic Safety Administration*, Washington, USA, [Online], Available: <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813111> [Accessed: 5 Jan. 2023]
- Prokop, M., Pilař, L. and Tichá, I. (2020). "Impact of Think-Aloud on Eye-Tracking: A Comparison of Concurrent and Retrospective Think-Aloud for Research on Decision-Making in the Game Environment", *Sensors* 2020, Switzerland, vol. 20, no. 10, p. 2750, <https://doi.org/10.3390/S20102750>
- Ramnath, R., Kinnear, N., Chowdhury, S., Hyatt, T., Rogers, C. and Kinnear, N. (2020). "Interacting with Android Auto and Apple CarPlay when driving: The effect on driver performance A simulator study Report details", *IAM RoadSmart*, [Online], Available: https://iamwebsite.blob.core.windows.net/media/docs/default-source/default-document-library/iam-roadsmart-trl-simulator-study_infotainment.pdf, [Accessed: 2 Feb. 2023]
- Regan, M. A., Hallett, C. and Gordon, C. P. (2011). "Driver distraction and driver inattention: Definition, relationship and taxonomy", *Accident Analysis and Prevention*, vol. 43, no. 5, ISSN 1771–1781. <https://doi.org/10.1016/J.AAP.2011.04.008>
- Solman, N. (2002). "Analysis of interaction quality in human–machine systems: applications for forklifts", *Applied Ergonomics*, no. 33, pp. 155-166, doi 10.1016/s0003-6870(01)00052-7
- Stouffer, K., Zimmerman, T., Tang, C., Lubell, J., Cichonski, J., Pease, M. and McCarthy, J. (2020). "Cybersecurity Framework Version 1.1 Manufacturing Profile", <https://doi.org/10.6028/NIST.IR.8183R1>
- Tullis, T. and Albert, B. (2013). "*Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics*", Waltham, USA: Elsevier Inc. ISBN 978-0-12-415781-1

SPECIAL SECTION
EFFICIENCY AND RESPONSIBILITY
IN EDUCATION

TRAINING IN PSYCHOSOCIAL SUPPORT: EXPERIENCE OF THE PSYCHOLOGICAL SERVICE OF THE FIRE RESCUE SERVICE OF THE CZECH REPUBLIC

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Annotation: In the wake of recent events such as the COVID-19 pandemic or war conflict in Ukraine, there is a growing need not only for professionals to be equipped with the skills and information to fulfill the needs of psychological support in challenging situations. The Fire Rescue Service of the Czech Republic (FRS CR) has over ten years of experience in training officers and employees in psychosocial support. An established education system allows trained firefighters to become members of the post-trauma care team and provide direct care for people affected by emergencies. The FRS CR collaborates with other Czech security forces to reflect on the latest approaches in dealing with challenging events and stress. They also developed standards for psychosocial crisis support to regulate the organization and coordination of support during major disasters. This experience can be useful as guidelines for other professionals and organizations interested in providing psychosocial support education.

Key words: Critical incident stress management, first psychological aid, psychosocial support, the post-trauma care team, the psychological service of the Fire rescue service of the Czech Republic

1. Introduction

Due to recent events such as the COVID-19 pandemic and the conflict in Ukraine, there has been an increased interest in training for providing psychological support to people in difficult situations. However, there are also risks associated with educating “lay” people in this topic due to inconsistent methodologies and goals, which may influence the variation in the quality of this training (Ni et al, 2023). Keeping records of these courses and verifying their quality and effectiveness is also inconsistent (Wang et al, 2021). The Fire Brigade of the Czech Republic (FRS CR) has been educating officers and employees (hereinafter firefighters) in this area for over a decade. Beyond evaluating the courses with feedback from participants, as is the usual practice (Wand et al, 2021), it verifies training effectiveness through practical application and modifies courses based on intervention analysis.

This text is devoted to an analysis of these experiences in recent years. It also covers the development and approach of FRS CR's training to assess its suitability for other settings. My research objective is to describe the recommendations that emerge from the analysis for the design of psychosocial support training. The research questions fulfilling this objective are:

1. Which areas does the FRS CR's practice highlight as crucial for consideration when providing and training in psychosocial support?
2. What recommendations do these areas suggest beyond the currently available guidelines?

Development of psychological support training at FRS CR

The psychological service of FRS CR (PS FRS CR) has trained firefighters in psychological areas since its establishment in 2003, firstly to support them in coping with difficult work situations as mandated by the Law on Service (Act No.361/2003 Coll). At the time of the formation of PS FRS CR, there were fifteen psychologists, each in one region of the Czech Republic. It was clear, that the limited capacity of a few professionals could not cater for the needs of all the activities defined for the psychological service: the basis for the personnel work, post-traumatic care for officers and assistance for victims of emergencies (Vrbová and Dohnal, 2010). To address this, the psychologists adopted the System of Critical Incident Stress Management based on the cooperation with International Critical Incident Stress Foundation (ICISF, 2023). They trained volunteers from firefighters in a several-day course focused on practical training in providing collegial support and methods such as debriefing and defusing. Other units of the Integrated Rescue System (IZS), such as the police and the health service, have adopted a similar system of training (Baštecká, 2005). Trained firefighters then became members of the post-trauma care team (TPP) to be engaged in peer support and often direct intervention for people affected by emergencies, even though it is not part of their course yet. This approach has not only made psychological support more available but also facilitated a psychological service to the firefighters.

Lately, the area of psychological intervention, namely in psychological first aid (in Czech “První psychická pomoc”, PFA), started to be the central topic of training. In 2008, depending on the development of the intervention activity, the methodological guidelines for the course on Psychological first aid (PFA) were developed. Subsequently, in 2009, an extension course PFA II, which is focused on providing support to specific population groups (e.g. children, people with disabilities). With the creation of these courses, which started to be regularly (usually 1 to 2 times per year) conducted by psychologists in the regions, the intervention work of the TPP has also been fully defined. This is evident in the development of the separate statistics that have been kept since then. At the same time, the number of team members has also increased slightly over the years, from 159 to 302 members. This suggests an interest in the training and their activities.

PFA how the PS FRS CR approaches it is a specific psychosocial intervention, similar to e.g., providing information in the form of a leaflet or specific professional services such as legal or social (Hoskovcová, 2009). It is a set of practices aimed at stabilizing the psychological condition in order not to worsen the situation of the affected person. The main steps are the provision of basic human needs, including the promotion of a sense of security, the provision of information and, where appropriate, referral to further care. This definition is in line with the currently published WHO guidelines for the provision of psychosocial support (2019).

The content of the PFA courses follows the recommendations of the RAPID system, which has been research-validated by Everly and colleagues (2012), and is also consistent with other recommended guidelines, such as Hobfoll’s principles used by WHO (2013). The Psychological Service is continually working to reflect on the latest approaches in the field of stress management and trying to incorporate them into courses. Collaboration with other Czech security forces psychologists and experts is helpful. Several psychologists

of the FRS CR are also members of the Crisis, Disaster and Trauma Psychology Group of the Czech-Moravian Psychological Society.

Networking and linking of knowledge have also accompanied PS FRS CR since its inception. Based on the experience with flood relief in the spring 2010, the psychological service in cooperation with a group of experts under the Ministry of the Interior (MI) wrote Standards for psychosocial crisis support and outcome-focused collaboration (2010). This document became essential to anchor the care provided with clear goals and objectives, even between the different branches of the state and the collaborating organizations. Table 1: Standards for the direct provision of support is an overview of the standards selected.

Table 1. Standards for the direct provision of support

Standard	Description
Team, collegial, and civic collaboration	Motivate the helper to perform well and manage tasks together with others rather than attempting them alone.
Active seeking; making and ending first contact	Establish principles that will contribute a reasonable level of trust between persons directly involved in an emergency.
Situational orientation and possible cooperative agreement	Identify and verify needs and values, strengths and resources, and coping strategies. Set out cooperation specifically for each individual affected, taking into account their needs and values.
Support in communicating bad news	Choose a type of dialogue that emphasizes that the person is not alone in dealing with the problem when breaking bad news. Provide necessary information and instructions.
Promoting self-help , mutual assistance, and the creation of action plans	Support the wounded person's resolve to make their own way by helping other victims.
Promoting rights and interests	Identify methods and ways in which the victim can regain confidence and reintegrate back into the community.
Linking to medium- and long-term assistance	Ensure a smooth progression to the medium-term and long-term phases after immediate assistance.
Supporting the preparedness of affected people and communities for the next event	Spread personal and general awareness that disasters are unfortunately a common part of life, but that every individual can prepare for it and that the best way to cope is to deal with it directly and together.
Information and education; communication with the public and the media	Truthfully communicate about the disaster, using all available means, informing about ways of coping with the disaster. Handle information and awareness-raising materials appropriately.
Documenting the event, helping and development	Proper documentation leads to the preservation of memory of the event, leads to the recording of positive changes, and evaluates the results of assistance and cooperation.

Source: MV-GR HZS ČR, 2010

Another fundamental document is the Standard operating procedures of IZS units in providing psychosocial support (STČ 12/IZS, 2012), which regulates the organisation and coordination of psychosocial support during emergencies, where several intervening security forces come together as well as other cooperating units¹⁰. Systematic character of care delivery has become a part of the training of TPP, and the recent events prove how important it is for effective work. The TPP also uses ancillary materials and new educational technologies including DVDs, communication cards, and mobile applications.

¹⁰ These include, for example, clergymen, health workers or workers of non-governmental organizations (NGO).

The Psychological Service has developed manuals and leaflets for public to be used in training and dissemination of useful information¹¹.

2. Materials and Methods

As I described above, the training and provision of psychosocial support within the FRS CR is comprehensively systemic. Its effectiveness is measured not just by firefighters interest in the courses but mainly by the application of acquired competences in coordinated IZS unit activities. Events in recent years have brought many new insights of the current system. It is a common practice of the FRS CR to analyze the experience and to incorporate it further into training and work practices. This paper aims to summarize the analysis of three recent incidents and derive recommendations for further educational development. Those events are: the pandemic (COVID-19), the tornado in South Moravia (Tornado), and coping with the effects of the war conflict in Ukraine (Ukraine).

The process of events analysis is primarily a qualitative methodology approach. The first crucial stage is the collection of data and evidence for analysis during the incident. Currently, the collection focuses on quantitative data on interventions delivered, which all support providers record for statistical purposes, and on qualitative notes, kept by the FRS CR psychologists coordinating psychosocial support. This care is taken to ensure the security of sensitive data.

All three events affected the whole territory of the Czech Republic, which is why the entire psychological service, which currently consists of 17 psychologists, 5 assistants and 302 TPP members, was involved in their processing. In dealing with the conflict in Ukraine and the pandemic situation, all psychologists in their regions collected the data. From the Tornado, we processed data from four psychologists who were in a coordinating role in the event. The evidence is collected through a semi-structured report that is sent by the psychologists to the head office of PS FRS CR. This report focuses on the number of interventions carried out (summarising PFA and crisis interventions, depending on the provider's training), identification of the groups affected and their needs, provision and progress of support provided and closure of the activity conducted. The number of interventions provided and a description of the providers in each event is shown in the results section in the first column of Table 2.

The psychologists then discuss the individual findings together to identify challenges and strengths. The work follows the form of a focus group during a one-day meeting following the event. The criterion of effectivity is the promptness and accessibility of the care, the coverage of the affected population, and the transfer of care to the local community ideally, or to the long-term support of one of the involved units (usually NGOs). These are goals in compliance with the purposes of the PFA (WHO, 2019).

My task for this article consisted of a qualitative analysis of outcomes from the three incidents mentioned above. I followed the method of content analysis, with the first part of this analysis already conducted for each incident by PS FRS CR. That is, extracting the underlying content from the experiences during the incidents and creating categories that are key to the outcomes. I was comparing these categories within events and was looking for potential connections. The final step was to return the categories found to their content. In this step, I was analyzing

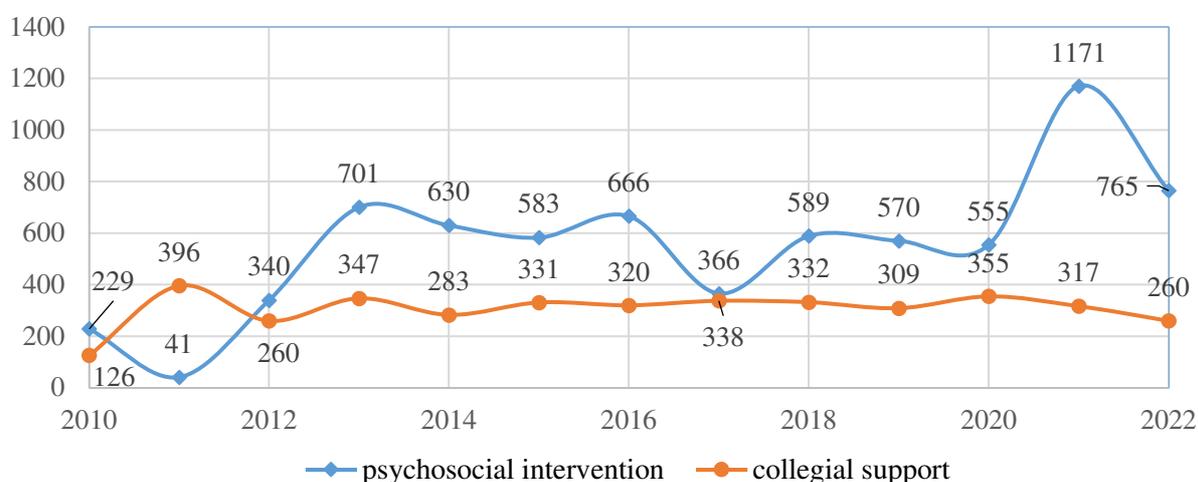
¹¹ Available at: <https://www.hasici-vzdelavani.cz/content/materialy-ke-stazeni-1>.

whether the categories differed from each other. The observation of these differences led to the derivation of changes that were applied in the provision of psychosocial assistance.

3. Results and Discussion

Table 2: Analysis of recommendations for the development of psychosocial support (2020-2023) presents the highlighted strengths and weaknesses of the work conducted during the three defined events that emerged during the evaluation meetings of the PS FRS CR. It also reports on the number of interventions and the providers involved. Figure 1: Psychosocial intervention care and collegial support provided by TPP (2010-2022) shows the increase in interventions delivered by trained TPP members in recent years beyond these events. From a qualitative perspective, it is evident that the amount of support provided to people during emergencies is increasing and therefore further development of providers is needed.

Figure 1. Psychosocial intervention care and collegial support provided by TPP, 2010-2022



Source: Own calculation¹²

To answer the defined research questions, Table 2 I have converted the suggestions into the field of psychosocial support training, which has been taken into account in the wake of the incidents. This comparison is based on my experience as a lector of these courses and on reflection on the methodological documents for these courses.

