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Exploring Barriers to Technology Adoption in Livestock Farming: A Descriptive Comparative Analysis Between Finland, Germany, and Albania

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Abstract: *Ongoing developments in digital technologies have been the major driving force for improving productivity and sustainability in livestock farming, leading toward higher economic profits, increased safety standards, and mitigating the impacts of climate change. This paper provides insights into the implications related to the implementation of digital technologies in livestock farming. Through a quantitative survey were investigated the challenges of adoption, similarities, and differences among selected farmers in the regions of Northern Savonia (Finland), Baden Wurttemberg (Germany), and Korça (Albania). In Finland and Germany, the survey was conducted online; while in Albania farmers were contacted face-to-face through a structured questionnaire. A total of 166 participants' observations were documented. The results show a low adoption rate for automated feeding systems, drones for data collection, and GPS for traceability in Finland and Germany. In Albania prevails a low rate of adoption almost in all types of defined technologies. Farmers in three countries indicated uniformly high investment costs and costs of maintenance services as important barriers to not using digital technologies. Differently from their counterparts, farmers in Albania identified the insufficiency of subsidies, lack of strategies to promote digitalization, poor data infrastructure (connectivity), and lack of skills and knowledge to run digital technologies as other significant barriers to adoption. Furthermore, a consistent policy framework that addresses the individual needs of farmers in the respective countries, provides adequate incentives and information and involves stakeholders is critical for determining the most efficient ways of digitization in livestock production.*

1. INTRODUCTION

Modernizing livestock farming through digitalization involves incorporating sensors, drones, robots, and other technologies to improve animal welfare and productivity (Groher et al., 2020).

Due to the increasing utilization of digital technology, there has been an acceleration of research over the last years concerning adoption rates at the farm level. The array of research on the adoption and effects of digital agriculture in OECD nations shows that digital technologies are widely used in crop agriculture. However, less is known about how these technologies are being adopted in livestock farming. Regarding this matter, Barkema et al. (2015) observed that adoption rates of milking robots range significantly among different countries, with adoption rates in Finland and Germany hovering around 15%. Subsequent studies by Gabriel and Gandorfer (2023) and Pfeiffer et al. (2021) suggest that the adoption of various digital technologies such as robots, digital information platforms, sensors, and FMIS is rapidly increasing and already playing a significant role in agriculture and livestock farming in several European countries.

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Only a few studies have provided evidence regarding the factors that drive or inhibit digitalization in livestock farming. McFadden et al. (2022) identified several factors that affect the adoption of precision agriculture technologies at the farm level, including investment costs, lack of relevance for the farms, lack of human capital, imbalance in costs and benefits in vertically integrated chains, uncertain intellectual property rights, and lack of broadband connectivity. Similarly, Pierpaoli et al. (2013) conducted a systematic literature review providing evidence that the most important factors influencing the adoption of precision agriculture technologies were farm size, costs, higher revenues to acquire a positive benefit/cost ratio, total income, land tenure, farmers' education, familiarity with computers, and access to information via extension services.

Even though the digitalization of agriculture is considered important for the agricultural transformation in the Western Balkans (Edmeades & Edinaldo, 2018), the adoption of digital technologies is notably limited. In Albania, there is limited technological advancement in livestock farming (Marku et al., 2024). Even though there is substantial potential for the implementation of digitalization, especially in large-scale farms, rates of adoption remain unclear. To address the challenges related to the adoption of digital technology, it is important to identify the barriers that hinder implementation progress. However, the ability of digital technologies to support the sustainable growth of livestock farming is dependent on the specific circumstances in each country where they are implemented. Hence, in this study small-medium size livestock farms were investigated in the regions of North Savo (Finland), Baden-Wurttemberg (Germany), and large livestock farms in Korça (Albania), to provide evidence on the status of digitalization, identify constraints to adoption and analyzing similarities and differences between countries. The findings can serve as an initial step for farmers and policymakers in Albania (a country that aspires to enter the EU) to overcome barriers to adoption.

2. MATERIAL AND METHODS

This research presents the findings of the empirical study conducted in three nations, two member states of the EU, and one non-EU country. The target population of the survey consisted of livestock farms (mainly dairy, beef, pig, sheep, and goats) located in three distinct regions: Northern Savonia, known for its high-quality livestock farming in Finland; Baden-Wuertemberg, a predominantly rural state in Germany; and Korça region, where livestock production has a significant role in the development of the local and national economy.

