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PROMOTING INNOVATION ADOPTION IN THE AGRICULTURAL SECTOR: THE CASE OF LITHUANIA AND THE CZECH REPUBLIC

Purpose. *The purpose of the study – to assess the differences in agricultural innovativeness in Lithuania and the Czech Republic and to explain the need and ways of promoting agricultural innovativeness in both countries.*

Methodology / approach. *First, a comparative analysis of statistical data was conducted (a quantitative study). Data from the Statistical Office of the Republic of Lithuania and the Czech Republic, Eurostat, and the United States Department of Agriculture (USDA) were used for the analysis. Lithuanian agricultural indicators were evaluated in the context of the EU. Additionally, 10 experts were interviewed (a qualitative study). Five experts were interviewed from each of Lithuania and the Czech Republic. The interviews were conducted using a semi-structured approach.*

Results. *The study reveals that farmers in both the Czech Republic and Lithuania face obstacles in obtaining financial support for innovation and in accessing information about cutting-edge farming techniques, regardless of the size of their farms. However, the situation in the Czech Republic is somewhat less complex due to its larger agricultural sector, making the issue of financial support for innovation more straightforward to navigate compared to Lithuania. Farmers in both countries demonstrate a favourable attitude toward innovation. The study presents practical recommendations for enhancing the agricultural innovation ecosystem and the adoption of innovations in the agricultural sector. It emphasises the need to simplify the application process for financial assistance and improve communication strategies so that farmers are well informed and prepared to implement new technologies. Furthermore, it calls for increased community-building initiatives among farmers to foster an environment conducive to knowledge sharing and collaboration. Insights from expert interviews indicate that providing personalised advice and customised training programs can significantly bolster the ability of small and medium-sized farms to innovate and compete effectively not only in the local market but also in global ones.*

Originality / scientific novelty. *This article contributes to the academic discourse on agricultural innovation by providing a comparative analysis of the innovativeness of the agricultural sectors in two different Central and Eastern European countries. It uniquely addresses many challenges faced by farmers, including environmental concerns, limited access to financial support, and a shortage of qualified agricultural experts. The novelty of the study lies in its dual methodology – combining quantitative data from statistical analyses with qualitative insights from expert interviews.*

Practical value / implications. *This approach not only enriches the understanding of agricultural innovation in Lithuania and the Czech Republic but also highlights the need for tailored strategies that take into account the specific socio-economic contexts of small and medium-sized farms. By identifying the barriers to innovation adoption and highlighting the differences in agricultural policies and practices between the two countries, this research provides valuable practical insights for policymakers and stakeholders seeking to improve agricultural productivity and*

sustainability.

Key words: *agricultural economics, agricultural innovation, agricultural indicators, agricultural productivity, organic farms.*

1. INTRODUCTION

Before starting the analysis, it is important to study the agricultural statistics of Lithuania and the Czech Republic to understand the current situation and identify the main challenges and opportunities for innovation. In addition, the statistics facilitate a comparison of the agricultural sectors in the two countries, enabling the identification of the most effective application of innovations in each. In the Czech Republic, the average area per agricultural holding increased from 93 to 106 hectares in 2023. Concurrently, the number of people employed in agriculture decreased by 28.3 % to 173.8 thousand. The output of the agricultural industry in 2023 decreased by 7.9 %. This decline was influenced by a drop in the value of crop production by 17.4 %, while animal production, on the other hand, recorded year-on-year growth of 6.3 % in 2023. Cereals (41.1 %) and industrial crops (24.5 %) had the most significant share of crop production. In animal production, milk production (54.1 %), pigs for slaughter (14.7 %) and cattle for slaughter (12.5 %) contributed most significantly. The share of crop production (53.3 %) continued to prevail over animal production (39.7 %). The entrepreneurial income of farmers fell, compared to the 2022 data, by 58.0 % (Czech Statistical Office, 2023). In Lithuania, the average area per agricultural holding increased from 22.2 to 31.6 hectares in 2023. The total number of agricultural enterprises decreased from 132.0 to 88.0 thousand, of which 2,951 are certified organic farms. The number of people working in agriculture also fell from 23,964 to 22,981. Gross agricultural production in 2023 was EUR 1,126.7 million; livestock production amounted to EUR 686.4 million, an increase of 0.66 % compared to 2022; crop production amounted to EUR 440.3 million, an increase of 22.07 % compared to 2022. The sales revenue of agricultural companies in 2023 was EUR 1.7 million, almost unchanged compared to 2022. The gross profit of agricultural companies is EUR 206.8 million in 2023, a decrease of 40.07 % compared to 2022 (Statistics Lithuania, 2023a).

Innovation adoption drives economic growth and is critical to the modernisation of businesses, including farms and the agricultural sector as a whole. Also, issues such as lack of concern for the environment, natural resource depletion, lack of ecological approach, shrinking and fragmentation of farms, agricultural trade liberalisation, and global climate change have become main challenges to agricultural growth and development. These factors have begun to reduce farm incomes and economic benefits to the state and call for various types of innovations.

According to the literature (Amabile, 2020), in a competitive business environment, innovation is becoming a necessity without which business organisations risk failure. Innovative activities can increase productivity, improve product quality, increase consumer satisfaction and save resources. Innovation is also a prerequisite for more sustainable activities, which is why not only businesses but also the agricultural sector is interested in innovation. According to Padgureckienė (2015), innovation is

one of the priority means of increasing competitiveness of agricultural producers in both the international and local markets.

Farmers are already aware that they need to improve their practices in order to be successful (Jámbor et al., 2020), but all actors in the agricultural sector need to take steps to ensure a sustainable and successful operating model (Pouvreau et al., 2019). Researchers Jewell et al. (2020), Vidickienė et al. (2013) believe that to get out of the crisis in the agro-industrial complex, it is necessary to make greater use of the potential of scientific and technological progress. However, it is important to go beyond technological innovations (Dadelytė & Mačiulytė-Šniukienė, 2020).

Sund et al. (2018) analysed the concept, models and ecosystem of innovation. Singh et al. (2015) examined the processes of economic development and the impact of innovation sectors, including agriculture, on the economy. Corrales-Estrada (2019) explored how to transform the mindset of potential entrepreneurs in emerging markets into innovative ones by fostering connections with people in science – experts, academics. Bennett & Jennings (2013) studied how to improve agricultural efficiency through innovative solutions. Blakeney (2022) investigated the links between agricultural innovation and sustainable development.

The purpose of the study – to assess the differences and related factors in agricultural innovativeness in Lithuania and the Czech Republic as well to discuss and propose ways of promoting agricultural innovativeness in both countries.

The structure of the paper is as follows: the introduction focuses on the importance of the topic and justifies the relevance of the topic. Section 2 presents the literature review. Section 3 describes the methodology used to achieve the aim of the paper. Section 4 presents and analyses the results of the study and Section 5 discusses the main conclusions of the paper.

2. LITERATURE REVIEW

2.1. Essence of agricultural innovation. Economists distinguish two main types of innovation – process innovation and product innovation. The conceptualisation of innovation has separated it from the concept of invention. Inventions become innovations only when business is involved in the improvement process (Pilipavičius, 2017; Jewell et al., 2020). The OECD Oslo Manual provides the following definition of innovation: “an innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (OECD/Eurostat, 2018).

Modern academic literature also identifies innovation with novelty, but today the term does not refer only to new products. To summarise, in the definitions of Valentinavičius (2006); Pilipavičius (2017), innovation is treated as a process (e.g. introduction, development, adaptation).

Innovation is the process of developing and introducing new ideas, processes, products, or services that add value and solve existing problems. It encompasses creativity, experimentation, and risk-taking. Innovation can take the form of concrete,

developed and implemented solutions, such as new products, technologies, methodologies, or business models. These innovations can take various forms, including new products, technologies, methods, or business models, with the common thread being their ability to enhance operational efficiency or generate new opportunities. The distinction between these concepts lies in the fact that innovativeness is a capability and a process, whereas innovation is the result that emerges from this capability and process. Rizzo et al. (2023) identified several barriers to innovation adoption, including complexity, innovation avoidance, and a perceived lack of control over innovation.