Table 2. Analysis of recommendations for the development of psychosocial support, 2020-2023

	Good Practices	Shortcomings	For training
COVID-19 Duration: 12/03/2020 - 25/12/2021 Interventions: Cannot be specified. The example includes 339 supportive phone calls conducted by FRS	Collaboration with documentarians and technicians ¹³	Difficulties with distance work	Verified information and materials; Utilizing online methods
	Creating educational video materials	Difficulty unifying remote interventions	Training on providing support remotely
	Using online technologies	Difficulties in obtaining verified information	Interagency and interprofessional cooperation

¹² Charts and tables are created by the author on the basis of the PS FRS CZ internal data. The statistical data are unpublished outputs of a regular annual evaluation. Limited outputs can be found at regular statistical yearbooks here: <https://www.hzscr.cz/clanek/statisticke-rocenky-hasickeho-zachranneho-sboru-cr.aspx>

¹³ The results of this work are available at: <https://www.youtube.com/@psychologhasici5008>

Prague Involved: Psychological service FRS CZ	Connecting with cross-departmental professional supervision (under MI)	Inaccurate work evidence	Clarifying work evidence
Tornado Duration: 30/06/2021 - 03/07/2021 Interventions: 4194 by FRS CZ only Involved: Psychological services of IZS, NGO and volunteer professionals	Dividing work by sector	Disorganization in work setup	Consistent coordination system
	Involvement of external interveners and volunteer psychologists	Insufficient facilities	Providing facilities and materials for quick training
	Coordinating from a central point (head psychologist of FRS CR and MI)	Difficulty in coordinating volunteers	Establishing contacts, networking
	Support materials (flyers) and differentiation tapes	Inaccurate evidence, difficulties in the transfer of follow-up care	Using local community resources
	Connecting with local support sources for long-term care	Lack of time for verification/training	Clarifying work evidence
Ukraine Duration: 01/03/2022 - 31/03/2023 Interventions: 3580 under FRS CR coordination Involved: Psychological services of IZS, NGO, and volunteer professionals from the community	Established facilities and work coordination	Long-term work in the coordinator position	Working in a coordination team
	Collaborating with IZS and external agencies	Events beyond the scope of work under STC 12/IZS	Monitoring personal boundaries
	Utilizing technologies for information gathering and processing	A large number of involved helpers, often without experience	Supporting helpers, group and peer support
	Early seeking long-term support and good evidence.	Risk of data abuse	Security of the evidence
	Use of community resources (volunteers, experts)		Utilizing community resources (volunteers, professionals)

Source: Own creation

The aim of this text was to present the system of psychosocial support training at the FRS CR with the intention of outlining important aspects for the development of similar training in other organizations. The research questions asked about areas that can be identified through analysis of practical experience of providing this support and whether these areas lead to recommendations that go beyond the guidelines already identified.

The PS FRS CR is conducting an evaluation of the system and training through an effectiveness of the practice undertaken. At the same time, as noted in the summary study of the Red Cross (Fox et al, 2012), it is difficult to research the effectiveness of PFA and psychosocial intervention as such. Therefore, the psychological service has developed internal criteria for the effectiveness of its work, which are linked to the availability and feasibility of the necessary support at the emergency and to its closure and transfer to the affected local authorities or supporting NGOs. Thanks to this way of processing, it is possible to define the areas that are important, therefore possible to answer the first research question as well.

Looking into the history of psychosocial support in the FRS CR, it can be noted that the recommendations still develop and elaborate the basic standards that the psychological service set at the beginning of its existence. Table 3: Recommendations and standards for training in psychosocial support summarize guidelines in comparison to established

standards for the provision of this support. A standard that was not assignable to any recommendation is “Active seeking; making and ending first contact”. It is contained in the implementation of training itself as a voluntary activity.

Table 3. Recommendations and standards for training in psychosocial support

Recommendations for Education	Standard
Use verified information and materials; Utilization of online methods	Information and education; communication with the public and the media
Interagency and interprofessional cooperation	Team, collegial, and civic collaboration
Clarify and secure evidence	Documenting the event, helping and development
Establishing contacts, networking	Linking to medium- and long-term assistance
Using local community resources	Supporting the preparedness of affected people and communities for the next event
Working in a team, coordination	Situational orientation and possible cooperative agreement
Monitoring personal boundaries	Support in communicating bad news , Promoting rights and interests
Supporting helpers, group and peer support	Promoting self-help, the creation of action plans

Source: Own creation

The results of the analysis conducted are consistent with WHO (2013) and Red Cross (2018) guidelines on using validated information, promoting community resources, self-care, and guarding one's own boundaries in PFA training. In response to the second research question, the experience of providing care under the auspices of the fire service further requires ensuring the safety of the information transmitted and received, encouraging coordination and collaboration, and maintaining evidence of the work provided. For PFA courses, this means ensuring the development of competence to recognise the intervention provided, thus knowing the boundaries of their work and being able to monitor their actions. And to take the competence of collaboration with the person affected and with colleagues, which includes peer support.

This article aimed to identify key recommendations applicable to other areas, but their use should be acknowledged within certain limits. As the historical review has shown, our courses work with a homogeneous group of volunteer firefighters. The intention of the courses is to build on their experience and develop their skills in providing psychological first aid and peer support in the acute emergency. These are not crisis intervention courses (Hoskovcová, 2009) and are not targeted at any specific group of those affected (e.g. hospital patients). For example, Humpl and colleagues (2013) offer recommendations for these areas. Psychologists specialising in this field conduct these courses, and it is a comprehensive care system. The importance of developing an educational system versus individual PFA courses is also reflected in the summary analysis of the courses conducted by Movahed and colleagues (2023). This is a great advantage of the PS FRS CR, and it can be difficult to design courses in this way if the system is still being developed and the methodological materials for it haven't been prepared yet. The guidelines mentioned above should also be followed in this case.

4. Conclusion

Considering the standards established in 2010 and the current recommendations resulting from experience, we see how important it is to define values and principles for conducting psychosocial support training. Using verified materials and methods, learning to collaborate and coordinate, invoking the resources of the affected person (or in other contexts, the client or the patient), keeping safe evidence, and support for interveners are increasingly at the forefront of importance and should be considered as guidelines for training lay people in psychosocial support. These recommendations are based on the work of professional rescuers in emergencies but may be useful in developing training in other areas of psychosocial support.

References

- Act 361/2003 Coll, “*On the service relationship of members of the security forces*”
- Baštecká, B. (2005). “*Terénní krizová práce: psychosociální intervenční týmy*”, Prague: Grada, ISBN 80-247-0708-X
- Critical Incident Stress Foundation, ICISF – Education & Training Programs, <https://icisf.org/>, accessed 2023
- Everly, G. S., Jr, Barnett, D. J. and Links, J. M. (2012). “The Johns Hopkins model of psychological first aid (RAPID-PFA): curriculum development and content validation”, *International journal of emergency mental health*, 14(2), 95–103
- Fox, J. H., Brukle, F. M., Bass, J., Pia F. A., Epstein, J. L. and Markenson, D. (2012). “The Effectiveness of Psychological First Aid as a Disaster Intervention Tool: Research Analysis of Peer-Reviewed Literature From 1990-2010”, *Disaster Medicine and Public Health Preparedness*, 6(3), 247-252, ISSN 1935-7893, DOI 10.1001/dmp.2012.39
- General Directorate of the Fire Brigade of the Czech Republic [MV-GŘ HZS ČR] (2010). “Standardy psychosociální krizové pomoci a spolupráce zaměřené na průběh a výsledek”, Praha: MV-GŘ HZS ČR, ISBN 978-80-86640-51-8
- Hoskovcová, S. (2009). “*Psychosociální intervence*”, Prague: Karolinum, ISBN 978-80-246-1626-1 (In Czech)
- Humpl, L., Prokop, M. and Tobiášová, A. (2013). “*První psychická pomoc ve zdravotnictví*”, Brno: NCONZO, ISBN 978-80-7013-562-4 (In Czech)
- Movahed, M., Khaleghi-nekou, M., Alvani, E. and Sharif-Alhoseini, M. (2023). “The Impact of Psychological First aid Training on the Providers: A Systematic Review”, *Disaster Medicine and Public Health Preparedness*, 17, ISSN 1935-7893, DOI 10.1017/dmp.2022.27
- MV-GŘ HZS ČR (2012). “*Typová činnost složek IZS při poskytování psychosociální pomoci STČ 12/IZS*”, Prague: MV-GŘ HZS ČR (In Czech)
- Ni, C.-F., Lundblad, R. and Dykeman, C. (2023). “Diversity and Training Delivery Trends in Psychological First Aid During COVID-19: Implications for Researchers and Practitioners”, *Psychological Trauma: Theory, Research, Practice, and Policy*, Advance online publication, DOI 10.1037/tra0001447

Red Cross and Red Crescent Societies [RCS] (2018). “*A Guide to Psychological First Aid for Red Cross and Red Crescent Societies*”, Copenhagen: IFRC Reference Centre for Psychosocial Support, ISBN 978-87-92490-53-7

Vrbová, Z. and Dohnal, D. (2010). “*Koncepce psychologické služby HZS ČR pro období 2010/2015*”, Prague: MV-GŘ HZS ČR (In Czech)

Wang, L., Norman, I., Xiao, T., Li, Y. and Leamy, M. (2021). “Psychological first aid training: A scoping review of its application, outcomes and implementation”, *International journal of environmental research and public health*, 18(9), p.4594, DOI 10.3390/ijerph18094594

World Health Organization [WHO] (2013). “*Psychological first aid: Facilitator’s manual for orienting field workers*”, Geneva: WHO, ISBN 978-92-4-154861-8

WHO (2019). “*Psychická první pomoc: průvodce pro terénní pracovníky*”, Prague: Diakonie ČCE - Center for Humanitarian and Development Cooperation, ISBN 978-80-906509-9-2 (In Czech)

EFFECTIVENESS OF STUDYING BASED ON ELECTRONIC RESOURCES AND TEACHER PERSONALITY IN TEACHING ACCOUNTING AT A SECONDARY SCHOOL

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Annotation: This paper investigates the effectiveness of studying accounting from electronic resources among secondary school students. The most preferred electronic resource is explanatory videos including diagrams, texts and images. Also, presentation files containing the teacher's explanation are highly preferred. The aim of the paper is to evaluate whether the success of studies can be related to the use of electronic study resources. A carefully prepared didactic test presented to the experimental and control study group showed how the pupils react to test questions of different types. The results of this didactic test were used to statistically establish whether the success of solving this test depends or does not depend on the use of electronic study resources. In this way, it would be possible to measure the effectiveness of studying from electronic sources. Undoubtedly, the personality of the teacher is also very important in evaluating the student's success. Therefore, there is also an output from secondary research that will show how the teacher's personality has an effect on the student's success. The discussion will focus on a number of opinions that are often mentioned in regard to electronic resources for studying.

Key words: Accounting, electronic resources, learning effectiveness, learning success, secondary school

1. Introduction

Teaching Accounting as a subject at secondary school level in the Czech Republic begins in the second year of study in the economic fields (mainly the fields of Business Academy and Economic Lyceum). It is assumed that students already know basic concepts of economy and are aware of the basic processes in business enterprises. They can, therefore, better grasp the securing of these processes in Accounting as is common in the practice of companies and other types of accounting units.

A number of authors have analysed the relationship between the use of electronic resources and the results of accounting studies in universities in their research and other outputs. Martínez, Jaén and Gil (2022) point out the importance of ICT methods in the practice of university accounting. The impact of ICT use on the success of accounting students at several specific universities is also suggested by Terblanche et al. (2023). Krasodomska and Godawska (2020) also found a positive effect on the performance and success of students of different nationalities when studying accounting using e-learning.

These studies are most often focused on university study of Accounting. There are virtually no relevant outcomes regarding the effectiveness of learning from electronic resources in secondary schools.

The aim of the paper is to evaluate whether the success of accounting studies at secondary school can be related to the use of electronic information sources.

In addition, as a secondary aim, the contribution will evaluate how students evaluate the influence of their teacher on the students' learning success.

2. Materials and Methods

In order to proceed with this research, it was first necessary to determine which electronic resources students are familiar with and which ones they specifically use and prefer when studying Accounting in secondary school.

This was aided by a partial survey in 2021, when, due to epidemiological measures related to the COVID-19 disease, virtually all teaching had to be transferred to an on-line environment. Although the number of respondents to this survey was relatively small and no other links and relationships were explored, the following data can provide at least a basic understanding of the views and preferences of secondary school students in using electronic resources in their studies of Accounting.

Table 1. Preferred electronic resources for studying Accounting at secondary school

Order	Designation of the electronic resource	Preference rate (%)
1	Video with presentation including diagrams, text, pictures	48.4
2	Presentation file containing teacher's lecture	38.7
3	Plain text with interpretation	33.9
4	Instruction to find and study the topic independently	8.1
5	Copies of texts from textbooks	6.5

Source: Own calculation

For teachers, the use of electronic resources for students of Accounting brings undeniable advantages, especially in terms of time savings. In their survey, Grabinski et al. (2020) point out the significant initial time requirement in the preparation of electronic resources but also based on a survey among university teachers of Accounting. He emphasises the use of these resources mainly to make the educational process more efficient, to save time during actual teaching and to keep pace with changing technologies.

To assess the effectiveness of using electronic resources in the study of Accounting, a suitable topic was first selected. This topic is the assets or property of a business enterprise. In Accounting, the assets of a business enterprise are understood to be all that the enterprise owns, which can be valued in money and the enterprise uses these items for its activities.

Next, two equally-sized study groups were randomly defined; one group – the control group – completed the entire topic in the form of traditional frontal instruction. The second group – the experimental group – completed the entire topic by studying exclusively from electronic resources. Students were provided with two electronic resources identical in content: a video explaining the topic and a file with a teacher's presentation on the topic. Students could choose one of the resources according to their preferences or use both.

A special didactic test was created to verify and compare the results of both study groups.

This didactic test, which was presented to both the experimental and the control group, contained a total of 14 test items related to the interpreted topic. These were closed multiple-choice test items, always containing a task (question) and a choice of four answers, only one of which was correct. However, these test items were divided into three categories for further analysis of the results:

- a) test items focused on knowledge of general definitions and characteristics of the chosen topic (4 items), this set of test items will be referred to as "Definitions" in the following text of this paper;
- b) test items focused on the ability to make practically oriented applications, reasoning and inferences based on knowledge of general definitions and characteristics (6 items), this set of test items will be referred to as "Application" in the following text of this paper;
- c) test items focusing on literacy, i.e. the ability to understand the text of a question and to derive the correct answer based on this understanding (4 items), this set of test items will be referred to as "Literacy" in the following text of this paper.