A structured questionnaire was designed and delivered to farmers, comprising a wide range of questions organized into two sections. The first section contained questions related to demographic information (age, experience, education, employed workforce, type of livestock, and farm size). The questions in this part were tailored to farmers in the three nations. The second set of questions assessed the degree of adoption of digital technologies, their potential for use in the future, and the obstacles to their implementation at the farm level. The questionnaire was translated into each country's local language, and data was collected between November 2023 and February 2024. The questionnaire was distributed online in Germany and Finland, while in-person interviews were conducted in Albania to collect data.

Different aspects of digitalization in livestock farms and their characteristics are described and compared across three countries using a descriptive comparative approach. The description of phenomena associated with a subject population (in our case, livestock farms), estimating the proportions of a population that has these characteristics, and establishing associations between

variables are among the many research objectives that are attained by descriptive studies, according to Donald and Pamela (2014). To acquire knowledge and make inferences, our study's objective is to examine and comprehend the similarities and differences regarding implementation constraints. Analysis of 165 questionnaires was conducted, with 64 from Germany, 34 from Finland, and 37 from Albania. Due to disparities in farm sizes between the three countries, small- to medium-sized livestock farms in Germany and Finland participated in the study, whereas in Albania were considered only large-scale farms.

3. RESULTS

3.1. Adoption Trends of Digitalization and Prospective Uses in Livestock Farming

The digitalization of livestock farms holds significant potential for enhancing animal health, optimizing resource utilization, and promoting sustainable practices. This potential is attributed to recent technological advancements in big data analytics, artificial intelligence, and the Internet of Things (IoT) (Vlaicu et al., 2024). This section provides a critical review of the current use and future potential for investing in the digitalization of livestock farms in the selected survey countries. Based on a selected list of technologies, obtained through a literature review, the participating farmers were asked to indicate their current use or planned investment in digitalization. Accordingly, the primary categories of digital technologies that can be used in livestock farming include robots (milking robots, barn observations), sensors, farm management and information systems (FMIS), online platforms, mobile apps, automated feeding systems, drones, and GPS for traceability and data collection. Figure 1 indicates the current use of digital technologies in the selected farms.

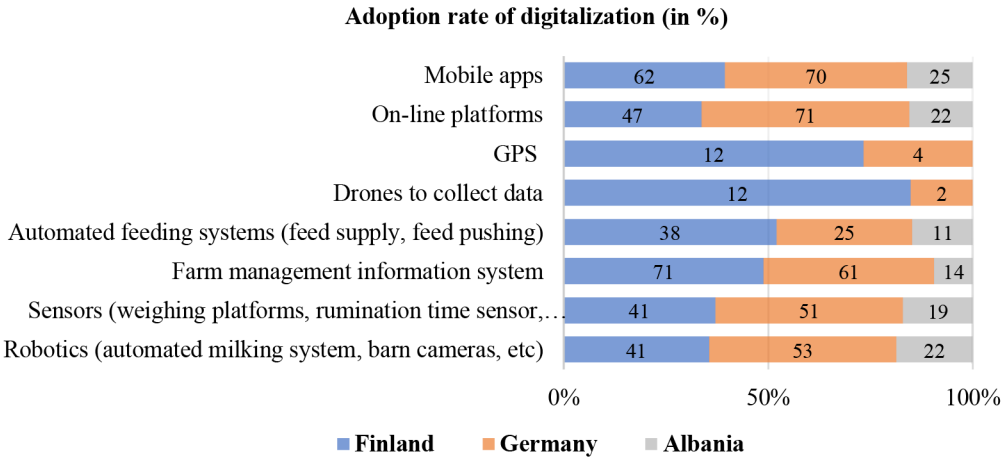

Figure 1. Current adoption rate of digital technologies in livestock farms
Source: Authors processing

The adoption of digital technologies varied slightly among farmers in Finland and Germany. There were significant differences in the adoption rates compared to farmers in Albania. The most commonly used digital tools in Germany and Finland were online platforms, mobile apps, and FMIS, indicating that digital platforms, regardless of farm size, enhance the opportunity to have a better link with customers, thereby facilitating market access. German farmers have higher rates of adoption for online platforms (71%), mobile apps (70%), robotics (53%), and sensors (51%). Finnish farmers are better at implementing FMIS (71%) and automated feeding systems (38%). The implementation rate ranges from 40% to 70% in both countries, showing an increasing trend

as reported in previous and recent studies (De Koning, 2010; Stygar et al., 2021; Utriainen et al., 2019). In Finland and Germany, the use of GPS and drones for data collection was not very common, and in Albania, these technologies were not utilized at all (see Figure 1). The most commonly used digital tools among Albanian farmers were mobile apps (25%), automated milking systems (22%), and online platforms (22%).