Farsani et al. (2024) argue that eco-innovation not only increases productivity but also promotes the responsible use of natural resources, which is a significant step in environmental protection. The authors' study underscores that pivotal indicators of innovation in agriculture encompass elements such as human capital and research, institutional framework, market sophistication, infrastructure, knowledge and technology, and creative and innovative endeavours (Farsani et al., 2024).

Glod & Wronka-Pospiech (2015) point out that it is only in the last few decades that innovation is no longer only about technological improvements, but also about organisational improvements. It can be assumed that such a broad treatment of the term "innovation" is due to the lack of terminology suitable for describing organisational/marketing improvements. It is worth mentioning the EU criteria used to define the innovativeness of agriculture (Ramanauskas & Kirstukas, 2009): the impact of innovations on products; the impact of innovations on the technological processes of production (improvement of the marketing system). The impact of innovations on the organisational transformation of the economic entity; the impact of innovations on research innovation (inventions, licenses, trademarks and other knowledge, related personnel training, recruitment of scientists and highly qualified personnel).

According to Ramanauskas & Kirstukas (2009), the minimum level of innovativeness means that the farm only adopts and adapts innovations developed by other enterprises, but does not develop and improve new products itself or participate in technological platforms (clusters). Thus, it can be argued that the more agricultural operators are involved in innovation, the higher the level of innovation in agriculture. On the other hand, the innovativeness of a country's agriculture also depends on the number of entities involved in innovative activities.

2.2. Factors of agricultural innovation. Today, agricultural innovation takes place in all economically and socially developed countries, but there is still a wide gap in agricultural innovation adoption. According to Jewell et al. (2020), the level of innovation development and adoption in the agricultural sector is low in many countries, even in developed countries, due to a range of factors, the lack of guarantees of return on investment being one of them. The lack of investment forces many farms to finance innovation themselves, which only large farms can do. This is the reason why most innovative ideas remain unrealised and why the problem of innovation uptake is particularly acute for small farms (Van Es & Woodard, 2017). Small farms have limited investment opportunities and can only invest in innovations that are low

risk and have a quick payoff.

Motives and barriers to innovation in Lithuanian agriculture have been studied by Ramanauskas &Kirstukas (2009); Vidickienė et al. (2013). Pilipavičius (2017) investigated the antecedents of innovation in small and medium-sized enterprises. Maziliauskas et al. (2018) examined the impact of innovation partnerships in agriculture. One of the most relevant studies was conducted by Bičkauskė et al. (2020), who examined the challenges of digitalisation in agriculture. In the Czech Republic, researchers such as Novotná & Volek (2015) have examined the productivity of small farms by analysing the relationship between farm size and labor productivity. In addition, studies by Čechura (2014) and Rudinskaya et al. (2019) have taken into account the heterogeneity of farms in terms of size when assessing technical efficiency. Furthermore, Bokusheva & Čechura (2017) have found evidence of a positive relationship between farm size, innovation and total factor productivity in Czech cereal production. However, it can be noted that there is a lack of recent studies that examine the innovativeness of Lithuanian agriculture and the measures to promote innovation.

One of the most studied factors determining the level of agricultural innovativeness is farm size. Small farms are less likely to innovate (Mwagi & Kariuki, 2015; Ramanauskas & Kirstukas, 2009). Small farms are particularly lacking in human resources. In a competitive business environment, the importance of finding skilled and motivated employees has increased. The generation of ideas, their development, shaping and implementation depend directly on people (Labarthe et al., 2021). Companies compete for the best professionals, but it is worth noting that the knowledge required for innovative activities is not innate and static. Therefore, human resource management cannot be limited to the search and selection of the best professionals (Ma & Yu, 2021). Innovative firms need to engage in HRM, which, according to Jewell et al. (2020), include investing in employees, fostering loyalty, setting long-term goals, and allocating tangible and intangible resources. According to a study by Ramanauskas & Kirstukas (2009), farmers spend little on human resource development and do not employ highly qualified staff. These trends are partly related to the shortage of highly skilled workers, which is partly due to the inadequacy of the education system to meet the needs of agriculture and the reluctance of young people to enter agricultural professions.

Krušinskas & Benetytė (2014) point out that the limiting factor in innovative activities may not only be the ability of human resources to innovate, but also the resistance of employees themselves to innovation. Resistance to innovation usually stems from the fear that innovation will make work more difficult, require more effort to learn, or even replace human labor. Pue et al. (2015) note that innovation is perceived as a novelty, which can lead to skepticism in conservative environments. Thus, resistance to innovation can come from both workers and non-workers. Therefore, one of the factors influencing farm innovativeness is the attitude of owners and workers towards innovation and the prevailing innovation culture on the farm.

Some of the factors that determine the innovativeness of an economy are related to the characteristics of its owners. According to Olum et al. (2020), education is the

most important characteristic of farmers that determines their propensity to innovate. Farmers with higher education are more likely to innovate. Higher education is thought to promote farmers' openness to innovation and a more rational and analytical evaluation of the benefits of technologies. On the other hand, Mwagi & Kariuki (2015) note that research on the relationship between farmers' education and innovation adoption is mixed. There are studies that show a negative relationship between education and propensity to innovate. This is explained by the fact that higher education also leads to a more critical evaluation of innovation, looking at the different aspects of benefits and costs.

Another factor for innovation is the age of the farmers. After structuring the results of studies on the determinants of farmers' innovativeness, Olum et al. (2020) point out that most studies find a relationship between innovativeness and age, with younger farmers more likely to adopt innovations. These trends are in line with Ramanauskas & Kirstukas (2009), who argue that young people have the highest innovative potential. It can therefore be argued that the deteriorating demographic situation in rural areas and the aging of rural communities are particularly worrying trends in agricultural development.

There are also several other factors of agricultural innovativeness that do not belong to any of the above groups of factors. Van Es & Woodard (2017); Toillier, Faure & Chia (2018) highlighted the lack of infrastructure – slow internet in rural areas. According to the authors, the slow internet makes it difficult to choose appropriate technologies for rural areas. To address this issue, investments are being made in broadband internet connectivity. According to Bičkauskė et al. (2020), the heterogeneity of the supply chain complicates the application of ICT in agriculture. It is difficult to find supply chain management technologies that are acceptable to all actors in the supply chain due to differences in size and capacity (especially when small farms are involved).

The analysis of the scientific literature (Mwagi & Kariuki, 2015; Ramanauskas & Kirstukas, 2009; Labarthe et al., 2021; Ma & Yu, 2021; Jewell et al., 2020) allowed us to summarise the variety of factors that influence the adoption of innovations in agriculture. It also identifies a group of measures to promote agricultural innovativeness, such as strengthening scientific and educational infrastructure, financial and advisory support, strengthening farming communities, and improving regional infrastructure (Table 1).

Agricultural innovation is driven by the growing demand for innovation, i.e. growing consumer needs, environmental requirements and competitiveness, but the innovativeness of farms (especially small farms) is constrained by several factors that can be divided into several groups: innovation-related factors, farm-related factors, economic and financial factors, social and institutional factors and other factors. It can be seen that many of the different factors of innovativeness are closely intertwined and conditioned by the socio-economic structure of a country. This makes it difficult to increase the level of agricultural innovation, as direct incentives such as financial incentives and extension mechanisms are not sufficient. Agricultural innovation

depends on the viability of regions, so it is essential to ensure the improvement of regional infrastructure to encourage generational renewal and the continuation of agricultural traditions.

Table 1

Factors affecting agricultural innovation adoption

Factors related to the innovation	Economic and financial factors	Social and institutional factors	Farm-related factors	Other factors
Cost, complexity, benefits to the economy (economic impact), scientific, environmental and other impacts	Capacity and sustainability of investment in innovation	Regional socio-demographic trends, lack of information and expertise, relevance of education to agricultural needs, political factors (national and EU policies, strategic guidelines, financial support)	Size, human resources, competitive strategy, farmer age and education, innovation environment	Internet infrastructure, complexity of agricultural supply chains

Source: compiled by authors.