The aim of the didactic test was, therefore, not only to determine the overall success rate of the students but above all, to verify their competence of knowing the basic concepts, to be able to apply them in practical situations and to understand the written specialised text.

3. Results and Discussion

After the evaluation of the didactic test, there were 33 answers of the students from the control group and also 33 answers of the students from the experimental group. First, the average solution success rate in the experimental and control groups was determined, followed by the median success rate and the mode of success rate. These basic statistics were found separately for the test items Definitions, Application and Literacy as follows:

Table 2. Basic statistics of the didactic test success rate in the control and experimental group

	Success rate of the control group (%)			Success rate of the experimental group (%)		
	Definitions	Application	Literacy	Definitions	Application	Literacy
Average	66	78	58	63	72	55
Median	75	80	50	66	80	50
Mode	75	100	50	75	100	50

Source: Own calculation

The stated values indicate that the control group, when the students studied the selected topic in the form of traditional frontal instruction, shows a higher success rate of the didactic test from the point of view of basic statistics (average and median). From this point of view, the traditional form of teaching seems more effective. But is there a statistically significant relationship between students' success rate and the form of study of the subject area?

First, the normality of the data distribution was verified. It was determined whether the results of the students of the control group and the results of the students of the experimental group had a normal distribution. The Shapiro–Wilk test was used for this purpose. At the 5% level of significance, it was found that both the data in the experimental group and the data in the control group do not have a normal distribution.

A non-parametric test had to be used to find out whether the success of the didactic test of pupils in the control group and in the experimental group depends on the chosen form of study. The Mann–Whitney U-test was chosen. The following hypotheses were tested at the 5% significance level:

H_0 ... the success of the didactic test does not depend on the form of study

H_1 ... the success of the didactic test depends on the form of study

The relationship between the success of the didactic test and the chosen form of study was then determined separately for the test items Definition, Application and Literacy as follows.

Table 3. Values determined by the Mann-Whitney *U*-test

Didactic test item	<i>p</i> -value	<i>U</i> -test criterion
Definition	0.86502	2139.5
Application	0.43251	2152.5
Literacy	0.43251	2127.0

Source: Own calculation

It can be seen from this table that the *p*-value is in all cases higher than the established 5% level of significance. Also the test statistics are higher than the critical value (table value). Therefore, the hypothesis H_0 cannot be rejected for this non-parametric test. This result says that no difference was found between the success rate of both forms of study.

From these results, it can be assumed that the teacher him/herself could have influenced the success rate of the students in the didactic test in the test items of the Application by their approach and the style of teaching. The question can overall be posed whether there is a relationship between the teacher's personality and students' performance in their study of Accounting. These results obtained at the secondary school level are most often expressed in terms of grades on a grading scale.

Independently of the above evaluation of the results of the didactic test, in the first half of 2022, a rather extensive investigation of the factors that could influence the success rate in studying Accounting among secondary school students was carried out. More than 300 respondents – students from all over the Czech Republic took part in this survey. Almost 90 schools where the subject of Accounting is taught were approached. The respondents answered 12 questions that were supposed to determine what factors influence the academic success of pupils. Respondents were asked, among other things, how actual teachers affect their relationship to the study subject of Accounting. Students could answer that their teacher influences them positively, negatively or not at all in their study of Accounting.

Since in another part of the questionnaire survey the students also reported the grade on the grading scale they received in the study subject of Accounting in their last report; this also allowed us to test the following hypotheses:

H_0 ... the student's evaluation is not influenced by the teacher's personality

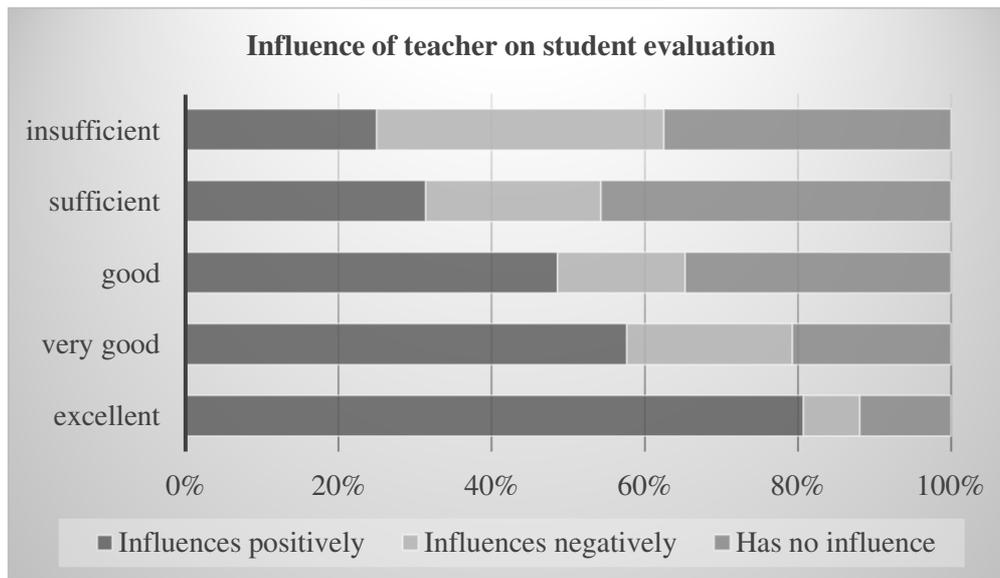
H_1 ... the student's evaluation is influenced by the teacher's personality

These hypotheses were tested using contingency tables and a *Chi*-square test, and in case of rejection of H_0 and thus finding that the evaluation depends on the given factor, the strength of this dependence was still calculated using Pearson's contingency coefficient.

This method was used to reject the H_0 hypothesis. Therefore, the teacher's personality influences students' learning success rate in the study subject of Accounting, and in a positive way.

In this case, the *p*-value of the performed *Chi*-square test was 4.717×10^{-7} . It means that the hypothesis H_0 is rejected. The Pearson Contingency Coefficient gives a value of 0.0049. It means that the influence of the student's assessment on the teacher's personality is very weak.

Figure 1. Graphical representation of the relationship between students' success rate in Accounting and their influence by the teacher



Source: Own elaboration

The topic of using electronic resources in education has been widely discussed for many years. Dusing, Hosler and Ragan (2012) focus on teachers' experience and attitudes in on-line Accounting education. More than 10 years ago, they described how to integrate modern on-line learning technologies into the teaching process optimally and further explored ways to increase the effectiveness of on-line courses compared to traditional courses. Although this paper does not contain any specific analysis or breakdown, it can be seen as a stimulus for possible future research.

Based on a survey of university teachers, Grabinski et al (2020) highlight the use of electronic resources and information technology, particularly in relation to greater efficiency of the educational process and time savings in teaching. The question up for discussion here, however, is whether these benefits can also be seen in secondary school teaching.

Regarding the students' perspective, for example, Ječmínek, Kuchařová and Pfeiferová (2020) note that students belonging to the millennial generation have a strong negative opinion of the classical style of lecture and the use of PowerPoint presentations in these lectures. However, according to these authors, this again applies mainly to university students. For secondary school students who encounter Accounting for the first time, the role of the teacher and his/her positive influence on the students is probably of utmost importance.

However, this view contradicts the claim of Taplin et al. (2017), who derives from the students' opinions that only a part (specifically one quarter) of the study materials should be converted into electronic form and that the personal approach of the teacher should prevail.

Interestingly, the consensus is mostly on the use of specific software products used to process accounting and related economic agendas that students may sooner or later encounter in practice. These products and their use can also be considered as electronic resources used in the teaching of Accounting. However, this is only a theoretical view. Machera and Machera (2017) state that embedding the use of computerised accounting software into mainstream

teaching not only responds to the demands of real-life practice but also helps them to master their academic assignments and ultimately improves their chances of finding employment. This is also confirmed by Ulman et al. (2020), stating that the inclusion of Enterprise Resource Planning (ERP) apps in the classroom is very beneficial to students. ERP systems are often based on or directly related to Accounting. However, the authors point out the need for sufficient time for this topic and an appropriate combination of teaching methods.

Šálková et al. (2022) state that future improvements in on-line learning can be seen in a significant shift from traditional textbooks (scripts) to e-books and from traditional lectures to a higher proportion of multimedia learning materials or lecture recordings. An interesting suggestion is the possibility of dividing on-line learning into two parts: teacher's explanation and individual on-line study.

4. Conclusion

This paper was primarily concerned with the possibility of effective use of electronic resources in the study of Accounting in secondary school. In line with all of the above, it can be concluded that although a number of papers deal with the issue of the use of electronic resources in the study of Accounting, most of them concern university students, not secondary school students. However, it is in secondary schools that students first encounter the field of Accounting.

The research carried out on a specific selected topic showed no statistically significant relationship between the way in which students studied this topic and their success rate in the special didactic test. Therefore, it cannot be said that the use of electronic resources in the study of Accounting in secondary school is significantly more effective in terms of student success rates. Only in the area of the didactic test items dealing with the ability to apply the acquired knowledge into real-life practice was the relationship statistically stronger. For further research, it may be inspiring to repeat a similar procedure with students in higher years who have more experience with Accounting and also more theoretical knowledge.

The positive contribution of this paper is certainly the fact that many secondary school students report that their teacher positively influences them during their studying of Accounting. This opinion was tested by statistical methods, which proved the hypothesis that the evaluation and academic success rate of students are influenced by the teacher's personality.

References

- Dusing, G. M., Hosler, J. C. and Ragan J. M. (2012). "Teaching Accounting Courses Online: One Instructor's Experience", *American Journal of Business Education*, vol. 5, no. 3, pp. 359-368, DOI 10.19030/ajbe.v5i3.7009
- Grabinski, K., Kedzior, M., Krasodomska, J. and Herdan, A. (2020). "Embedding E-Learning in Accounting Modules: The Educator's Perspective", *Education Sciences*, vol. 10, no. 4, pp. 1-19, DOI 10.3390/educsci10040097
- Ječmínek, J., Kuchařová, I. and Pfeiferová, D. (2020). "Theoretical accounting courses students' success rate at FEM CULS Prague Appraisal", *Proceedings of the 17th International Conference Efficiency and Responsibility in Education (ERIE 2020)*, Prague, pp. 144-150

- Krasodomska, J. and Godawska, J. (2021). "E-learning in accounting education: the influence of students' characteristics on their engagement and performance", *Accounting Education*, vol. 30, no. 1, pp. 22-41, DOI 10.1080/09639284.2020.1867874
- Machera, R. P. and Machera, P. C. (2017). "Computerised Accounting Software; A Curriculum that Enhances an Accounting Programme", *Universal Journal of Educational Research*, vol. 5, no. 3, pp. 372-385, DOI 10.13189/ujer.2017.050310
- Martínez, E. O., Jaén, J. M. S. and Gil, E. G. (2022). "Higher Education and Tutoring: Virtual Tutoring in Accounting", *Digital Education Review*, no. 42, pp. 16-33, DOI 10.1344/der.2022.42.16-33
- Mergendoller, J. R., Maxwell, N. L. and Bellisimo, Y. (2006). "The Effectiveness of Problem-Based Instruction: A Comparative Study of Instructional Methods and Student Characteristics", *Interdisciplinary Journal of Problem-Based Learning*, vol. 1, no. 2., pp. 49-69, DOI 10.7771/1541-5015.1026
- Šálková, D., Kučera, P., Regnerová, O. and Varvažovská, P. (2022). "Distance learning impact on study results with respect to learning environment", *Proceedings of the 19th International Conference Efficiency and Responsibility in Education (ERIE 2022)*, Prague, pp. 98-105
- Taplin, R., Kerr, R. and Brown, A. (2017). "Monetary valuations of university course delivery: the case for face-to-face learning activities in accounting education", *Accounting Education*, vol. 26, no. 2, pp. 144-165, DOI 10.1080/09639284.2016.1274913
- Terblanche, W., Lubbe, I., Papageorgiou, N. and van der Merwe, N. (2023). "Acceptance of e-learning applications by accounting students in an online learning environment at residential universities", *South African Journal of Accounting Research*, vol. 37, no. 1, pp. 35-61, DOI 10.1080/10291954.2022.2101328
- Ulman, M., Dvořák, M., Kánská, E. and Motyčková, V. (2020). "Teaching ERP concepts for non/users and users a survey among college students", *Proceedings of the 17th International Conference Efficiency and Responsibility in Education (ERIE 2020)*, Prague, pp. 309-315

MISCONCEPTIONS OF PRE-SERVICE TEACHERS IN THE FIELD OF AXIAL SYMMETRY

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Annotation: The paper is focused on pre-service mathematics teachers' solution of a task related to the axial symmetry of 1D- and 2D-figures. The task was part of several tests in our long-term research of the spatial ability and conceptual knowledge of pre-service mathematics teachers in the field of school geometry, which follows on from our previous research. We were primarily interested in whether and how the misconceptions, that students have formed at lower levels of education, can be influenced by university lessons. We have found that pre-service teachers do not have problems with prototypical shapes, but certain misconceptions regarding unusual tasks persist, although they are partially eliminated by university studies.

Key words: Axial symmetry, line segment, pre-service teacher education, rhomboid

1. Introduction

We have been observing for a long time that the state of teaching geometry in the Czech Republic is not, in our opinion, satisfactory. Not only students at all levels of education, but also their teachers are contended with problems in the field of geometry. Therefore, one of our priorities alongside one of the main goals of our long-term research is to improve the preparation of pre-service mathematics teachers in this area. In this paper, we focus in more detail on how pre-service mathematics teachers, who are studying mathematics at the Faculty of Mathematics and Physics of Charles University, solve one specific task related to axial symmetry in the plane. Spatial imagination and conceptual knowledge can be used when solving this task.

Spatial ability (also called spatial intelligence or spatial imagination) is usually defined as the ability to generate, retain, retrieve, and transform well-structured visual images (e.g., Lohman, 1996; Jeunet, N'Kaoua and Lotte, 2016). For example, a good level of spatial ability allows us to drive a vehicle, to avoid an obstacle or to play ball games.

Spatial ability is closely connected with mathematical skills and achievements, especially with geometry problem solving (Tam and Chan 2022; Putri, 2018; Cui and Guo, 2022; Young, Levine and Mix, 2018; Sorby and Panther, 2020). The sub-component of spatial ability related to mathematics is called *geometrical ability* or *geometrical imagination* (Dušek, 1964; Kuřina, 1987; Humphreys, 2020). According to Kuřina (1987), geometrical ability is a component of visual thinking, which consists in the ability to remember geometric shapes and their properties, and while doing so, we can usually use, or create, their 1D-, 2D- or 3D-models.