Although there is a clear trend of increasing digitalization at the farm gate, there is still limited information available for potential future investments. Therefore, besides the current adoption level, farmers were asked about their intention to invest in selected categories of digital technologies in the mid-term (planned investments in the next 5 years). The anticipated frequencies of future addition technologies are displayed in Figure 2. Finnish farmers are more willing to use digital tools, with a range of 12% to 24%. Drones (24%) are the most popular technology among them, followed by sensors (21%) and GPS (21%). German farmers also intend to use technology more extensively, particularly mobile apps (12%), robots (13%), and automated feeding systems (15%).

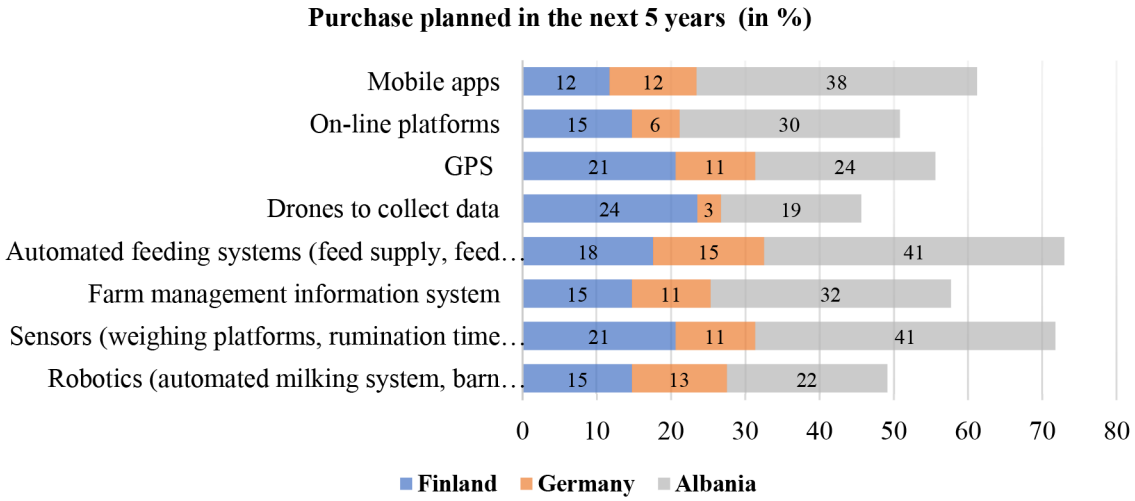

Figure 2. Projected investments in digitalization for the medium-term period.
Source: Authors processing

Despite Albania's relatively low current usage of digital technologies, the statistics from Figures 1 and 2 show that farmers have a strong ambition to invest in these technologies within the next five years. This implies that Albania's livestock industry has a great chance of gradually going digital.

The survey data from farmers includes information on the adoption of digital technologies at different periods in time. This covers current use, planned investments in the next 5 years, and trends for technologies not planned for at least the next five years. According to the results provided in Figure 3, Finnish farms have low adoption rates for automated milking and feeding systems (44% non-adoption rate), drones (65%), and GPS for traceability (68%). Similarly in Germany, a large number of farmers do not plan to use drones (95%), GPS (85%), automated feeding systems (61%), and sensors (38%) in the next five years. In Albania, over 50% of the surveyed farmers indicated that they do not intend to invest in digitalization in the next five years.

Though digital technology adoption varies by nation and is currently at a promising stage of development, with European countries such as France, Germany, and the Netherlands leading the way toward digitalization (Abiri et al., 2023), future investments will need to address the existing barriers to ensure equitable access and optimize the benefits of digitalization across the livestock farming context.