Considering the critical analysis of the current state of research in the world in the field of agriculture innovations and the identification of contradictions in previous works, the following research questions are posed: 1. What are the main differences between Lithuanian and Czech Republic in terms of agricultural innovativeness? 2. What factors have the greatest impact on agricultural innovativeness in Lithuania and the Czech Republic? The response to these questions would help making proposals to address them as effectively as possible.

3. METHODOLOGY

The study consists of two structural parts: exploratory statistics and qualitative research (Figure 1).

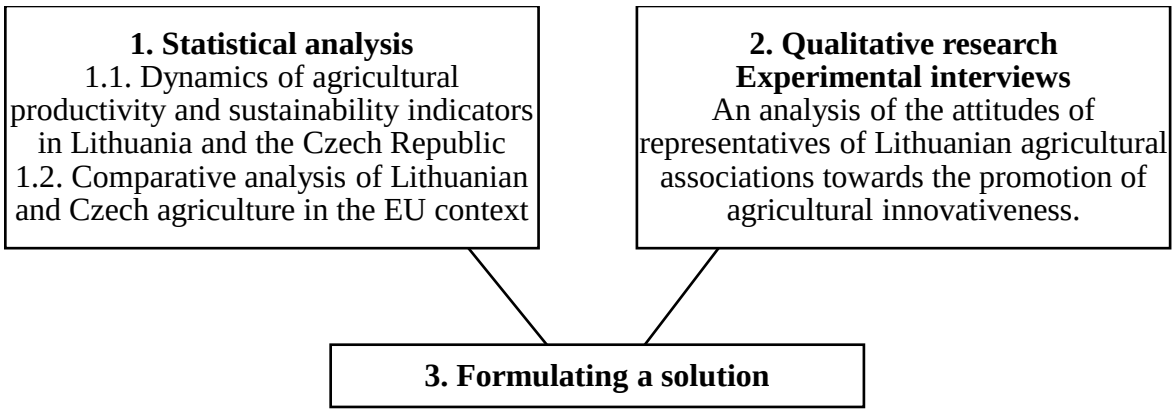

Figure 1. Conceptual study design

Source: compiled by authors.

The statistical analysis takes into account the indicators that support the need to promote innovation in agriculture. Since there are limited statistics on the level of agricultural innovation adoption, based on literature it is assumed that the level of

innovativeness can be revealed by productivity indicators (Heisey & Fuglie, 2018; Baležentis & Štreimikienė, 2015; Wang & Ahmed, 2004). The analysis is supplemented by indicators of organic farming, as eco-efficiency is an important prerequisite for agricultural innovation (Van Es & Woodard, 2017). In Lithuania, the analysis is carried out by looking at indicators of total agricultural productivity and organic farming.

Gross productivity, net profitability, and organic farming can serve as proxies for the level of innovation or innovativeness in the agricultural sector for several reasons (Benton & Bailey, 2019; Ouiminga, 2018). Gross productivity is defined as the amount of agricultural output relative to inputs. High productivity often reflects the effective adoption of innovations, such as the use of new technologies or techniques that increase output. Net profitability indicates the profit after all costs are deducted. Innovative farming methods have the potential to reduce costs and increase profitability, making this indicator a useful metric for assessing the level of innovation within a sector. Organic farming employs sustainable practices that mitigate adverse environmental impacts. Innovation in organic farming can include the introduction of new, environmentally friendly technologies and practices that help maintain or increase production while reducing environmental pollution (FAO, 2018).

The formula for gross productivity in the agricultural sector is:

$$Gross\ productivity = \frac{Agricultural\ output}{Input\ resources}. \quad (1)$$

This indicator is calculated by comparing the quantity of agricultural output (e.g., tonnes) with the inputs (e.g., labor, capital, land). This calculation provides a quantitative assessment of the efficiency with which inputs are used to generate output.

The analysis uses data from the Statistical Office of the Republic of Lithuania and the Czech Republic, Eurostat, Agridata and the U.S. Department of Agriculture (USDA). Lithuanian agricultural indicators are evaluated in the context of the EU.

Qualitative research can contribute a lot and provide a comprehensive analysis of the aspect under study (Sreejesh et al., 2014). Thus, in this paper, a qualitative research approach is used as a second and complementary instrument to explore the phenomenon under study, to identify the main issues of innovation in small and medium enterprises A structured interview was used that is identical questions are asked to all research participants (Kardelis, 2017).

Experts participating in the study are representatives of agricultural associations of Lithuania and the Czech Republic. It is assumed that the opinion of representatives of agricultural associations is valuable for identifying barriers to innovation and the need for incentives for Lithuanian small and medium-sized farms.

In our case a questionnaire consisting of six questions was designed to conduct the study. The primary inquiries addressed the following: 1) What are the key innovation trends in the agricultural sector from an economic perspective? 2) Which agricultural innovations (products, technologies, processes, organisations, or scientific advances) have the most significant impact on agricultural development? 3) How would you assess the promotion of agricultural innovation in Lithuania and the Czech

Republic? 4) What improvements could be made to promote agricultural innovation in small and medium-sized farms in Lithuania and the Czech Republic? Based on the results, additional questions also were asked by the experts. A total of 5 experts from each country were invited and agreed to participate in the study. The experts represented the Union of Small and Medium Farmers, the Union of Young Farmers and Youth, and the District Farmers' Associations of both countries. As the participants wished to remain anonymous, they are referred to in the text of the study in coded form (E1–E5) from Lithuania and (F1–F5) from the Czech Republic. All experts collectively represent a wealth of experience in agriculture, ranging from 15 to over 30 years, with a strong emphasis on balancing traditional farming practices with modern technologies. Their operations vary in size from small to large family farms, with a focus on organic produce, crop production and livestock. All share a common commitment to maximising productivity and sustainability, often using data-driven approaches and innovative techniques to improve efficiency and support their farming operations.

The study was carried out between 2022 and 2024. Each potential participant was initially contacted by phone to arrange the study. Once consent to participate in the study was obtained, time for the interviews was arranged. At the request of the informants, the interviews were conducted remotely using video conferencing tools convenient for the informants (Zoom, Teams). Prior to the interview, participants were informed of the purpose of the study. Participants took part in the interview process with the understanding that the study would help to identify the problems of innovation in small and medium-sized agriculture. Consent was obtained from the participants to record the interviews.

4. RESULTS

4.1. Analysis of the situation of agricultural indicators and innovation capacity in Lithuania and the Czech Republic. One of the main goals of promoting innovation in agriculture is to increase the productivity of the sector. According to theoretical analysis, the main indicator of agricultural productivity, which also measures the impact of innovation on agriculture, is the total agricultural productivity index. This indicator shows the relationship between all types of agricultural inputs (crop and pastureland, labor, agricultural machinery, fertilisers, etc.) and output (agricultural production). Based on the data provided by the USDA, it is possible to compare the dynamics of total agricultural productivity in Lithuania and the Czech Republic with 2015, taken as the base period (2015: 100 %) (Figure 2).

Figure 2 presents the USDA international agricultural productivity data for Lithuania, the Czech Republic, and the EU, along with the direct TFP index for Lithuania. It is crucial to acknowledge that agricultural productivity in Lithuania shows significant volatility in the long term compared to the Czech Republic and the overall EU average. Therefore, it is necessary to prioritise long-term productivity improvements to ensure that the growing needs of the population do not exceed the capacity to ensure food security (Fischer, 2020).

A recent study (Čechura et al., 2022) analysed the sources of TFP in Czech

agriculture and reported on Scale Efficiency (SEC): smaller producers lag behind larger ones due to scale effects. Large farms should focus on technological change, while small farmers cope with productivity losses through improvements in scale and technical efficiency. In the future, this competitive weakness can be expected to make small farms unable to withstand competitive pressures, which will be exacerbated by the efforts of large farms to acquire the resources available to small farms. It is necessary to increase the technical efficiency of small farms and to promote new cost-reducing practices and innovations.