Learning the properties of plane figures, solving construction tasks in the plane or transformations of the plane come with the development of geometrical ability in the plane. Understanding all these topics is also related to the level of procedural and conceptual knowledge, which are two key cognitive principles in mathematics education (Hiebert

and Lefevre, 1986; Star, 2005). The first one means the sequence of steps required to solve a problem, while the second one is usually described as an understanding of the underlying basic concepts, principles and relationships among them.

We already dealt with the conceptual knowledge of Czech pupils and students in the field of planar geometry in the research between years 2017 and 2020. In general, it turned out that pupils' and students' conceptual knowledge is not sufficient. Pupils and students make a number of misconceptions during their studies. Two of them, which we have found, are from the area of axial symmetry in the plane: (1) a line segment has only one symmetry axis; (2) a rhomboid is an axially symmetrical figure (Moravcová et al., 2021; Moravcová et al., 2019). The second of the mentioned misconceptions was also described by several foreign researchers (e.g., Aktaş and Ünlü, 2017; Son, 2006; Leikin, Berman and Zaslavsky, 2000) and is probably related to the fact that pupils/students are not confronted with a sufficient number of non-models (i.e., figures which are not axially symmetrical) during their studies. On the other hand, prototypes (Tall et al., 2001) and figures in a prototypical position are preferred. Working only with prototypes of shapes relates to the first of the five levels of van Hiele's theory model describing how students learn geometry (van Hiele, 1986), however, this level corresponds to the abilities of primary school pupils (Burger and Shaughnessy, 1986).

Our empirical research realized between 2017 and 2020 mainly monitored the conceptual knowledge of pupils and students who were about to move forward onto the higher level of education, and did not compare changes in the knowledge of individual persons. On the contrary, now we are focusing on the geometrical ability and conceptual knowledge of pre-service mathematics teachers through a longitudinal study (Surynková et al., 2021). We test our students at the beginning, during and at the end of their university studies. Thanks to this, we can observe what problems they come up with and whether these problems are eliminated during the studies at the faculty. In this paper, we pay attention to the two aforementioned misconceptions and deal with the research question of 'whether university lessons can positively influence (i.e., eliminate) the occurrence of these misconceptions among pre-service mathematics teachers.

First, the following text introduces the research sample and methods of our current research, including the description of the test task on which this article is focused. Then, in the Results section, the most interesting data obtained are presented, and these are subsequently discussed in the Discussion section. The paper ends with a brief summary and a mention of our further plans in this area.

2. Materials and methods

The research, which began in 2020, is based on the input, mid-term and output testing of pre-service teachers who are studying mathematics in combination with another subject. Students are tested at the beginning of their studies, then from three to six times during the university studies (always an output test, sometimes also an input test in the subjects *Basics of Planimetry*, *Stereometry* and *Fundamentals of Projection Methods*), and at the end of the study. Some of the tests were realized online due to the Covid-19 pandemic. The testing is not anonymous, allowing us to compare individual students' results over time. The first tested students are now in their 3rd year of studies, so we do not yet have data from their final output test.

Here we will describe in detail the data related to one task that has been part of four mid-term tests – two input and two output tests for the subject *Basics of Planimetry*. This subject is taught in the summer semester of the first study year. Its content is designed to repeat, supplement and deepen the secondary school curriculum of planimetry. One of the aims is to strengthen the conceptual knowledge of pre-service teachers and eliminate potential misconceptions. Students always wrote the input test at the beginning of the relevant semester (in years 2021 and 2022), and the output test in the same year with an interval of at least 4 months after completing the course. The input test 2021 was realized online. However, we do not observe that this fact has any influence on the results. Students had no reason for cheating, because the result was not a part of any formal assessment.

The test task assignment contained images of 4 planar figures: a line segment, a rhomboid, a square, and an isosceles trapezoid. For each of them, we asked about the number of symmetry axes. The task was formulated as multiple-choice question, students chose from the options: 0, 1, 2, 3, 4, or *another number* for each of the figures. According to the Czech national curriculum, lower secondary school graduates should be able to solve this task.

The data obtained were processed both quantitatively (we monitored how many students answered correctly and how many incorrectly) and qualitatively (we were interested in what mistakes the students made). Furthermore, we compared the results of students at the input and output tests and monitored other possible dependences of the results, for example on gender or on the combination of study subjects. In addition to standard statistical tables, charts and characteristics, such as relative frequency, we used Pearson's χ^2 test (at a significance level of .05, unless otherwise stated) and Fisher's exact test¹⁴ in the cases where the input conditions for the χ^2 test were not met. In addition to our research question formulated above, we stated following null hypotheses:

H₀₁: Gender and students' success rate in the test are independent.

H₀₂: Respondents' study specialization and their success rate in the test are independent.

3. Results and Discussion

Table 1 summarizes the numbers of students tested in the *Basics of Planimetry* course. The last column shows the numbers of students who wrote both tests – input and output one. Someone wrote only one of the tests (e.g., for health reasons). In total, we work with the data of 124 respondents (the sum of the first two numbers in the last row of Table 1).

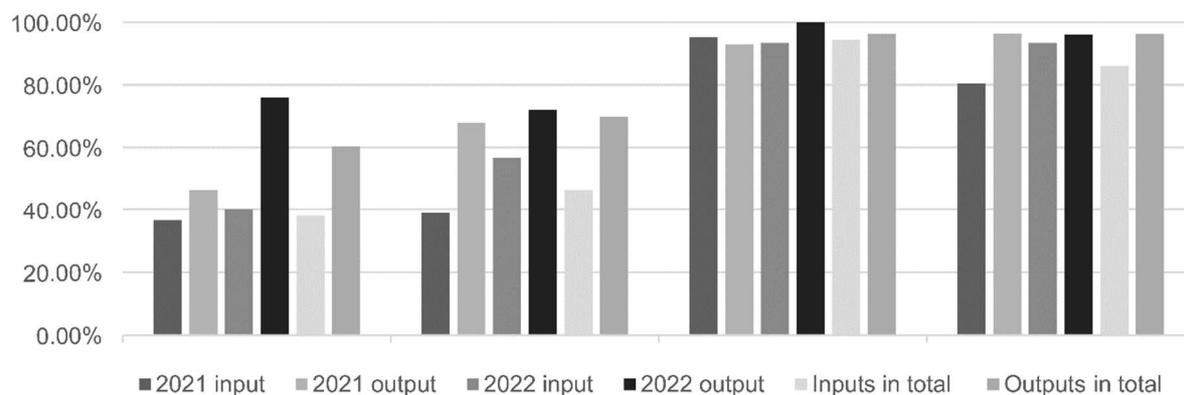
Table 1. Numbers of tested students

	Input test	Output test	Both tests
2021	41	28	26
2022	30	25	18
Total	71	53	44

Source: Own data

¹⁴ The *p*-values of Fisher's test were calculated using an online application on the website (Social Science Statistics, 2018) [cit. 17.04.2023].

Figure 1. Relative frequencies of correct answers to individual questions: What is a number of symmetry axes of a/an (a) line segment, (b) rhomboid, (c) square, (d) isosceles trapezoid



Source: Own data

The histogram in Figure 1 shows the relative frequencies of correct answers to individual subquestions in individual tests and in individual years, and also the relative frequencies of correct answers in the input and output tests for both years together.

Some findings are evident from the histogram. First of all, we can see that in tasks (a) and (b), i.e., to determine the number of symmetry axes a segment line and a rhombus, students made more mistakes than in tasks (c) and (d), in which they determined the number of symmetry axes of a square and an isosceles trapezoid. Table 2 summarizes the relative frequencies of individual responses in detail.

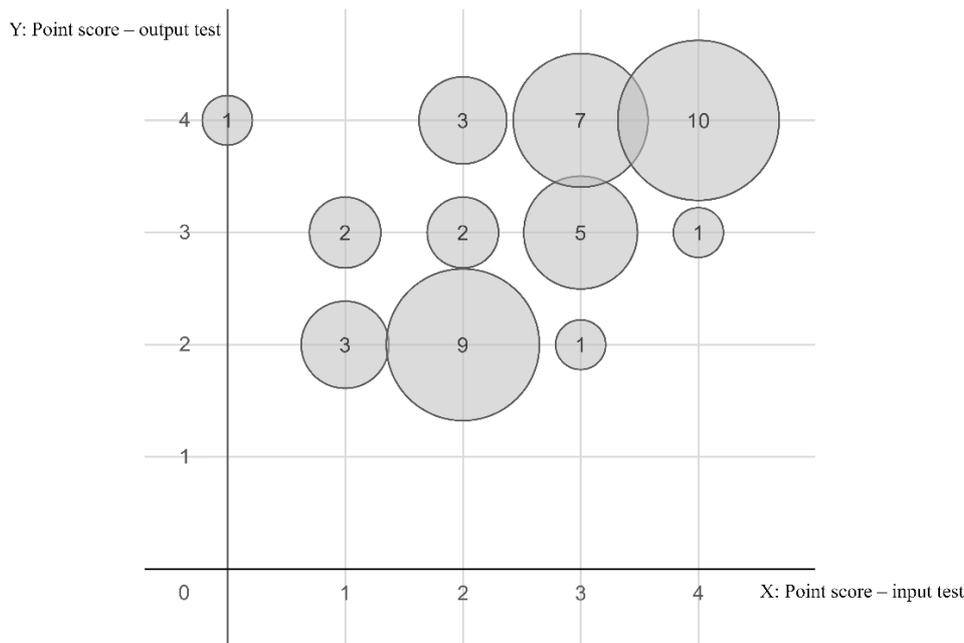
Table 2. The relative frequencies of individual choices of answer; frequencies of correct answers are highlighted

Answer	Input test (both years together)				Output test (both years together)			
	Segment	Rhomboid	Square	Trapezoid	Segment	Rhomboid	Square	Trapezoid
0	2.82	46.48	1.41	4.23	1.89	69.81	0.00	3.77
1	54.93	7.04	2.82	85.92	35.85	5.66	0.00	96.23
2	38.03	32.39	1.41	2.82	60.38	15.09	1.89	0.00
3	1.41	1.41	0.00	4.23	0.00	7.55	1.89	0.00
4	0.00	12.68	94.37	1.41	0.00	1.89	96.23	0.00
another	2.82	0.00	0.00	0.00	1.89	0.00	0.00	0.00
missing	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00

Source: Own data

Furthermore, we can observe that there was a certain increase in the success rate between the input and output tests. We can also demonstrate this increase with the bubble chart (Figure 2), which shows the relationship between the number of correct answers in the input test (X-axis), the output test (Y-axis) and the number of students who had this point score (each student could get a maximum of 4 points for this task in each test, 1 point for each figure).

Figure 2. Increase in student success rate in the output test compared to the input test



Source: Own data

The results thus confirm that pre-service mathematics teachers really have the above-mentioned misconceptions. However, the data further indicate that university education can partially eliminate the occurrence of those misconceptions.

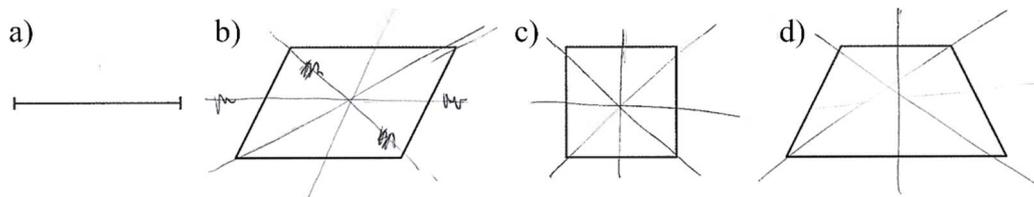
We also focused in more detail on the success rate of students in problematic tasks, i.e., in tasks on a line segment and a rhomboid. We noticed that men were more successful in the input and output tests. However, Pearson's χ^2 test, respectively Fisher's test, did not allowed us to reject null hypothesis H_{01} , except for the line segment task in the output tests (in this task, the value of test criterion K was approximately 7.6, which is even more than the critical value 6.335 on the significance level of .01). We also noted that students who studied mathematics in combination with descriptive geometry, physics or computer science (i.e., the students whose major faculty is the Faculty of Mathematics and Physics) had a higher success rate. However, further statistical analysis showed that null hypothesis H_{02} cannot be rejected again.

This research confirmed our previous finding that students develop misconceptions in the axial symmetry topic (specifically: a line segment has only one axis of symmetry and a rhomboid is an axially symmetrical figure) during their school years, and these misconceptions persist even among pre-service mathematics teachers.

The misconception of the only one line segment axis may come from the confusion of the terms 'a line segment axis' and 'a line segment *symmetry* axis'. In addition, the question on a number of line segment axes is an atypical task – tasks on the axial symmetry of 1D-figures almost do not occur in Czech textbooks (Moravcová et al., 2021). The most common incorrect choices of the number of rhomboid symmetry axes were 2 or 4, just like in our previous research (Moravcová et al., 2021). The same misconception was also described, e.g., by Aktaş and Ünlü (2017), Son (2006) or Hacısalıhoğlu-Karadeniz et al. (2015).

Several students approached solving problems procedurally. They tried to draw axes in the picture. However, the majority of those who chose this procedural method solved the task incorrectly (Figure 3). This observation is consistent with researches which have found that pre-service mathematics teachers prefer procedural knowledge while they lack conceptual knowledge in geometry (e.g., Son, 2006; Thaqi, Giménez, and Rosich, 2011; Hacısalıhoğlu-Karadeniz, Kaya and Bozkuş, 2017). It is also obvious that students who make these mistakes do not have the sufficient level of geometrical ability.

Figure 3. Procedural approach to solving the test task, student's solution with typical incorrect answers a) 1, b) 2, and correct answers c) 4, d) 1



Source: Own data

The slightly higher success rate in favour of men corresponds also to our earlier findings (Moravcová, 2021) and to other researches (e.g., Kambilombilo and Sakala, 2015). The higher success rate of students whose major school is the Faculty of Mathematics and Physics is probably related to their positive attitude towards mathematics (Ganley and Lubienski, 2016).

We were most interested in whether the success of pre-service teachers in problematic tasks would increase after taking university courses related to this topic. A total of 44 students took both the input and output tests. Only 2 of them got worse, 24 of them had the same number of errors (and usually the same mistakes), and 18 students improved. In addition, in the output test in 2022 (i.e., in the second one) the total success rate was higher than in the output test in 2021. One of the possible causes is, that after evaluating the results from the first year, we put even more emphasis on mentioned problems in teaching during the following year. The results correspond with our belief that appropriate education can have a positive effect on the elimination of some misconceptions. However, we must also emphasize that misconceptions are deeply rooted and their elimination is difficult (even in the second output test, only 60% of respondents answered all four questions completely correctly).