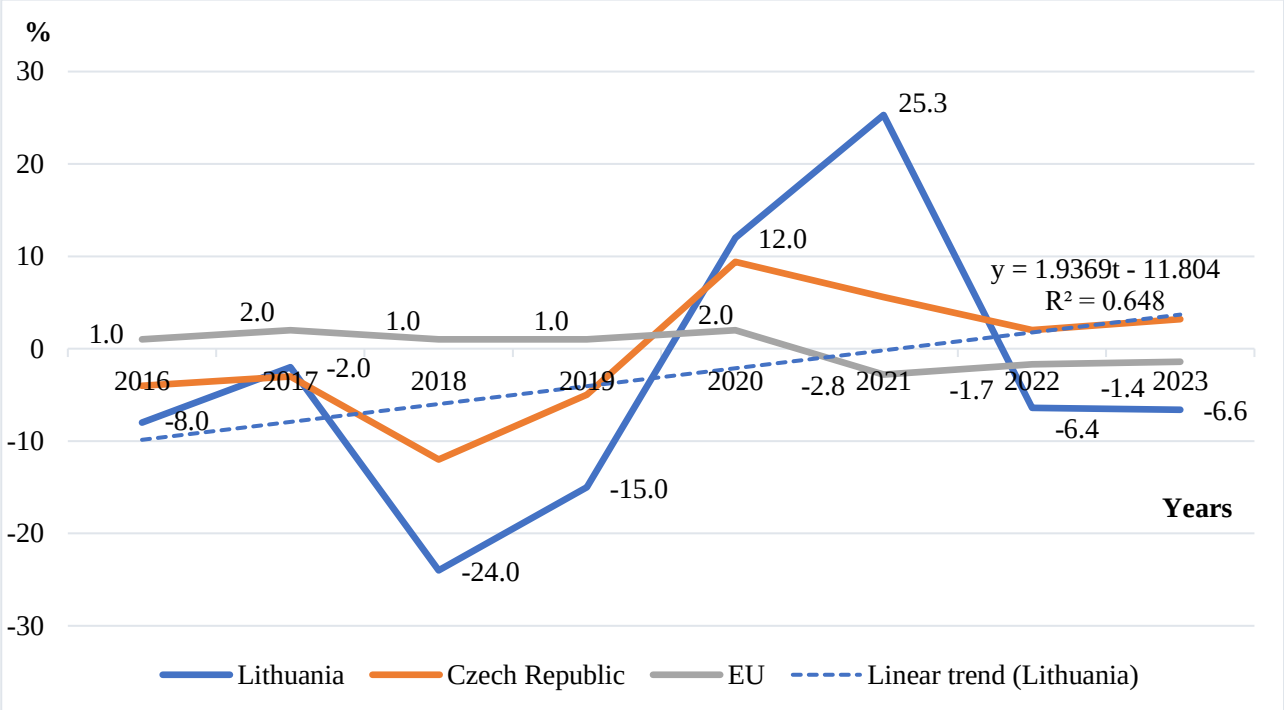

Figure 2. Total change in the agricultural productivity index (as a percentage of the 2015 figure)

Source: built based on data from USDA (2024).

The latest figures on agricultural productivity are provided by Eurostat, but this agency does not provide data on the gross agricultural productivity index. Eurostat statistics provide an assessment of the financial performance of agriculture, which indicates both the need for innovation and the capacity of farms to invest in innovation. One of the key indicators is the net profitability of agriculture. Eurostat data measure the net change in agricultural profitability compared to 2015. At EU level, the net profitability of agriculture has increased and has not been lower than in 2015 in any of the following years. EU agricultural units were particularly profitable in 2017. Thereafter, agricultural net profitability declined slightly, but remained at 6.2 % to 12.8 % higher than in 2015 but was lower than in 2015 in all other years of the analysed period (Figure 3).

The data in Figure 3 show that in all periods except 2020, the net profitability of agricultural units in Lithuania is lower than in 2015, while in the Czech Republic it increases. A particularly significant decrease in the net profitability of agricultural units is recorded in 2018 (-54.1 %). In 2022, a notable rise in the net profitability of

agricultural units was observed in Lithuania, reaching 263.6 %. This increase can be attributed to the impacts of the COVID-19 pandemic, along with various contributing factors, while in the Czech Republic the upward trend continued into 2022 and 2023, with net profitability peaking at 18.3 % in 2022. This growth can be attributed to several factors, including increased investment in technology and sustainable practices, improved export opportunities, and a focus on higher-value agricultural products. Thus, the development of the net profitability of agricultural units reflects both the need for innovation and the reduced capacity of agricultural units to invest in innovation. As is well known, reinvestment in innovation is a prerequisite for profitable activity (Maziliauskas et al., 2017).

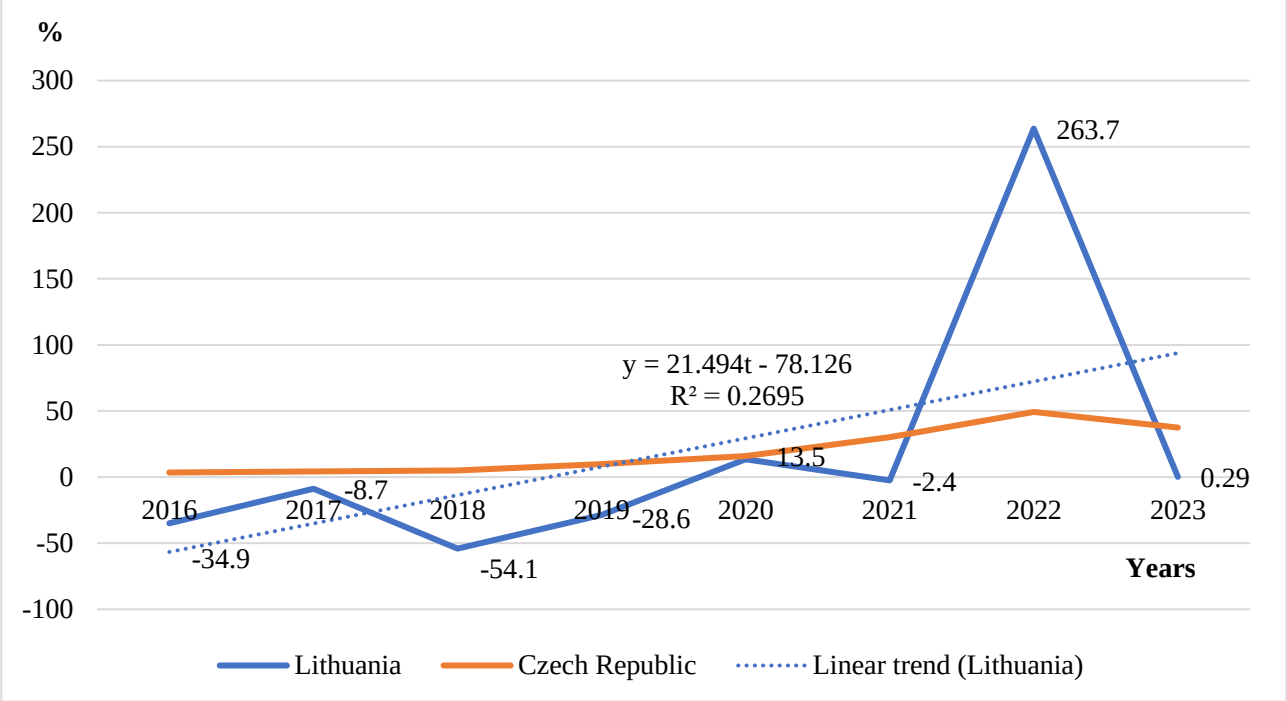

Figure 3. Change in net profitability of agricultural units in Lithuania and the Czech Republic compared to 2015, %

Source: built based on data from Eurostat (2022).

Since one of the main objectives of promoting innovation in agriculture is to make the agricultural sector more environmentally friendly, the statistical analysis of agricultural indicators should also take into account the number of certified organic farms. Statistics show that the number of organic farms in Lithuania has been decreasing since 2015 till 2020. After 2020, there is a noticeable recovery, with an increase in the number of organic farms in Lithuania till 2596 in 2023. This suggests that various factors, such as governmental policies, market demand for organic products, and support for sustainable farming practices, may have influenced these fluctuations. In contrast to Lithuania, the Czech Republic experienced a steady increase in the number of organic farms from 2015 to 2023. This indicates a robust and growing interest in organic farming within the country, possibly driven by increasing consumer preference for organic products and effective agricultural policies promoting organic practices (Figure 4).

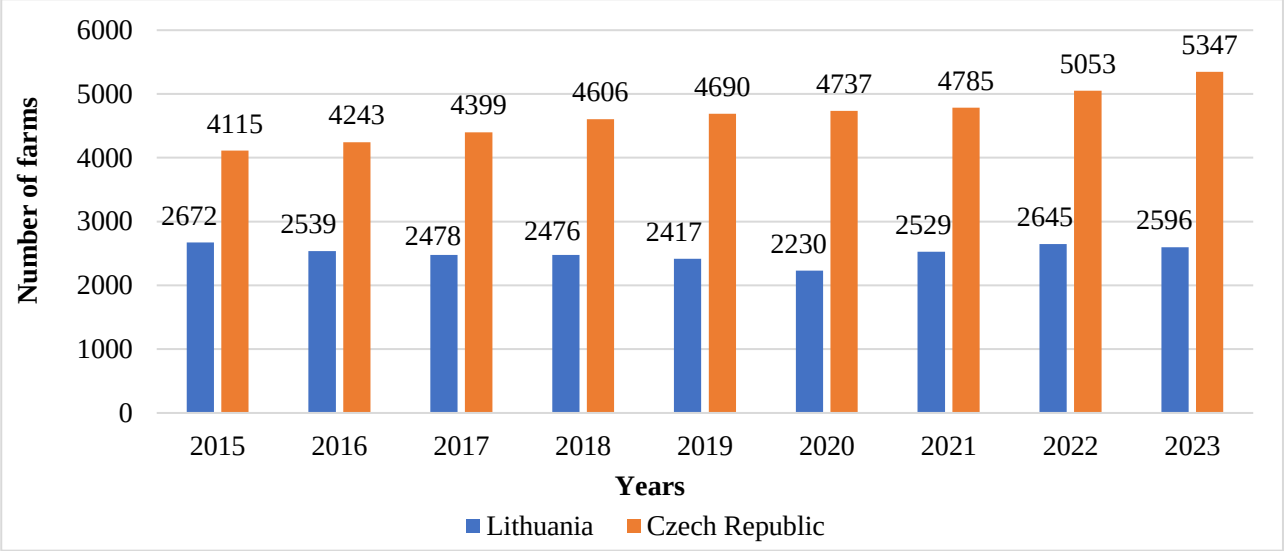

Figure 4. Dynamics of certified organic farms

Source: built based on data from Statistics Lithuania (2020); Czech Statistical Office (2024).

Lithuania has made significant progress in organic agriculture. From 2014 to 2022, the certified organic agricultural area will increase by 48 %, reaching 8.59 % of the country's total agricultural area. The average size of Lithuanian organic farms is about 0.39 km², which is about four times the size of conventional farms. The largest organic farm is 7 km² (Figure 5).

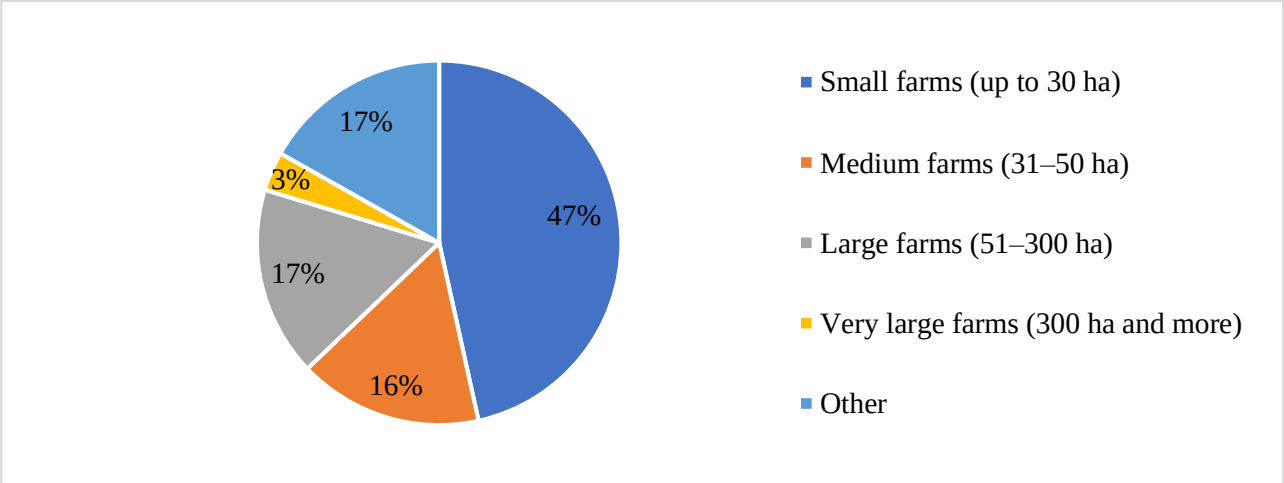

Figure 5. Distribution of organic farms by size in Lithuania

Source: built based on data from Statistics Lithuania (2023b).

Grasses and legumes: These account for 61.0 % of total organic production in Lithuania. While organic farming has grown, challenges remain. Implementation of measures has faced obstacles, resulting in slower development; the program has primarily benefited large-scale organic farms, potentially overshadowing smaller farms; positive environmental outcomes include reduced greenhouse gas emissions and soil erosion. Recommendations include more targeted support, emphasis on farmer cooperation, and consumer education.

The Czech Republic has 540,993 hectares of organic land, which is about 15.2 % of the total agricultural area: There are a total of 5,818 registered operators, including 4785 organic farmers. The number of organic farms has increased significantly: from

3 farms in 1990 to 4785 farms in 2021. The main crops are cereals, root crops, industrial crops, oilseeds, aromatic plants, fresh vegetables and fodder. For example, organic arable land covers 88,628 hectares, with significant production of grain cereals, soft wheat, spelt, rye, barley, oats, triticale, and more. The Czech Republic has been a leader in organic farming among the new EU members, and it is encouraging to see the growth and commitment to sustainable practices (Figure 6).

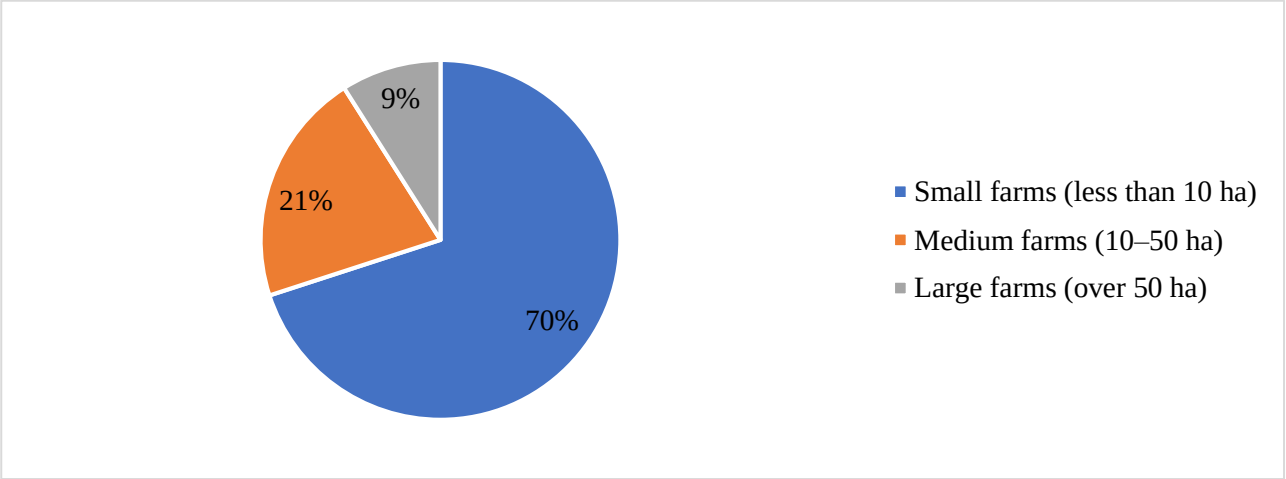

Figure 6. Distribution of organic farms by size in the Czech Republic

Source: built based on data from Czech Statistical Office (2024).