4. Conclusion

The paper presents two students' misconceptions related to the concept of axial symmetry in the plane (a line segment has only one symmetry axis, and a rhomboid is an axially symmetrical figure). Through repeated testing, we have found that pre-service mathematics teachers also hold these misconceptions. They can be partially eliminated with appropriate university education. Since teachers significantly influence the quality of education, we recommend, in agreement with other researchers, to emphasize conceptual knowledge and a development of geometric skills in the university preparation of pre-service mathematics teachers regardless of their gender and study subjects. In our next research activities, we intend to continue monitoring the geometric skills of pre-service mathematics teachers and project the obtained results into their preparation.

Acknowledgement

The paper has been supported by the Cooperatio Program, research area Subject Specific Education Research.

References

- Aktaş, G. S. and Ünlü, M. (2017). “Understanding of Eight Grade Students about Transformation Geometry: Perspectives on Students’ Mistakes”, *Journal of Education and Training Studies*, vol. 5, no. 5, pp. 103–119, DOI 10.11114/jets.v5i5.2254
- Burger, W. F. and Shaughnessy, J. M. (1986). “Characterizing the van Hiele Levels of Development in Geometry”, *Journal for Research in Mathematics Education*, vol. 17, no. 1, pp. 31–48, DOI 10.2307/749317
- Cui, X. and Guo, K. (2022). “Supporting mathematics learning: a review of spatial abilities from research to practice”, *Current Opinion in Behavioral Sciences*, vol. 46, DOI 10.1016/j.cobeha.2022.101176
- Dušek, F. (1964). “Rozvoj prostorové představivosti”, *Matematika ve škole*, vol. 14, no. 6, pp. 313–318 (In Czech)
- Ganley, C. M. and Lubienski, S. T. (2016). “Mathematics confidence, interest, and performance: Examining gender patterns and reciprocal relations”, *Learning and Individual Differences*, vol. 47, pp. 182–193, DOI 10.1016/j.lindif.2016.01.002
- Hacısalıhoğlu-Karadeniz, M., Baran, T., Bozkuş, F. and Gündüz, N. (2015). “Difficulties of prospective elementary mathematics teachers’ regarding to reflection symmetry”, *Turkish Journal of Computer and Mathematics Education*, vol. 6, no. 1, pp. 117–138, DOI 10.16949/turcomat.71538
- Hacısalıhoğlu-Karadeniz, M. H., Kaya, T. B. and Bozkuş, F. (2017). “Explanations of prospective middle school mathematics teachers for potential misconceptions on the concept of symmetry”, *International Electronic Journal of Elementary Education*, vol. 10, no. 1, pp. 71–82, DOI 10.26822/iejee.2017131888
- Hiebert, J. and Lefevre, P. (1986). “Conceptual and procedural knowledge in mathematics: An introductory analysis”, in Hiebert, J. (ed.) *Conceptual and procedural knowledge: The case of mathematics* (pp. 1–27), Hillsdale: Lawrence Erlbaum Associates
- Humphreys, J. (2020). “Geometry and the Imagination”, in Moser, K. and Sukla, A. Ch. (eds.), *Imagination and Art: Explorations in Contemporary Theory* (pp. 475–502), Leiden, Boston: Brill/Rodopi, DOI 10.1163/9789004436350_022
- Jeunet, C., N’Kaoua, B. and Lotte, F. (2016). “Advances in user-training for mental-imagery-based BCI control: Psychological and cognitive factors and their neural correlates”, *Progress in Brain Research*, vol. 228, pp. 3–35, DOI 10.1016/bs.pbr.2016.04.002
- Kambilombilo, D. and Sakala, W. (2015). “An Investigation into the Challenges In-Service Student Teachers Encounter in Transformational Geometry, “Reflection and Rotation”. The Case of Mufulira College of Education”, *Journal of Education and Practice*, vol. 6, no. 2, pp. 139–149
- Kuřina, F. (1987). “Geometrická představivost a vyučování stereometrii”, *Matematika a fyzika ve škole*, vol. 18, no. 3, pp. 201–212 (In Czech)

- Leikin, R., Berman, A. and Zaslavsky, O. (2000). “Learning through Teaching: The case of Symmetry”, *Mathematics Education Research Journal*, vol. 12, no. 1, pp. 18–36, DOI 10.1007/BF03217072
- Lohman, D. F. (1996). “Spatial ability and g”, in Dennis, I. and Tapsfield, P. (eds.), *Human abilities: Their nature and measurement* (pp. 97–116), Mahwah: Lawrence Erlbaum Associates
- Moravcová, V., Robová, J., Hromadová, J. and Halas, Z. (2019). “The development of the concept of axial symmetry in pupils and students”, in Fejfar, J. and Flégl, M. (eds.), *Proceedings of the 16th International Conference on Efficiency and Responsibility in Education 2019* (pp. 197–203), Prague: Czech University of Life Sciences Prague
- Moravcová, V., Robová, J., Hromadová, J. and Halas, Z. (2021). “Students’ Understanding of Axial and Central Symmetry”, *Journal on Efficiency and Responsibility in Education and Science*, vol. 14, no. 1, pp. 28–40, DOI 10.7160/eriesj.2021.140103
- Putri, R. O. E. (2018). “Spatial Skill Profile of Mathematics Pre-Service Teachers”, *Journal of Physics: Conference Series*, vol. 947, DOI 10.1088/1742-6596/947/1/012065
- Social Science Statistics (2018). “Chi-Square Test Calculator (2018, November 13)”, Retrieved from <https://www.socscistatistics.com/tests/chisquare2/default2.aspx>
- Sorby, S. A., Panther, G. C. (2020). “Is the key to better PISA math scores improving spatial skills?”, *Mathematics Education Research Journal*, vol. 32, pp. 23–233, DOI 10.1007/s13394-020-00328-9
- Star, J. R. (2005). “Reconceptualizing procedural knowledge”, *Journal for Research in Mathematics Education*, vol. 36, no. 5, pp. 404–411, DOI 10.2307/30034943
- Son, J. W. (2006). “Investigating preservice teachers’ understanding and strategies on a student’s errors of reflective symmetry”, in Novotná, J., Moraová, H., Krátká, M. and Stehlíková, N. (eds.), *Proceedings 30th Conference of the International Group for the Psychology of Mathematics Education*, Vol. 5 (pp. 145–152), Prague: PME
- Surynková, P., Moravcová, V., Robová, J. and Hromadová, J. (2021). “Testing of Pre-Service Mathematics Teachers’ Spatial Abilities”, in Fejfar, J. and Flégl, M. (eds.), *Proceedings of the 16th International Conference on Efficiency and Responsibility in Education 2021* (pp. 141–147), Prague: Czech University of Life Sciences Prague
- Tall, D., Gray, E., Bin Ali, M., Crowley, L., DeMarois, P., McGowen, M., Pitta, D., Pinto, M., Thomas, M. and Yusof, Y. (2001). “Symbols and the bifurcation between procedural and conceptual thinking”, *Canadian Journal of Science, Mathematics and Technology Education*, vol. 1, no. 1, pp. 81–104, DOI 10.1080/14926150109556452
- Tam, Y. P. and Chan, W. W. L. (2022). “The differential relations between sub-domains of spatial abilities and mathematical performance in children”, *Contemporary Educational Psychology*, vol. 71, DOI 10.1016/j.cedpsych.2022.102101
- Thaqi, X., Giménez, J. and Rosich, N. (2011). “Geometrical Transformations as Viewed by Prospective Teachers”, *Proceedings of the Seventh Congress of the European Society for Research in Mathematics Education* (pp. 578–587), Rzeszów: University of Rzeszów, ERME

Van Hiele, P. M. (1986). *“Structure and insight”*, New York: Academic press

Young, C. J., Levine, S. C. and Mix, K. S. (2018). “The Connection Between Spatial and Mathematical Ability Across Development”, *Frontiers in Psychology*, vol. 9, DOI 10.3389/fpsyg.2018.00755

AUDIOVISUAL MATERIAL AS A TOOL FOR HISTORY TEACHING

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Annotation: This paper aims to introduce the reader to the issue of audiovisual material as a means of teaching history at secondary school. The main source of the paper is a survey conducted as a questionnaire survey focused on teachers. The paper shows their perspective on the choice of material and their preference. Then it discusses specifically the use of video as a teaching tool with regard to the type of video and technical or linguistic background. It also shows the frequency of the use of these kinds of materials within lessons and the ability to work with reflection on the video itself. The results are compared with similar articles that address the use of video in the classroom from the perspective of students and teachers. The paper summarises this information in its conclusion.

Key words: Educational materials, film, history education, history teaching, video

1. Introduction

The aim of this paper is to provide an insight into the use of audiovisual material in teaching history at secondary school level, i.e., for students from 11 to 19 years old. The paper is based on research conducted through a questionnaire survey.

Audiovisual material (video) is widely used in pedagogical practice. The research, therefore, asks the question of how the material performs in comparison with other materials used, such as illustrations, presentations, audio recordings, or historical sources. In addition to the comparison to other sources, the paper aims to find out what specific videos are used in the classroom, as well as how often students work with the material. The results of the research are compared with similar research in the field of pedagogy. This research is purely focused on the teachers' views.

The use of modern technologies is an increasingly topical issue. The pioneer in this field has certainly been Robert Stradling (2003), who was extensively recommending the use of various types of materials within the classroom, in particular giving emphasis to the need to analyse and interpret the materials. This is followed by the work of Viliam Kratochvíl (2019). Kratochvíl defined the necessity for history teaching to expand the student's historical consciousness precisely by working with diverse materials, from illustrations and cartoons to documentary films. The modern concept of history is not just to present the student with the bare facts but to make them think about the context and let them do their own research using the research method. The pupil becomes an active element who explores the material actively. They ask themselves questions related to it and actively seek answers, thereby expanding their knowledge.

This paper primarily draws on and compares the research with the results of similar studies that have been conducted across the world and published in peer-reviewed articles. These articles can be divided, according to their focus, as some look at issues from the students' perspective and others from the teachers' perspective.

A large-scale study was conducted by a team around Sef Yildirim (2018) in which they explored the views of 800 year 4 pupils within the Turkish province of Agri. A qualitative study with respect to documentary films was provided by a study conducted during the Covid 19 pandemic conducted on a sample of 33 students (Gusnissa et al., 2021).

An example of a study from an educator's perspective was conducted at Kazan Federal University by Liliya Nasrutdinova and her team (Nasrutdinova, Mahinina and Shustova, 2022), who investigated the use of video on Master's students in history teaching, specifically 33 students. A similar study was conducted by David-Alexander Wagner (2019) on Norwegian secondary school teachers. This study was purely qualitative and was conducted through interviews with 19 teachers.

Mixed research in which both students and teachers participated was conducted by an Australian team of researchers around Debra Donnelly (2014), in which 361 students and 203 teachers participated. Finally, it is worth mentioning the very good research carried out using a pedagogical experiment by Martin Merkt's team (2021), who carried out their research in secondary schools in Germany, comparing, in particular, the different perspectives on teaching using video and using text in a textbook. The paper compares the results of these and other studies in the discussion.

The paper is divided into four sections. The first section, Materials and Methods, is devoted to the survey and its implementation. Then, the results of the survey are summarised. The Discussion compares the results with those of similar research. Subsequently, everything is summarised and concluded in the last section.

The paper set out the following research questions. What teaching materials do teachers of history at lower and upper secondary school prefer to use in their teaching? How common is the use of audiovisual materials in history lessons at lower secondary school or upper secondary school? What types of audio-visual material do teachers in lower and upper secondary school choose to use during history lessons?

With respect to these research questions, the article provided clear answers in the form of graphs and tables.

2. Materials and Methods

The research was carried out using a questionnaire survey. This questionnaire was constructed and subsequently validated. To facilitate the data collection, an online questionnaire, specifically a Google Form, was chosen and sent to several history teachers who met a predetermined characteristic – actively teaching history at secondary school.

The questionnaire was divided into several parts. Within the personal part, the respondent was asked about their gender, age and years of practice. The key question was on which type of school they teach history.

The second part of the questionnaire focused on the use of teaching material in the lessons. The teacher had to choose which materials from the list they use or could add their own type (primarily presentations, worksheets, technical texts, illustrations, audio recordings and videos). They were asked to rank these materials, according to their preference, from most to least used. This question was purely subjective.

The last part of the questionnaire was devoted to the specific work with audiovisual material in the lessons. The first closed-ended question addressed the frequency of use of the material, whether the teacher uses the video in at least one lesson during the week, during the month, during the semester or during the whole school year. There was also the possibility that the teacher did not use video at all (this was also an option for the other questions). The questionnaire aimed to find out which type of video is used more often, whether documentary, educational video, historical film (historical source), animation or fictional film/series.

The next question asked the respondent if the school provided sufficient technology for the teacher to use the material. The following question was about the language, as some materials could not be found in Czech. Therefore the respondent was asked if they also used materials in other languages and if they needed subtitles.

The last questions in the questionnaire were of the attitudinal type. The respondent could express agreement or disagreement with the given term. The first term was linked to the need for possible reflection after watching the video, and the second was a subjective term focused on whether the teacher in question considered the video to be suitable material for teaching history.

The form was then sent out online, and data collection took place from autumn 2022 to spring 2023. In total, 65 teachers from across the Czech Republic who met the requirement to teach history participated in the survey. The majority of responses were from respondents who are members of the SYPO (Systematic support for all teachers and principals) methodological cabinets. The questionnaire was sent to the members of the Social Science Cabinet, who disseminated the questionnaire further.

I categorised the respondents by years of practice, with each category based on salary schedules that divide public school teacher salaries.

As shown in Table 1, the majority of participants in the research were women. There is also a difference in years of experience, with the primary group being teachers with up to 12 years of experience. Also of note is the significant representation of teachers with over 33 years of experience.

Table 1. Distribution of respondents by years of practice

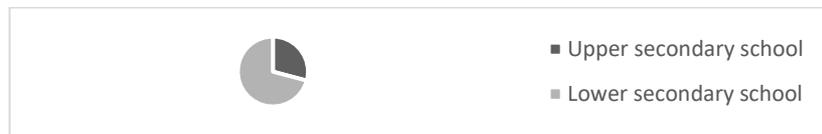
Years of practice	Men	Women	Total
0–2	5	6	11
3–6	5	10	15
7–12	3	11	14
13–19	2	5	7
20–27	0	9	9
28–32	0	5	5
33+	1	10	11

Source: Own data

The next division of respondents is based on whether they teach at the lower secondary school (in the Czech Republic usually called upper primary school) or (upper) secondary school. Students are aged 11 to 15 in lower secondary and aged 15 to 19 in upper secondary school.