In summary, the need to promote innovation in Lithuanian small and medium-sized agriculture can be justified by economic and environmental impact indicators. The analysis of economic indicators shows that although Lithuanian agricultural production has increased by 30.4 % since 2015, agricultural productivity, yields and profitability have decreased, which reduces the potential of Lithuanian farmers to reinvest in innovation. Moreover, Lithuania's performance in the EU context shows that its farms are not catching up with the Community average for agriculture. In the Czech Republic, agricultural yields have risen thanks to the contribution of large farms. And it has become a leader in the EU. The assessment of the environmental perspective of agriculture is limited. Official statistics provide only a few indicators that allow a partial assessment of the development of more environmentally friendly agriculture. The indicators show that in Lithuania, in contrast to the Czech Republic, the number of organic farms has decreased, but the volume of many of the most important types of organic production has increased.

4.2. Assessing the need to promote innovation in small and medium-sized agriculture from an expert perspective. The need to promote agricultural innovation is assessed based on expert interviews. All experts recognised the importance of agricultural innovation. Expert E2 stated that Lithuanian agriculture can be competitive only through innovation. The experts tended to have a positive view of innovation in Lithuanian agriculture, noting an increase in the number of innovative farmers (E1, E2, E3; E5) and an increase in the availability of innovations on farms (E2). At the same time, however, the experts note that innovation on Lithuanian farms lags in the EU context (E2). According to expert E4, only a small proportion of farms introduce new technologies into their work processes (Table 2).

Agricultural innovation is essential for the survival and competitiveness of small and large farms in the Czech Republic, as it increases productivity and sustainability. While larger operators (F4, F5) may have more resources to adopt new technologies, smaller farms (F1, F2, F3) can benefit from simpler, low-cost innovations. The country has made significant progress in supporting agricultural innovation and integrating digital tools, but there is a need for continued investment in research, development, education and training. Continued focus on these areas will allow the Czech Republic to position itself as a leader in agricultural technology and ensure the future growth of its agricultural sector.

Table 2

Assessment of the innovativeness of agriculture in Lithuania and the Czech Republic and problematic aspects

Subject	Subtitle	Interviewed expert
Positive evaluation	Farmers' engagement in innovation	"Farmers' interest in innovation is growing every year. Information is beings ought, and experiences are being actively shared" (E1); "In Lithuania, we have seen significant progress in the last 5 years, with farmers' commitment to innovation increasing"(E2); "Our farmers are becoming competitive through innovation" (E3); "Experience shows that more and more farms are choosing to innovate in their operations" (E5). (F1) "I see a trend towards precision agriculture, which is becoming accessible even for smaller farm…" (F2) "I see a growing interest in agri-tech solutions. These innovations can significantly enhance efficiency and profitability for medium-sized farms like ours". (F5) "I see agricultural innovation as a key driver for future growth"
	Increasing access to innovation	"...the innovations themselves are becoming more affordable in financial terms (e.g. sensors, automatic irrigation systems" (E2)
Problematic aspects of innovati-veness in agriculture	Slow innovation process	"...in Lithuania, only a small number of farmers are still innovating on their farms, so it is difficult to identify trends, but there is a noticeable introduction of new technologies in to the work process" (E4); "...no tall farmers are interested in innovation and new opportunities" (E3). "Overlooks the specific needs of small and medium-sized farmers, because practical realities or financial capabilities" (F1)
	Financial capabilities of small, medium-sized farmers	"While there are some effective programs, they do not always align with the practical realities and financial capabilities of medium-sized farmers, who require additional support in navigating innovation. A more inclusive approach is needed that addresses the unique circumstances of all farms, particularly in terms of training and resource allocation" (F3)
	Anxiety about the future	"...recently, farmers are beginning to hesitate about whether it is a good time to invest in innovation, as a potential crisis is approaching and the 'financial assistance' needs to be preserved. However, with the price of raw materials and energy resources rising, it is very important to innovate" (E3)

Source: compiled by authors.

According to the E3 expert, the threat of the financial crisis is increasing doubts about innovation, as farmers feel anxious and tend to cut back and disinvest. However, with the rising cost of raw materials and energy resources, innovation is crucial. According to the F3 expert, innovation programs do not always match the practical realities and financial capabilities of medium-sized farmers, who need additional support in navigating innovation. A more comprehensive approach is needed that addresses the unique circumstances of all farms, particularly in terms of training and resource allocation.

In assessing the Lithuanian agricultural innovation system, the experts found that there is sufficient access to innovation support (E1, E2, E5), training and seminars (E1, E4). However, they noted and highlighted problematic aspects of innovation support. Expert E2 noted that there is not enough funding available. It is important that farmers have access to financial incentives. Experts E1 and E2 stated that the financing systems are too complex for many farmers.

The assessment of the Czech Republic's agricultural innovation system reveals several significant trends and impacts across different types of innovation. Precision agriculture is gaining traction and becoming more accessible to smaller farms through shared resources and cooperatives, thus optimising input use and minimising waste (F1). Growing interest in agri-tech solutions, particularly data analytics for yield forecasting and smart irrigation systems, is improving operational efficiency, particularly for mid-sized farms. (F2) In addition, the use of automation and robotics (F3) is addressing pressing labor shortages and increasing productivity in the sector. Product innovation, particularly in seed technology and crop protection (F4, F5). The transition to sustainable practices, including precision agriculture and bioengineering, is in line with global market demands for sustainability, making these approaches economically relevant. Finally, the integration of digital technologies and the Internet of Things (F5) is expected to lead to better resource management and increased yields, marking a transformative change in the agricultural landscape (Table 3).

Table 3

Assessment of the innovation promotion system in Lithuania and the Czech Republic and problematic aspects

Subject	Subtitle	Interviewed expert
1	2	3
Positive assessment of agricultural innovation system in the country	Financial support available	"I am positive. Funding is available" (E1); "Financial support is available for businesses to encourage farmers to innovate on their farms. If the idea is good and has a good enough basis to bring economic benefits to Lithuania, financial support is available for small farms" (E2); "...I see a lot of interesting and useful projects for Lithuanian farmers to encourage innovation in agriculture" (E5)
	Available training/workshops	"...seminars and training that are accessible to small farmers" (E1); "events that are open to both new farmers and those who have been in the field for many years" (E4); "...conferences and seminars that inspire, encourage innovation and improve the work process" (E5)

Continuation of Table 3

1	2	3
Problematic aspects of promoting innovation	Complex incentive mechanism/abundance of information	"...for some reason, small farms are not making the most of their opportunities. Institutions, projects... It's too complicated for most of them" (E1); "And we need to help farmers not to get lost in the wealth of information. In this day and age, there are so many opportunities to improve farming that sometimes farmers don't know where to start" (E2)
	Lack of information	"...our farmers are a little reluctant to do this, let's say they listen to the seminar material, but then they still want to research it, weigh it, understand it themselves. But there is not much reliable information, especially in English. Of course, the language barrier plays a role..." (E4)
	Neglects small-medium sized farms	The existing promotional efforts for agricultural innovation tend to overlook the specific needs of small and medium-sized farmers (F1, F2, F3)

Source: compiled by authors.

During the interviews, the experts also assessed the potential for promoting innovation in Lithuanian and Czech small and medium-sized agriculture. Three experts (E1, F1 and E3) stated that more personalised advice should be provided. Expert E3 stated that personal advice is very important because "there are so many directions of innovation nowadays, it is important that farmers choose the innovation that best meets the needs of their farm". But on the other hand, there are not that many experts who can give really good quality personalised advice. Farmers are left to figure out what to use and how to use it, but the abundance of innovations leads to some confusion. Informant E1 also said that there is a need to strengthen the farming community so that farmers can share their experience not only in innovation but also in using financial mechanisms. Expert E4 believes that more emphasis should be placed on promoting organisational innovation, as this would help to exploit the need for farm specialisation and niche products. Expert E5 believes that the most important thing is to improve communication, not only by increasing it, but also by providing more information in "plain language". F5 noted the need for a more inclusive approach that considers the unique circumstances of all farms, particularly in terms of training and resource allocation. To increase effectiveness, direct support for implementation should be prioritised, especially for smaller and medium-sized farms (Table 4).