In Figure 1, a majority of lower secondary school teachers. Thus, the results of this questionnaire are closely related to this level of education.

Figure 1. Proportion of teachers by school type



Source: Own data

It is necessary to mention that since most of the respondents were members of methodological cabinets, they are primarily active teachers who are involved in extracurricular projects and, therefore, can be expected to be more motivated to use modern technologies and teach using new methods. The research can be influenced by this fact.

3. Results and Discussion

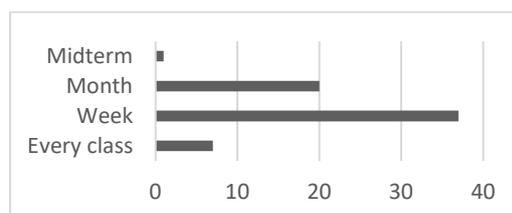
The results of the questionnaire survey were summarised and categorised. Some of the data were processed as tables or graphs. For some questions, only the net results are provided here without graphical displays due to the length of the paper.

The first part of the questionnaire, which focused primarily on the use of particular materials in the classroom, showed that video is overwhelmingly used in the classroom. It was the most preferred material as 64 (i.e. 98.5%) of the 65 respondents used it within lessons. Presentations (made by presentation program like PowerPoint) achieved similar results, with 61 (i.e. 93.8%) of the 65 respondents choosing it. Similarly, worksheets were chosen by 57 (i.e. 87.7%) of the respondents. However, all other materials achieved very positive results, with more than 60% of respondents using these supportive materials in their lessons (these were illustrations, technical texts and audio recordings). None of the materials proved to be unpopular.

For the question of ordering the material according to teacher preference, 35 respondents out of 65 chose video as the most preferred tool, with another 24 respondents choosing video as the second most preferred choice. Teachers placed similar popularity on presentations, with 28 respondents selecting them the first and 15 respondents selecting them the second. Illustrations and worksheets also achieved similar positive results. However, from these raw data alone, it can be seen that there is a great deal of interest in video from teachers and that it is the preferred material with regard to engagement in the lesson itself.

The frequency of use only demonstrates the preference for the material. Seven of the 65 respondents include video in every lesson. The majority of respondents subsequently chose to use video at least once a week or at least once a month, as shown in Figure 2.

Figure 2. Frequency of video use within class



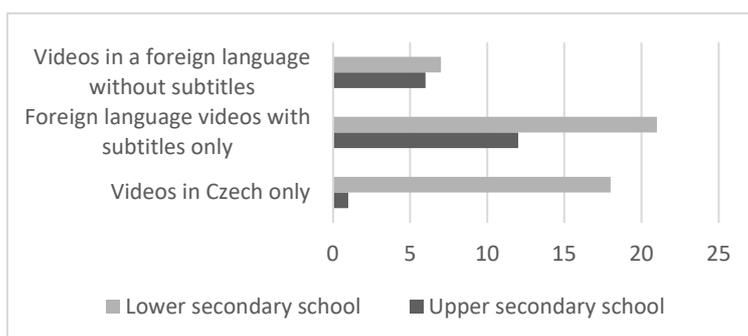
Source: Own data

The next item was a consideration of the school's facilities, whether it provides teachers with classrooms that have sufficient equipment to implement video lessons (projector, television, or other display and sound equipment, or a combination of multiple devices). Here, 63 of 65 (i.e. 96.9 %) respondents confirmed that most classrooms at their school provide sufficient technology, and only two respondents answered that technology is only in some classrooms but not in most.

Regarding the use of video in a foreign or Czech language, differences can be observed with regard to the type of school. While teachers at lower secondary schools do not use foreign videos, even with subtitles, at upper secondary schools, it could be expected that the opposite would be the case.

As can be seen in Figure 3, the use of foreign-only videos is primarily implemented in lower secondary schools. For the upper secondary schools, the use of videos with or without subtitles predominates. Interestingly, despite the fact that 18 of the 46 respondents who teach in lower secondary schools voted for videos in Czech only, a larger number of respondents in this category, namely 21, also voted for the option of using videos with subtitles and 7 for the option of using videos in a foreign language. Thus, language is not always the primary deciding element for the selection of a given material.

Figure 3. Videos and language with regard to school type



Source: Own data

In terms of the type of video, the most popular among teachers was the documentary, chosen by 60 of the 65 respondents. An educational video was the second most popular type, with 54 respondents out of 65. Movies and series, along with historical sources, were chosen by more than 50% of the respondents in both cases, around 40 respondents. The least preferred was an animation, which was selected by only 24 teachers.

At the end of the questionnaire, there were two purely attitudinal questions. Respondents had to decide whether they agreed or disagreed with the statement. As can be seen in Table 2, the vast majority of respondents agreed completely with both statements, and the remainder tended to agree.

Table 2. Respondents' attitudes towards the statements expressed as a percentage

Statement	Agreed	Rather agree
"After watching the video, I reflect and discuss the material and its content with the students. As well as any continuity with the material taught."	85%	15%
"I find the video a good teaching material, and I like to use it in history lessons."	89%	11%

Source: Own calculation

Overall, the results provided positive feedback on the use of video in history teaching at both levels of secondary schools. Teachers prefer video as a teaching material and are aware of the need for discussion and reflection on the material. Neither the technical background of the schools nor the language of the material is an issue in using the material.

The research relevant to the one implemented within this paper was presented in the introduction. This section primarily discusses the results and differences in methods and instruments. We begin with the research that has worked with video in history lessons, but is oriented towards the students' perspective and not the teacher's.

The team around Sefa Yildirim (2018) conducted extensive research in Agri province. It was mixed research with two experimental groups of 403 and 452 students, to which two control groups of 138 and 58 students were formed. The experimental group received a lesson with video, and the control group received a lesson with text and audio only. The pupils completed a questionnaire of 50 questions of which 7 were qualitative. The study group was interviewed. The research differed in size as it was carried out on a large group; moreover, it was not purely quantitative, as qualitative methods were used. However, the results were similar, as better results in terms of knowledge acquisition were achieved by students who were taught using video.

Gusnissa et al. (2021) conducted research on 33 pupils, focusing on the relationship to documentaries. This research was also mixed. Its first part was a questionnaire survey, the results of which yielded that pupils receive perceptions 40% visually and 40% aurally. 80% of the pupils preferred documentary films as the main tool for learning.

The qualitative part of the research involved 6 pupils who went through an interview and a subsequent knowledge test. This pedagogical experiment showed that while students scored around 42 out of 100 before watching the documentary, their scores improved dramatically to 80 out of 100 after watching the documentary. This research dealt with a small group of students but showed that the students themselves preferred the video as a tool, as well as that it had a positive effect on them in gaining knowledge.

The team around Martin Merkt (Merkt et al., 2011) conducted two pedagogical experiments at secondary schools in Germany. The research sought to compare the performance of students taught using a textbook, an adapted video and a traditional video. The first research was conducted on a sample of 60 pupils, who were divided into three groups and each received a lesson with one material. Subsequently, through a questionnaire survey, interest in history and the impact of the material on this interest was measured. A knowledge test was added to this questionnaire to test what knowledge the pupils they had gleaned from the material. The second experiment was conducted in a laboratory setting and involved 156 students. This time, the pupils worked with the material for 45 minutes and then had to write an essay based on their findings. For both experiments, the results of interest and effect on knowledge came out best for the video.

In his article, Metzger Scott (2010) discusses the possibilities of using fictional films in the classroom and the positive impact on students' interest in history. Specifically, he demonstrates this with the film 300, which is about the Battle of Thermopylae. However, he points out the necessity of using only parts of the video to support the interpretation visually.

The team around Alan Marcus (Marcus and Stoddard, 2009) investigated students' perspectives on the materials and their credibility. It was found that students primarily trusted their history teacher, with the second most consistent result for historical sources. In third place were documentaries, as students appeared to trust them more than school textbooks. The film also won out over internet sources and it is evident that from the pupil's point of view video is trustworthy material.

All of these studies were oriented towards the students' perspectives and their outcomes, either in terms of the impact of the material on the students' knowledge or their interest in history. It can be seen that the video achieved positive and affirmative reactions from the pupils, which coincides with the results of this paper. The following studies focused, like this paper, on the teacher's perspective.

A large research that focused on teachers as well as students was undertaken in Australia (Donnelly, 2014); 203 teachers and 361 pupils were involved. This was again mixed methods research conducted using a questionnaire survey followed by interviews with 20 teachers and then lesson observations with 6 of these teachers. The research explored the perspectives of teachers who used video as an instructional material as well as the pupils' responses to the use of this material. Similar to the results of the questionnaire in this paper, it was found that teachers see a wide and great use within the engagement of audiovisual material, which, in addition, has a positive response from students. This research was unique in exploring that perspective from both sides of teaching.

The research aimed at teachers was conducted at the Kazan Federal University (Nasrutdinova, Mahinina and Shustova, 2022). This research bore similar characteristics to the presented research in that it was a questionnaire survey that explored the use of technology and materials in the classroom. The results of the questionnaire showed that 32 out of 37 teachers preferred video lessons over traditional classroom instruction. The research conducted for this paper had a similar result, where 35 out of 65 teachers chose video as the best material when ranking the material. The research in Kazan was conducted primarily on teachers with short experience in education (still studying), while the research described here had a large number of teachers with many years of experience, so its results are more favourable to video. However, both papers produced the same result, namely that video was the most preferred material in the teacher selection process.

David-Alexander Wagner (2019) and his team described a study that was conducted on Norwegian secondary school teachers. This research was entirely qualitative and was conducted using semi-structured interviews with 19 teachers from urban districts. Here, although the primary involvement of video in the lessons was shown, the teachers chose video to capture the attention of the students. However, this research shows that teachers are aware of the need for reflection after watching the video and reflecting on what pupils may have observed in the video.

Stoddard (2012) presents a study conducted through interviews with three teachers and primarily based on classroom observations. This study looks at the process of material selection itself, showing primarily the different roles of video, from simply being a tool to capture attention to being chosen for the sake of conveying key information to students.

Overall, we can compare each study and research with this one and agree that they achieve similar results. The teacher's perspective is very much in favour of the use of audiovisual material and its positive results on the students themselves.

4. Conclusion

This paper aims to bring the perspective of teachers teaching history – an insight into the selection of material in lesson preparation. The results showed that video is not only used extensively but is also the most preferred material. It showed that neither language nor the technical background of the schools is an issue for the use of audiovisual material. It also showed that teachers use different types of videos, most often documentaries. In this respect, this research coincides with others that is often primarily oriented towards documentary film. It is important to point out that teachers are aware of the need to reflect on the material after watching it and to analyse and interpret different parts of it.

This article is part of my doctoral research, which focuses on the use of audiovisual material as a means of teaching modern history. The teachers' perspectives gained here will subsequently be discussed with the student side of the pedagogical experiment that I will implement and publish in my dissertation.

Acknowledgement

I would like to thank the Department of Applied Cybernetics at the University of Hradec Králové for financial support for the publication of this article.

References

- Donnelly, D. (2014). "Using Feature Film in the Teaching of History", *Journal of International Social Studies*, vol. 4, no. 1, pp. 17–27
- Gusnissa, M. A. *et al.* (2021). "Assure research and development: The documentary video of REOG DANCE TO ENHANCE learning outcomes in history learning", *IOP Conference Series: Earth and Environmental Science*, vol. 747, no. 1, p. 012075, DOI 10.1088/1755-1315/747/1/012075
- Kratochvíl, V. (2019), "*Metafora stromu ako model didaktiky dejepisu: k predpokladom výučby*", Bratislava, Slovakia: Raabe (In Slovak)
- Marcus, A. S. and Stoddard, J. D. (2009). "The inconvenient truth about teaching history with documentary film: Strategies for presenting multiple perspectives and teaching controversial issues", *The Social Studies*, vol. 100, no. 6, pp. 279–284, DOI 10.1080/00377990903283957
- Merkt, M. *et al.* (2011). "Learning with videos vs. learning with print: The role of interactive features", *Learning and Instruction* [Preprint], DOI 10.1016/j.learninstruc.2011.03.004
- Metzger, S. A. (2010). "Maximizing the educational power of history movies in the classroom", *The Social Studies*, vol. 101, no. 3, pp. 127–136, DOI 10.1080/00377990903284047
- Nasrutdinova, L., Mahinina, N. and Shustova, E. (2022). "Creating video lectures on literary history academic disciplines: Psychological and didactic approaches", *VII International Forum on Teacher Education* [Preprint], DOI 10.3897/ap.5.e1189
- Stoddard, J. D. (2012). "Film as a 'thoughtful' medium for teaching history", *Learning, Media and Technology*, vol. 37, no. 3, pp. 271–288, DOI 10.1080/17439884.2011.572976

Stradling, R. (2003). “Jak učit evropské dějiny 20. století”, Available at:
https://www.msmt.cz/file/36206_1_1/ (Accessed: 23 June 2023)

Wagner, D.-A. (2019). “Critical thinking and use of film in Norwegian lower Secondary History Classrooms”, *History Education Research Journal*, vol. 16, no. 2, pp. 274–290, DOI 10.18546/herj.16.2.08

Yildirim, S. (2018). “The effect of educational videos used in history education on academic success”, *Journal of Education and e-Learning Research*, vol. 5, no. 3, pp. 193–207, DOI 10.20448/journal.509.2018.53.193.207

EVALUATION OF DISTANCE EDUCATION AT THE UNIVERSITIES OF THE CZECH REPUBLIC DURING THE COVID-19 PANDEMIC FROM A STUDENTS' PERSPECTIVE

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Annotation: As a result of the COVID-19 pandemic, educational institutions in the Czech Republic were closed on 11 March 2020 until further notice. Czech schools were the second longest fully closed schools in Europe. There has been a rapid transformation to distance learning. The objective of the presented paper is to define effects this closure had on selected university students and how these university students evaluate distance learning. Questionnaire survey among university students was used in order to find out students' opinion. According to the study results, there is no statistically significant relationship between students' abilities to adapt to changes in teaching forms during the Covid-19 pandemic and the number of completed semesters at university, their previous study results, nor their character and personality qualities. This study shows that the Covid-19 pandemic did not have a significant effect on the average study results of students at economics universities in the Czech Republic.