Czech farmers suggest that tailored support and training programs are essential to address the unique challenges faced by small farmers. They advocate more accessible subsidies and better cooperation between government agencies and agricultural organisations to increase awareness of and access to innovative practices. Financial incentives for mid-sized farms and mentorship programs linking larger and smaller farms are also seen as beneficial. Similarly, Lithuanian farmers emphasise the need for social and institutional measures to promote innovation in small and medium-sized farms. They stress the importance of increased access to distance learning, as travel can be a challenge for small farmers. Experts also stress the need for critical evaluation

of innovations to help farmers make informed choices rather than blindly adopting foreign practices. They note that negative experiences with innovation can reduce farmers' willingness to innovate in the future, underscoring the need for a more thoughtful approach to introducing new agricultural practices.

Table 4

Improving the system of promoting innovation in small and medium-sized agriculture in Lithuania and the Czech Republic as assessed by experts

Subject	Subtopics	Excerpts from interviews
Possibilities for improving the system of innovation support in small and medium-sized agriculture	Personal consultations	"More personal advice should be given" (E1); "...If possible, I would like to see more personal advice given to farmers" (E3)
	Fostering organisational innovation	"I would also encourage more focus on organisational innovation. Today, consumers are looking for niche products and are interested in buying directly from farms. Farm specialisation and direct sales are on the rise, but this is far from being a fully exploited niche" (E4). (F2) medium-sized farmers, who require additional support in navigating innovation.
	Strengthening farming communities	"...there is a lack of strong communities to share experiences in both innovation and the use of financial mechanisms" (E1)
	Improving communication	"In Lithuania, there are many elderly farmers who find innovations difficult to understand and access, and if they could be provided with information in a "language they can understand", it would be a great incentive to innovate" (E5)
	A wealth of information	"I would get information about innovation in Lithuanian. I would like to see more information on innovation. A farmer needs to invest, he/she needs to weigh the benefits of an innovation from all sides" (E4, F3, F4)
	Critical innovation assessment	"We also need more innovation experts who can critically assess innovation. There is no point in copying the experience of foreign farmers and adopting everything they do. It is precisely because of this approach, where there is no real selection of innovations, that we end up with an innovation that disappoints the farmer. He/she will be much less likely to be interested in other innovations later" (E4)
	Distance training	"More free, remote training so that farmers can attend at their convenience. It must be understood that it is problematic for farmers to leave their farms, especially small farmers who do not have a large labour force" (E1)
	Holistic approach	A more inclusive approach is needed that addresses the unique circumstances of all farms, particularly in terms of training and resource allocation. To enhance effectiveness, direct support for implementation should be prioritised, especially for smaller and medium-sized operations (F5)

Source: compiled by authors.

After the interviews, the experts were asked additional questions. The experts were asked what could encourage farmers to become more involved in science integration and cluster activities. For Lithuanian farmers, Expert E1 noted that only

those already advanced in innovation could participate, suggesting that promoting interest in simpler, less innovative activities could be a first step. However, Expert E4 recommended organising farmers into communities based on specialisation to increase their participation. Czech farmer F1 highlighted the challenges of the funding application process and advocated simplification measures. Suggestions included reducing documentation requirements, providing clear, user-friendly guidelines, and using online platforms for submissions. Experts F2, F3, F5 offered that simplifying funding application processes and improving collaborative efforts for information sharing, such as regional innovation hubs and digital platforms, can further empower farmers and encourage greater participation in innovative practices, ultimately positioning the Czech Republic as a leader in agricultural technology.

A supplementary question also revealed the experts' views on how to improve the system for applying for innovation funding. Both Lithuanian and Czech farmers face challenges in accessing innovation funding, but experts in each country propose tailored solutions to improve the application process and information exchange. In Lithuania, experts emphasise the need for clearer information on funding criteria and application stages, rather than just simplifying the application process. They advocate increasing the availability of personalised advice and more comprehensive examples to guide farmers through the application process. Some experts suggest that the descriptions of the criteria should be revised to remove complex terminology, as many farmers find it difficult to complete applications without the help of a consultant. In the Czech Republic, local agricultural cooperatives play a crucial role in improving the exchange of information among farmers. They recommend holding regular workshops and community meetings to keep farmers informed about innovations and funding opportunities. The creation of digital platforms for sharing success stories and regional innovation hubs would facilitate knowledge sharing and networking. In addition, a comprehensive online portal that consolidates information on funding and best practices, as well as planned regional forums and webinars, would further improve communication and encourage broader participation among farmers. Both countries highlight the importance of clear communication, accessible resources, and community engagement to help farmers effectively navigate the innovation funding landscape.

In both Lithuania and the Czech Republic, there is a pressing need for customised support systems that address the unique challenges faced by small and medium-sized farmers. In the Czech Republic, farmers advocate for more accessible subsidies and streamlined cooperation between government agencies and agricultural organisations to raise awareness of innovative practices. Financial incentives for mid-sized farms and mentorship programs linking larger farms with smaller ones could serve as vital mechanisms to foster collaboration and knowledge transfer. Lithuanian farmers have emphasised the necessity for social and institutional measures that enhance access to education and innovation, particularly through distance learning initiatives. By critically evaluating innovations rather than adopting foreign practices blindly, farmers can make informed decisions that cater to their specific circumstances, thereby increasing their willingness to embrace new agricultural methods. To further encourage

farmer participation in innovation funding and science integration, both countries could benefit from simplifying the application processes and improving information exchange. The establishment of strong networks facilitating knowledge-sharing among farmers, agricultural experts, and researchers is also recommended.

Such networks would help identify and address the unique challenges faced by small and medium-sized farms. Furthermore, both countries could benefit from fostering partnerships between universities, research institutions, and the agricultural sector to promote applied research that directly addresses the needs of farmers. This would lead to the development of tailored solutions that enhance productivity and sustainability. In addition, promoting access to modern technologies and digital tools can empower farmers to adopt innovative practices. Government initiatives that subsidise the acquisition of new technologies or provide grants for technological upgrades could significantly impact farm efficiency and competitiveness.

It is imperative to underscore the significance of sustainability in agricultural practices. The implementation of eco-friendly practices through educational initiatives and incentives has been demonstrated to be advantageous for farmers and contributes to broader objectives of environmental protection and climate resilience.

5. DISCUSSION

To summarise the results of the study, it is important to note that agricultural productivity in Lithuania has significant long-term variability compared to the Czech Republic and the EU average. To ensure the adequate provision of food to meet the growing needs of the population, it is essential to prioritise long-term productivity improvements.

In the Czech Republic, smaller producers face challenges due to scale effects, which limit their competitiveness. Large farms should prioritise technological advancement, while small farmers should concentrate on expanding their operations and enhancing technical efficiency. This will promote new cost-saving methods and innovation, enabling them to effectively compete in the long term.

An analysis of survey data reveals that, with the exception of 2020, the net profitability of agricultural units in Lithuania was consistently lower than in 2015, while in the Czech Republic it exhibited an increase. In Lithuania, a substantial surge in net profitability of 263.6 % was witnessed in 2022, largely attributable to the repercussions of the pandemic. In contrast, the Czech Republic maintained its upward trend in 2022 and 2023, with net profitability peaking at 18.3 % in 2022. This growth can be attributed to increased investment in technology and sustainable practices, improved export opportunities, and a strategic focus on higher value agricultural products. Consequently, the evolution of net profitability for agricultural entities mirrors the necessity for innovation and the constrained capacity to invest in such innovations.

The interviews with Lithuanian and Czech experts revealed both similarities and differences in their perspectives on agricultural innovation. Both country groups agree on the key role of innovation for the sustainability and competitiveness of farms and

emphasise the need for tailored support and training programs, especially for small and medium-sized farms. Lithuanian experts have observed an increase in farmers' engagement with and access to innovation. However, they are concerned about slow adoption rates and complex financing mechanisms that do not match the financial realities of many farmers. In contrast, Czech experts highlight significant progress in agricultural innovation and access to digital tools, while stressing the need for continued investment in research and development, especially for small and medium-sized farms. Furthermore, while Lithuanian experts emphasise the need for tailored advice and community building to navigate innovation, Czech experts advocate for simplified funding application processes and increased cooperation between government and agricultural organisations. Overall, both groups emphasise the importance of transparent communication and robust support systems to foster an enabling environment for agricultural innovation, albeit with a different emphasis on specific challenges and solutions.

According to Lithuanian and Czech experts, innovation is pivotal for enhancing the sustainability and competitiveness of agricultural operations. This assertion is consistent with the findings of Baležentis & Štreimikaitė (2015), who discuss the critical role of efficiency and productivity in Lithuanian agriculture. Similarly, Čechura et al. (2022) explore the importance of innovation in driving productivity and efficiency in Czech farms, emphasising that farm size can influence the adoption of innovative practices. Consequently, both nations acknowledge the imperative of fostering agricultural innovation to sustain a robust agricultural sector that can meet domestic and international demands. Notwithstanding this common recognition, Lithuanian and Czech experts identify unique challenges that impede the effective implementation of innovative practices. Lithuanian respondents often point to constrained access to funding and financial support as substantial impediments. They argue that smaller farms, which predominate in the Lithuanian agricultural landscape, encounter difficulties in obtaining the necessary investments for adopting new technologies or practices. This concern is in line with the work of Baležentis & Štreimikaitė (2015), who highlight the financial constraints faced by many Lithuanian farmers.

In contrast, Czech experts frequently point to regulatory hurdles and bureaucratic inefficiencies as the primary obstacles to innovation, arguing that overly complex regulations can stifle creativity and slow down the adoption of new technologies. To further stimulate agricultural innovation, experts from both Lithuania and the Czech Republic underscore the importance of cultivating a culture that embraces change and experimentation. This culture of innovation can be cultivated through various initiatives, such as encouraging young entrepreneurs in agriculture, supporting start-ups focused on agri-tech, and promoting research projects that aim to solve real-world farming challenges. Both Lithuanian and Czech experts underscore the critical importance of innovation in enhancing the sustainability and competitiveness of farms, particularly small and medium-sized enterprises (SMEs). This perspective is consistent with the conclusions of Heisey & Fuglie (2018), who emphasise that agricultural

research and policy reform are pivotal for stimulating innovation in high-income countries. Their analysis underscores that targeted investment in research can substantially influence the adoption of new technologies, a finding that aligns with the insights of Lithuanian experts on the significance of customised support and training programs.

It is noteworthy that while both groups acknowledge the role of innovation, Lithuanian experts express concern about the slow adoption rates of new technologies, which they attribute to complex financing mechanisms that do not align with the financial capabilities of SMEs. This sentiment resonates with the concerns raised by other studies, such as those by Rijswijk et al. (2020), who point out that bureaucratic barriers and complicated funding processes can hinder innovation uptake among smaller agricultural enterprises. Conversely, Czech experts evince a more optimistic outlook on the adoption of innovative practices, attributing this to a supportive policy framework and access to EU funding. This discrepancy in perspectives may be indicative of differing national contexts or varying levels of government support, underscoring the necessity for customised approaches to foster innovation across diverse agricultural landscapes.

6. CONCLUSIONS

The concept of innovation is defined by the criteria of novelty and improvement. Only those innovations that have a positive impact on the performance of the enterprise can be considered innovations. There are 4 main groups of innovations in the agricultural sector: product, process, marketing and organisational innovations. Agricultural innovativeness is characterised by quantitative criteria (number of innovative farms) and qualitative indicators (type of innovation, level of involvement in innovative activities). The importance of innovation in this sector is justified by its impact on farm competitiveness, productivity, product quality, sustainability and the creation of higher value added.

Innovation in agriculture was found to be driven by growing consumer demands, environmental requirements and increasing competitiveness. However, the ability and choice of agriculture to innovate is influenced by several factors that can be grouped under the headings of innovation and farm characteristics, economic and financial factors, and social and institutional factors.

The need to promote innovation in small and medium-sized agriculture is supported by economic indicators. The main indicators of the need for additional innovation in small and medium-sized agriculture are the lack of productivity growth and low profitability of Lithuanian agriculture since 2015. Lithuania's performance in the EU context shows that the country's farms are not catching up with the EU agricultural average. There is a lack of statistical data on innovation by small and medium-sized farms and on the environmental dimension of innovation.

The qualitative research shows that the innovativeness of small and medium-sized farms is increasing, but farmers face difficulties in accessing financial support for innovation and in finding information on innovation. Lithuanian and Czech experts

agree on the importance of agricultural innovation for sustainability and competitiveness, especially for small and medium-sized farms, and stress the need for tailored support and training. However, they differ in their focus, with Lithuanian experts concerned about slow adoption and complex funding, while Czech experts emphasise advances in digital tools and the need for streamlined funding processes and collaboration.

The study identifies several key differences in innovation performance between Lithuania and the Czech Republic. These differences are evident in innovation rates, with a notable disparity in the adoption of new technologies. While a limited number of farms in Lithuania are integrating new technologies into their operations, the Czech Republic has witnessed a consistent and notable increase in the number of organic farms from 2015 to 2023. Additionally, the analysis of investments and financial support reveals contrasting patterns. In Lithuania, farmers encounter challenges in accessing financial support for innovation and obtaining information on innovation, while the Czech Republic has made substantial progress in supporting agricultural innovation and integrating digital tools. In Lithuania, there is a need to prioritise the promotion of organisational innovation to leverage the demand for farm specialisation and niche products. In contrast, in the Czech Republic, precision farming is gaining traction and becoming more accessible to smaller farms through shared resources and cooperatives. Considering the study's findings, we have proposed our recommendations on fostering innovation in Lithuania and the Czech Republic. Specifically, we recommend providing farmers with more personalised advice, enabling them to choose the most appropriate innovations for their specific circumstances. Furthermore, the development of robust farmer communities, where members can exchange experiences and best practices regarding innovation and financial mechanisms, is crucial. Simplified funding application processes and intuitive e-systems would facilitate this exchange. To enhance innovation accessibility, there is a need to augment the availability of training and seminars, particularly in local languages. Seminars should provide a wide range of information, prioritising detailed presentations on incentive mechanisms and assistance in filling out funding applications.

7. LIMITATIONS AND FUTURE RESEARCH

The present study provides valuable insights into agricultural innovation in Lithuania and the Czech Republic. However, it also has limitations that should be considered in future research. A major drawback is the use of qualitative interviews, which provide depth but may not fully capture the range of perspectives of different agricultural stakeholders, especially small farmers, who may be underrepresented. In addition, the quantitative data used to analyse agricultural productivity and innovation levels may lack the level of detail needed to draw meaningful conclusions about specific types of farms or regions within each country. Furthermore, the rapidly changing nature of agricultural innovation means that findings may quickly become outdated as new technologies and practices emerge. It would be beneficial for future

research to include a broader range of stakeholders, including smaller farms and emerging agricultural entrepreneurs, to gain a more comprehensive understanding of the barriers and enablers to innovation. Longitudinal studies could also provide insights into changes in agricultural practices over time and the impact of different support mechanisms. In addition, an examination of the role of digital platforms and cooperative models in facilitating access to innovation could provide valuable guidance on how to increase agricultural productivity in a sustainable way. Finally, comparative studies with other EU countries facing similar challenges could enrich the discourse on agricultural innovation and inform policy decisions aimed at promoting sustainable agricultural practices across the region.

The use of the Total Factor Productivity (TFP) index and other indicators, such as net profitability, as measures of innovation implementation, is subject to certain limitations. TFP and net profitability do not directly measure innovation, but outcomes may arise from innovation. This may result in an incomplete understanding of the innovation process. Additionally, external factors such as market fluctuations, weather patterns, and policy changes may influence these indicators, though their direct relation to innovation may not be apparent. To enhance the comprehensiveness of the assessment, it would be advisable to incorporate direct innovation indicators such as the number of new technology deployments, the extent of research and development, and investment in innovation. These would provide a more accurate and comprehensive picture of the implementation of innovation.

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