Key words: Covid-19, Czech Republic, distance learning, distance education, university, students' perspective

1. Introduction

It is well known that the Covid-19 pandemic led to an unprecedented shift in educational methods towards remote teaching, mainly in the higher education sector, as it is becoming increasingly reliant on technology. According to Muhaimin et al. (2023), 'Many educational stakeholders, such as teachers, students, and school administration staff, have not prepared to face the transition because of the fast switch to distance learning.' In response to the Covid-19 pandemic (and in line with nationwide announced lockdowns), students from more than 50 nations were restricted from physically attending their schools, and Czech students were no exception. On March 11, 2020, all elementary, secondary, and higher vocational schools and universities in the Czech Republic were closed until further notice. Universities were closed for a total of 135 days. There was little or even no time left to prepare, modify, or adjust for the change of educational methods, as the situation was highly unexpected. (Ministerstvo zdravotnictví ČR, 2020; UNESCO, n.d)

Distance teaching, remote teaching, and online teaching are seen as synonyms referring to the type of teaching where the instructors (teachers, lecturers) are not present at the same place or time as the students. Its main goal is to replicate regular classroom communication. Synchronous and asynchronous distance learning is distinguished. Synchronous distance learning is in the form of live webinars or virtual classes. It enables real-time interaction and instant feedback; therefore, this format is closer to traditional educational systems. Asynchronous is represented, for example, by video recordings or provided materials, as it does not require real-time engagement. (Muhaimin et al., 2023) Chambers et al. (2023) consider distance learning to be diverse and flexible.

According to Imran et al. (2023), effective learning in higher education is largely dependent on the appropriate choice of delivery mode. The traditional educational system (face-to-face teaching) has been historically considered to be the most reliable. George et al. (2014) published one of the systematic reviews on knowledge, skills, and outcomes of online learning, stating that online learning is equally efficient as traditional teaching. Nevertheless, there are many specific factors influencing the efficiency of teaching (Lorenza and Carter, 2021; Mok et al., 2021; Yau et al., 2022).

As Hodges et al. (2020) point out, the teaching in the summer semester of 2020 was emergency remote teaching, and it should not be compared with well-founded and planned distance teaching. There is a question remaining about to what extent the unexpected and unprepared switch (owing to the Covid-19 pandemic) to online teaching has addressed the quality standards of remote education. (Engel et al., 2023)

The distinct factors for high-quality distance education are on both – students' and teachers' levels. Key success factors of distance education consist of social engagement, providing the possibility for active interaction, and close student-teacher relationships (Jensen et al., 2020). Students' individual self-regulatory and socio-emotional competencies, as well as adequate digital equipment, are vital for successful participation in online learning. Teacher-related aspects of learning success consist of social presence, communication skills such as collaboration, dialogue, and suitable format and structure of communication. As said by Engel et al. (2023), the factors influencing the efficiency of online learning have been subject to many studies; nevertheless, no overarching theory has been developed.

The authors chose to evaluate this distance learning forced by the closure of schools during the COVID-19 pandemic from student's perspective, namely students of selected economics universities in the Czech Republic. The objective of the presented paper is to define effects this closure had on students of economic universities in the Czech Republic and how these university students evaluate distance learning.

This paper is organized as follows. First, the authors present the background of distance teaching – its attributes, aspects, and factors. Next, they describe their research methodology, provide the results of our survey, and discuss the limitations of the study. Finally, they present the conclusion.

2. Materials and Methods

The method of mixed research was used, which is a combination of qualitative and quantitative research. It is through a combination of methods that the weaknesses of particular research methods can be overcome, and a higher quality research output can be achieved. The authors chose a questionnaire survey as the method used for data collection, which was first verified during a pilot study and subsequently as a part of preliminary research. The questionnaire was conducted using Google Forms. The questionnaire contains closed and open-ended questions. In some of those questions, the authors also use the 5-point so-called Likert scale to provide options for answers. The questioning is divided into two parts. The initial filter questions serve to classify the respondents and thus divide them into groups for future evaluation of queries. In the first part of the questionnaire, the respondents are asked about their chosen study program, the form of study, their current study period or specific study results, and their character traits. In the second part, the respondents are asked questions that ascertain their facts, opinions, motives, and attitudes

within the distance education framework they have undergone. The actual questionnaire survey examines how the addressed students perceived distance learning, how the teaching was conducted, and whether the teaching scope and time allocation were sufficient. The overall difficulty of distance learning and satisfaction or dissatisfaction with the distance learning process is also examined. Last but not least, the paper also deals with the evaluation of the technical security of distance learning, remote communication with the teacher, and the influence of distance learning on acquired knowledge and study results.

In total, 750 respondents were approached. The final sample was based on the ratio of filled questionnaire returns, which was 36.53%, as 274 completed questionnaires were submitted. The majority of all responses (71%) were from women, which corresponds to the male-to-female ratio at the chosen school type – economics university. Within the questionnaire framework, both bachelor's and master's study program students were questioned, their answers were 81% to 19%, and the overwhelming majority of all respondents (97%) were students studying full-time. The research took place from 1/10/2022 to 3/23/2022.

For the needs of the research, the following research questions (RQ) were asked based on the literature review:

RQ₁: Has the Covid-19 pandemic had a negative effect on the level of education of university students?

RQ₂: What impacts did distance learning have on university students during the Covid-19 pandemic?

RQ₃: How do the character and personality qualities, study results, and the present duration of studies of university students affect their adaptation to changes in teaching techniques during the Covid-19 pandemic?

Based on the research questions, four hypotheses (H) were established, for which the association was subsequently tested in the Statistica program.

Hypothesis H₁: There is no relationship between the students' number of completed semesters at university and their ability to adapt to changes in teaching during the Covid-19 pandemic.

Hypothesis H₂: There is no relationship between students' previous study results and their ability to adapt to changes in teaching forms during the Covid-19 pandemic.

Hypothesis H₃: The Covid-19 pandemic did not have a significant effect on the average study results of students at economics universities in the Czech Republic.

Hypothesis H₄: There is no relationship between students' character and personality qualities and their ability to adapt to changes in teaching during the Covid-19 pandemic.

The correlation method, namely Kendall's rank correlation coefficient, was used to evaluate the hypotheses. Kendall's test makes no assumption about the nature of the probability distribution and can handle any number of individual outcomes. Kendall's Tau is, therefore, a non-parametric test that takes values $\in (-1;1)$ (Hendl, 2009). It is calculated according to the following formula (1):

$$\tau_k = \frac{P-Q}{n(n-1)/2} \quad (1)$$

P ... number of concordances (matched pairs)

Q ... number of discordances (mismatched pairs)
 n ... number of observations. (Neubauer et al., 2016)

3. Results and Discussion

The survey asked students about the positives and negatives of the transition to distance education. The biggest problem for students was social isolation, and they also encountered inconsistent approaches from individual teachers and teaching platforms. Students had a big problem with maintaining concentration and attention. Lower study motivation and psychological exhaustion can also be noted. On the contrary, communication with teachers, working with computer technology, changing teaching methods, or insufficient equipment with teaching materials did not pose significant problems for them.

Among the other problems that the students were asked about in the following open-ended questions, they also disclosed the negative effect of prolonged sitting at the computer, when their spine, head, and back hurt, or their eyesight deteriorated, etc. As a result of staying at home, the students as well mentioned worsened relationships in the family, as they were often under their parents' constant supervision and complained about privacy loss. Distance learning also did not allow practical teaching and made it more difficult for students to communicate with each other while working on joint tasks.

On the contrary, distance learning also offered students some positives. They praised the opportunity to access (watch or listen to) the teaching materials from home and repeatedly, which enabled them to organize better individually and, if necessary, combine studies with work. Among the other benefits of online studies, students mentioned more time for family, saving time and money when commuting, and the possibility of effectively using the time between individual study blocks. Some students also positively assessed that they did not come into contact with diseases at mass study events and therefore did not get sick. Students positively evaluate more study materials, as teachers had to share or publish them, which is not an obligation in face-to-face teaching.

The positive effect of online teaching can also be seen in the answers to the following question, which asked students about their active online participation in education compared to regular face-to-face teaching. Almost 30% of respondents said that online learning allowed them to attend more lectures (theoretical and practical exercises) than before. 15% of respondents said the opposite. However, students focused less on the teacher's explanation in almost half of the cases, and nearly 80% of them engaged in other activities during the lesson, such as working on a computer, cooking, cleaning, reading, knitting, etc. The question is to what extent this lack of concentration and dedication with other activities during the lesson was reflected in the answers to the following question, in which students in 30% of cases state that distance education provided them with worse insights and knowledge than the traditional face-to-face form.

In this questionnaire survey, students state that the time required for studying is comparable to or somewhat lower than during face-to-face teaching.

Students had the opportunity to comment on their non-participation in classes and the time requirement in the following open-ended question. The students had much trouble keeping their attention. The teacher should have addressed them during the lectures or looked at them, and there needed to be more clarity in the explanation. Also, communication at the seminars

could have been more practical. Teachers often only lectured and had no feedback, and no conversation developed on the given problem. Students also forgot their lessons at home. On the contrary, students positively evaluated the recorded lectures with the possibility of their repeated playback and the ease of individual study organization.

In the following two questions, students were asked to evaluate the overall difficulty of online and face-to-face teaching using a 5-point Likert scale, where the choice of answers ranged from very manageable to very difficult, and then verbally. From the results, the difficulty level was comparable on average and had positives and negatives. Students see final credits and exams they could do from home as more manageable, saving time. They also appreciated a more significant amount of study materials available in digital form.

On the contrary, the difficulty of studying is determined by the negatives already mentioned above, e.g., students had problems with concentration, motivation, and understanding of more complex, especially technical subjects.

Another series of questions deals with the assessment of students' communication with teachers. The 5-point Likert scale with a range from completely satisfied to completely dissatisfied was used as well. The answers show that the students were satisfied with the communication with the teacher and the feedback provided during online teaching. Only 4% of students were completely dissatisfied. Transmission most often occurred via email or within individual online platforms – Google Classroom, Microsoft Teams, Zoom, or even LMS Moodle or Unifor. However, students report long delays in getting answers and fragmented means of communication with individual teachers.

The questionnaire survey also examined the teaching platforms used in online teaching and the students' satisfaction with them. The learning took place most often through Google tools - Google Classroom and Google Meets, then Zoom, LMS Unifor, and LMS Moodle. MS Teams and recorded lectures published on the subject's university platform (in 4% of cases) were also used. The vast majority of students were satisfied with working with the online tools. Only 4% of students did not work well with the online tools or found it difficult. Students saw problems mainly in the inconsistency of learning platforms when they frequently switched and logged in to other platforms.

Regarding the time allowance for individual subjects during distance learning, 70% of students saw it as sufficient, 22% would welcome its increase within the semester, and the remaining 8% would even favor extending the semester.

At the end of the questionnaire survey, students were asked about the study results they achieved during distance learning. Students mostly had no problems with fulfilling their study obligations and achieved similar study results as before. In fact, more than three-quarters of them state that the examination period was easier than when they were examined face-to-face and would continue to replace face-to-face examinations with a distance form. They also say that they spent less time preparing for the exams and often collaborated with others or consulted study materials when preparing them.

In the last question, students were asked about their opinion regarding the preferred form of study at universities. 56% of students would favor a combination of face-to-face and distance learning, 26% of respondents would want purely face-to-face learning, and the remaining students would wish for exclusive online learning.

The statistical results used for hypothesis testing are shown in Table 1.

Table 1. Statistical evaluation of the hypothesis, 2023

Hypothesis	Kendall's Tau	P - value	Acceptance
H ₁ - There is no relationship between the students' number of completed semesters at university and their ability to adapt to changes in teaching during the Covid-19 pandemic.	0.067659	0.4103970	YES
H ₂ - There is no relationship between students' previous study results and their ability to adapt to changes in teaching forms during the Covid-19 pandemic.	0.0433018	0.0675849	YES
H ₃ - The Covid-19 pandemic did not have a significant effect on the average study results of students at economics universities in the Czech Republic.	0.486471	0.2875983	YES
H ₄ - There is no relationship between students' character and personality qualities and their ability to adapt to changes in teaching during the Covid-19 pandemic.	0.568745	0.0897562	YES

Source: Own processing

There is a low positive association (0.067659) between the number of completed semesters at university and respondents' ability to adapt to changes in teaching during the Covid-19 pandemic. The significance level for Kendall's Tau is 5 %. When the p-value of 0.4103970 is compared with the significance level α , which is 0.0500, it is possible to accept the null hypothesis H₁ and state that these two variables are not statistically significantly dependent.

Furthermore, the relationship between previous study results and students' ability to adapt to changes in teaching during the Covid-19 pandemic was tested – H₂. This time, Kendall's Tau value is 0.0433018, indicating a very low positive dependence. However, the P-value is again greater than the significance level of 0.0500; therefore, the null hypothesis is confirmed, as there is statistically the non-existence of a relationship between these variables.

The same is the case with testing hypothesis H₃, whether there is a relationship between the Covid-19 pandemic and students' study results. There is a moderate to substantial positive association. The p-value of 0.2875983 is higher than the significance level of 0.0500, and again, there is a confirmation of independence, thus the null hypothesis.

Even with the fourth hypothesis, where this time, the relationship between character and personality qualities of students and their ability to adapt to changes in teaching during the Covid-19 pandemic was tested, the value of Kendall's Tau of 0.568745 indicates a moderate to substantial positive association. The P-value is again higher than the 5% significance level, confirming the null hypothesis.

As for the research questions, the first research question (RQ₁) can be answered based on the H₃ confirmation that the Covid-19 pandemic did not have a significant negative effect on the level of education of university students.

The second research question (RQ₂) regarding the impact of distance education during the Covid-19 pandemic on university students was answered in a questionnaire survey. The results were discussed above.

The third research question (RQ₃), investigating the influence of students' character and personality qualities, study results, and study time on their adaptation to changes in teaching during the Covid-19 pandemic, can be answered through the confirmed hypotheses H₂ and H₄.

As part of the research, the authors analyze the effects of the university's closure on selected university students and provide insight into how these university students evaluate distance education through a questionnaire survey. The questionnaire survey was conducted on a sample of 274 students from two selected economics universities in the Czech Republic.

The questionnaire survey results revealed the problems that students faced notably during online teaching, such as social isolation, problems in the family, non-uniform approaches of teachers, inconsistent teaching platforms, and issues with practical education or communication. It was also challenging for them to stay focused and find the motivation to study. The negative effect of long-term sitting at the computer on the musculoskeletal system and vision was also mentioned. These findings align with Conrad et al. (2022), who identified a lack of social interactions, class format, and perceived technical skills requirements as the main obstacles in the transition to online learning during the COVID-19 outbreak in Canada.

However, distance education is also associated with some positives. Students praised saving time and money, the possibility to view learning materials from home and repeatedly, and the possibility of effectively using the time between individual study blocks. Students do appreciate more study materials in digital form. These are similar findings to Shim & Lee (2020).

Distance education also caused an increase in participation in several lessons and lectures. Nevertheless, many students added that they focused less on the explanation and devoted themselves to other activities. Students defend their active non-participation in classes by saying they had trouble maintaining attention. In addition, this was also made possible by the fact that the teachers mostly did not contact them during the lesson, nor did they require feedback. Mok et al. (2021), Amir et al. (2020), and Lorenza & Carter (2021), similarly to this research outcomes, bring up learner autonomy concerns as a significant obstacle necessary for students to overcome.

Respondents state that the time required for studying is comparable to or somewhat lower than during face-to-face learning. Students also rate the difficulty of completing the online (distant) course as almost similar to face-to-face teaching methods. Students especially see getting final credits and passing the exams as significantly easier. The time allowance for individual subjects during distance learning was sufficient.

The most frequently used teaching platforms during online education were Google tools - Google Classroom and Google Meet, Zoom, LMS Unifor, and LMS Moodle or MS Teams, with which the vast majority of students were satisfied. Students saw problems in this area, mainly in the inconsistency of online platform usage.

Another series of questions dealt with the assessment of students' communication with teachers. From the answers, it is possible to state the students' overall satisfaction with the communication with the teacher and the feedback provided. However, students report

long delays in getting back answers and fragmented communication with individual teachers. Communication most often occurred via email or within the learning platforms mentioned above.

Students were asked about the study results they achieved during distance learning. Students mostly completed the subjects without problems and achieved similar study results as before. The majority also stated that remote testing was even easier and would like to continue to replace face-to-face testing with remote testing.

In the end, the students answered a question about their opinion on the preferred form of higher education. 56% of students would favor a combination of face-to-face and distance learning, 26% of respondents would want purely face-to-face learning, and the remaining students would wish for exclusive online learning.

In the authors' opinion, an online form of education can be a very effective tool to supplement traditional face-to-face teaching. However, face-to-face teaching cannot be entirely replaced with online teaching.

Several articles and studies are devoted to the shift from face-to-face educational models to online modes in higher education and the impacts of the shift on students and teachers. While some studies are focused only on one point of view (either students' or teachers'), e.g., Shim & Lee (2020), Mok et al. (2021), and Conrad et al. (2022); Yau et al. (2022) analyzed both - students' and teachers' perceptions of online teaching. Imran et al. (2023), who systematically examined the teaching and learning modes adopted during COVID-19, came to the conclusion that blended learning (a combination of face-to-face and online learning modes) is the most effective mode of teaching, even post-COVID-19.

There are several limitations to the presented research. As already mentioned, the study was conducted solely on a sample of students from 2 economics universities in the Czech Republic. Google Forms were used for the questionnaire, as students were addressed by mass e-mail (with a link to the questionnaire) and asked to participate in this study. Investigating the proposed hypotheses in other economics universities, fields, and countries would also be worth exploring.

4. Conclusion

One of the COVID-19 pandemic results was that on March 11, 2020, all primary, secondary, and higher vocational schools and also universities in the Czech Republic were closed until further notice. Overall, Czech schools were the second longest fully closed schools in Europe (UNESCO, n.d.). As a result of such a massive closure of schools, there was a rapid transformation from regular face-to-face teaching to distance (online) one.

Czech economics university students' perception of the teaching methods' shift toward distance education is associated both with positives as well as negatives. Social distancing and family-related obstacles were the most commonly mentioned issues from the range of social aspects of students' point of view. The problems regarding the inconsistent approach from individual teachers and the absence of practical learning were perceived negatively. On the other hand, students appreciated the materials provided by teachers and better opportunities to manage their time (e.g., enabling them to work part-time). More than half of the respondents would actually welcome a shift to blended learning.

According to the authors' study results, there is no statistically significant relationship between students' abilities to adapt to changes in teaching forms during the Covid-19 pandemic and the number of completed semesters at university, their previous (pre-pandemic) study results, nor their character and personality qualities. Most importantly, this study shows that the Covid-19 pandemic did not have a significant effect on the average study results of students at economics universities in the Czech Republic.

Acknowledgement

This paper was created within the project SGS-2023-007, 'Current Challenges and Problems of Modern Society from the Perspective of Finances and Accounting' at the University of West Bohemia, Faculty of Economics.

References

- Amir, L. R., Tanti, I., Maharani, D. A., Wimardhani, Y. S., Julia, V., Sulijaya, B., et al. (2020). "Student perspective of classroom and distance learning during COVID-19 pandemic in the undergraduate dental study program Universitas Indonesia", *BMC Medical Education*, vol. 20, no. 1, DOI 10.1186/s12909-020-02312-0
- Chambers, J., Mistry, K., Spink, J., Tsigarides, J. and Bryant, P. (2023). "Online medical education using a Facebook peer-to-peer learning platform during the COVID-19 pandemic: A qualitative study exploring learner and tutor acceptability of Facebook as a learning platform", *BMC Medical Education*, DOI 10.1186/s12909-023-04268-3
- Conrad, C., Deng, Q., Caron, I., Shkurska, O., Skerrett, P., and Sundararajan, B. (2022). "How student perceptions about online learning difficulty influenced their satisfaction during Canada's Covid-19 response", *British Journal of Educational Technology*, vol. 53, no. 3, pp. 534–557, DOI 10.1111/bjet.13206
- Engel, O., Zimmer, L. M., Lörz, M. and Mayweg-Paus, E. (2023). "Digital studying in times of COVID-19: teacher- and student-related aspects of learning success in german higher education", *International Journal of Education Technology in Higher Education*, vol. 20, no. 12, DOI 10.1186/s41239-023-00382-w
- George, P. P. et al. (2014). "Online eLearning for undergraduates in health professions: A systematic review of the impact on knowledge, skills, attitudes and satisfaction", *Journal of Global Health*, DOI 10.7189/jogh.04.010406
- Hendl, J. (2009). "*Přehled statistických metod zpracování dat: analýza a metaanalýza dat*", Prague: Portál (In Czech)
- Hodges, C., Moore, S., Lockee, B., Trust, T. and Bond, A. (2020). "*The Difference between Emergency Remote Teaching and Online Learning*", *EDUCAUSE Review*. [Online], Available: <https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning> [10 Jun 2023]
- Imran, R., Fatima, A., Elbayoumi Salem, I. and Allil, K. (2023). "Teaching and learning delivery modes in higher education: Looking back to move forward post-COVID-19 era", *The International Journal of Management Education*, DOI 10.1016/j.ijme.2023.100805
- Jensen, L., Price, L. and Roxå, T. (2020). "Seeing through the eyes of a teacher: Differences in perceptions of HE teaching in face-to-face and digital contexts", *Studies in Higher Education*, vol. 45, no. 6, pp. 1149–1159, DOI 10.1080/03075079.2019.1688280

- Lorenza, L. and Carter, D. (2021). "Emergency online teaching during COVID-19: A case study of Australian tertiary students in teacher education and creative arts", *International Journal of Educational Research Open*, vol. 2, DOI 10.1016/j.ijedro.2021.100057
- Ministerstvo zdravotnictví ČR. (2020). "Mimořádné opatření – uzavření základních, středních a vysokých škol od 11. 3. 2020", [Online], Available: <https://www.mzcr.cz/mimoradne-opatreni-uzavreni-zakladnich-strednich-a-vysokych-skol-od-11-3-2020/> [5 Apr 2023] (In Czech)
- Mok, K. H., Xiong, W. and Bin Aedy Rahman, H. N. (2021). "COVID-19 pandemic's disruption on university teaching and learning and competence cultivation: Student evaluation of online learning experiences in Hong Kong", *International Journal of Chinese Education*, vol. 10, no. 1, DOI 10.1177/22125868211007011
- Muhaimin, M., Habibi, A., Riady, Y., Alqahtani, T. M., Chaerunisaa, A. Y., Wijaya, T. T., Milanda, T., Yusop, F. D. and Albelbisi, N. A. (2023). "Covid-19 distance and online learning: a systematic literature review in pharmacy education", *BMC Medical Education*, DOI 10.1186/s12909-023-04346-6
- Neubauer, J., Sedláčik, M. and Kříž, L. (2016). "Základy statistiky", Prague: Grada (In Czech)
- Shim, T. E. and Lee, S. Y. (2020). "College students' experience of emergency remote teaching due to COVID-19", *Children and Youth Services Review*, 119, 105578, DOI 10.1016/j.chilyouth.2020.105578
- UNESCO, n.d., "COVID-19 Education Response", [Online], Available: <https://covid19.uis.unesco.org/global-monitoring-school-closures-covid19/country-dashboard/> [10 Apr 2023]
- Yau, A. H. Y., Yeung, M. W. L. and Lee, C. Y. P. (2022). "A co-orientation analysis of teachers' and students' perceptions of online teaching and learning in Hong Kong higher education during the COVID-19 pandemic", *Studies in Educational Evaluation*, DOI 10.1016/j.stueduc.2022.101128

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JEL Classification System / EconLit Subject Descriptors

Basic classification and detailed classification you can find on a web page:

<https://www.aeaweb.org/econlit/jelCodes.php>

A. General Economics and Teaching

- A1 General Economics
- A2 Economic Education and Teaching of Economics
- A3 Collective Works

B. History of Economic Thought, Methodology, and Heterodox Approaches

- B1 History of Economic Thought through 1925
- B2 History of Economic Thought since 1925
- B3 History of Economic Thought: Individuals
- B4 Economic Methodology
- B5 Current Heterodox Approaches

C. Mathematical and Quantitative Methods

- C1 Econometric and Statistical Methods and Methodology: General
- C2 Single Equation Models • Single Variables
- C3 Multiple or Simultaneous Equation Models • Multiple Variables
- C4 Econometric and Statistical Methods: Special Topics
- C5 Econometric Modeling
- C6 Mathematical Methods • Programming Models • Mathematical and Simulation Modeling
- C7 Game Theory and Bargaining Theory
- C8 Data Collection and Data Estimation Methodology • Computer Programs
- C9 Design of Experiments

D. Microeconomics

- D1 Household Behavior and Family Economics
- D2 Production and Organizations
- D3 Distribution
- D4 Market Structure, Pricing, and Design†
- D5 General Equilibrium and Disequilibrium
- D6 Welfare Economics
- D7 Analysis of Collective Decision-Making
- D8 Information, Knowledge, and Uncertainty
- D9 Intertemporal Choice

E. Macroeconomics and Monetary Economics

- E1 General Aggregative Models
- E2 Consumption, Saving, Production, Investment, Labor Markets, and Informal Economy
- E3 Prices, Business Fluctuations, and Cycles
- E4 Money and Interest Rates
- E5 Monetary Policy, Central Banking, and the Supply of Money and Credit
- E6 Macroeconomic Policy, Macroeconomic Aspects of Public Finance, and General Outlook

F. International Economics

- F1 Trade
- F2 International Factor Movements and International Business
- F3 International Finance
- F4 Macroeconomic Aspects of International Trade and Finance
- F5 International Relations, National Security, and International Political Economy
- F6 Economic Impacts of Globalization

G. Financial Economics

- G1 General Financial Markets
- G2 Financial Institutions and Services
- G3 Corporate Finance and Governance

H. Public Economics

- H1 Structure and Scope of Government
- H2 Taxation, Subsidies, and Revenue
- H3 Fiscal Policies and Behavior of Economic Agents
- H4 Publicly Provided Goods
- H5 National Government Expenditures and Related Policies
- H6 National Budget, Deficit, and Debt
- H7 State and Local Government • Intergovernmental Relations
- H8 Miscellaneous Issues

I. Health, Education, and Welfare

- I1 Health
- I2 Education and Research Institutions
- I3 Welfare, Well-Being, and Poverty

J. Labor and Demographic Economics

- J1 Demographic Economics
- J2 Demand and Supply of Labor
- J3 Wages, Compensation, and Labor Costs
- J4 Particular Labor Markets
- J5 Labor–Management Relations, Trade Unions, and Collective Bargaining
- J6 Mobility, Unemployment, Vacancies, and Immigrant Workers
- J7 Labor Discrimination
- J8 Labor Standards: National and International

K. Law and Economics

- K1 Basic Areas of Law
- K2 Regulation and Business Law
- K3 Other Substantive Areas of Law
- K4 Legal Procedure, the Legal System, and Illegal Behavior

L. Industrial Organization

- L1 Market Structure, Firm Strategy, and Market Performance
- L2 Firm Objectives, Organization, and Behavior
- L3 Nonprofit Organizations and Public Enterprise
- L4 Antitrust Issues and Policies
- L5 Regulation and Industrial Policy
- L6 Industry Studies: Manufacturing
- L7 Industry Studies: Primary Products and Construction
- L8 Industry Studies: Services
- L9 Industry Studies: Transportation and Utilities

M. Business Administration and Business Economics • Marketing • Accounting • Personnel Economics†

- M1 Business Administration
- M2 Business Economics
- M3 Marketing and Advertising
- M4 Accounting and Auditing
- M5 Personnel Economics

N. Economic History

- N1 Macroeconomics and Monetary Economics • Industrial Structure • Growth • Fluctuations
- N2 Financial Markets and Institutions
- N3 Labor and Consumers, Demography, Education, Health, Welfare, Income, Wealth, Religion, and Philanthropy
- N4 Government, War, Law, International Relations, and Regulation
- N5 Agriculture, Natural Resources, Environment, and Extractive Industries
- N6 Manufacturing and Construction
- N7 Transport, Trade, Energy, Technology, and Other Services
- N8 Micro-Business History

N9 Regional and Urban History

O. Economic Development, Innovation, Technological Change, and Growth†

O1 Economic Development

O2 Development Planning and Policy

O3 Innovation • Research and Development • Technological Change • Intellectual Property Rights†

O4 Economic Growth and Aggregate Productivity

O5 Economywide Country Studies

P. Economic Systems

P1 Capitalist Systems

P2 Socialist Systems and Transitional Economies

P3 Socialist Institutions and Their Transitions

P4 Other Economic Systems

P5 Comparative Economic Systems

Q. Agricultural and Natural Resource Economics • Environmental and Ecological Economics

Q1 Agriculture

Q2 Renewable Resources and Conservation

Q3 Nonrenewable Resources and Conservation

Q4 Energy

Q5 Environmental Economics

R. Urban, Rural, Regional, Real Estate, and Transportation Economics

R1 General Regional Economics

R2 Household Analysis

R3 Real Estate Markets, Spatial Production Analysis, and Firm Location

R4 Transportation Economics

R5 Regional Government Analysis

Y. Miscellaneous Categories

Y1 Data: Tables and Charts

Y2 Introductory Material

Y3 Book Reviews (unclassified)

Y4 Dissertations (unclassified)

Y5 Further Reading (unclassified)

Y6 Excerpts

Y7 No Author General Discussions

Y8 Related Disciplines

Y9 Other

Z. Other Special Topics

Z1 Cultural Economics • Economic Sociology • Economic Anthropology

Z2 Sports Economics

Z3 Tourism Economics