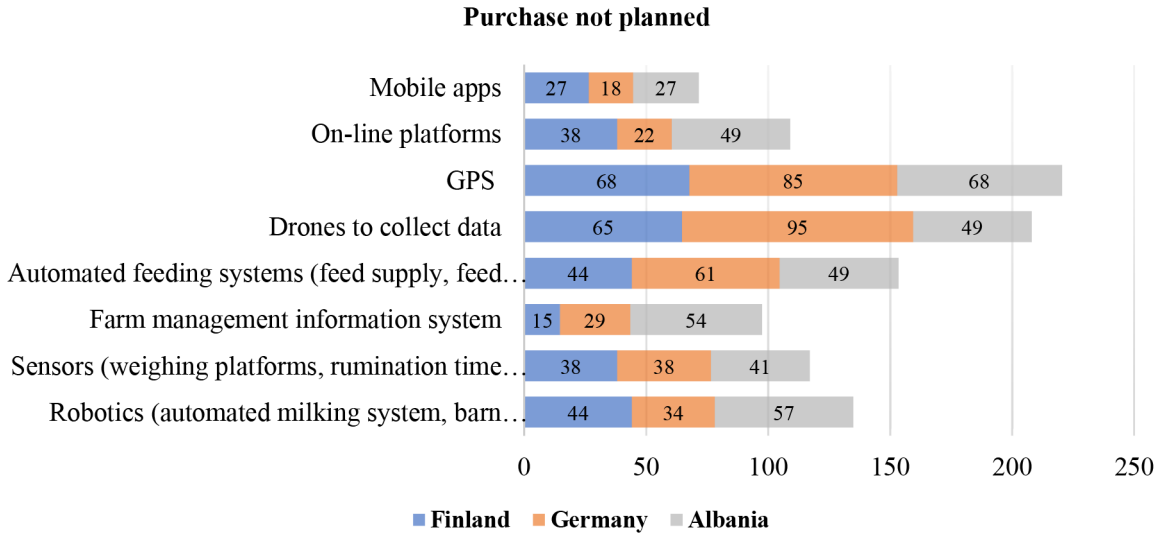

Figure 3. Non-adoption rate of digital technologies (at least the next five years)
Source: Authors processing

3.2. Identified Constraints to Digitalization

The discussion in this section covers the main obstacles to farmer's adoption in the three nations. In a specific questionnaire session, livestock farmers from three countries were asked to provide their opinions using specific statements organized on a Likert rating scale. The statements were related to the main constraints that prevent them from investing in digital technologies on their farms. The data in Table 1, report the selected barriers by Finnish farmers preventing them from adopting digital tools at the farm level. The most prevalent factors that play a particular role and add to the complexity of investing in digitalization are those related to economic and financial conditions. Specifically, 94% of the farmers mentioned the initial investment cost, while 85% cited high maintenance expenses.

Table 1. Constraints to digital technology adoption in Finnish livestock farms

Constraints	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Farm size	11.8	32.4	8.8	38.2	8.8
Farm ownership (own compared to rented)	18.2	15.2	51.5	12.1	3
High investment costs	0	2.9	2.9	70.6	23.5
High costs of maintenance services	0	5.9	8.8	70.6	14.7
Specialization in specific farm/business type	8.8	32.4	23.5	29.4	5.9
Relevance of digital tools to farm/business	5.9	23.5	23.5	41.2	5.9
Farmers age	11.8	32.4	11.8	23.5	20.6
Lack of knowledge and skills to run digital technologies	2.9	23.5	17.6	47.1	8.8
Lack of information on benefits	5.9	14.7	41.2	32.4	5.9
Poor data infrastructure (connectivity, internet)	5.9	38.2	11.8	23.5	20.6
Lack of adequate strategies to promote digitalization	3	36.4	42.4	6.1	12.1
Insufficient state subsidies for supporting investments in digital technology	0	20.6	52.9	20.6	5.9

Source: Authors processing

Additionally, according to the farmers' responses presented in Table 1, lack of knowledge and skills to run digital technologies, the relevance of application at the farm type, farm size, farmer's age, and poor connectivity are among the factors considered in the process of adopting digital technologies by Finnish farmers.

German farmers share similar opinions with their Finnish counterparts, citing costs as the single most significant constraint, implying that current technologies are prohibitively expensive. According to the data in Table 2, 75% of farmers in Baden-Wurttemberg, Germany, identified investment costs as the most significant obstacle to adoption, while 69% indicated high maintenance costs.

Table 2. Constraints to digital technology adoption in German livestock farms

Constraints	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Farm size	2.2	20.4	32.3	34.4	10.8
Farm ownership (own compared to rented)	3.2	25.8	46.2	18.3	6.5
High investment costs	3.2	4.3	17.2	50.5	24.7
High costs of maintenance services	3.2	5.4	22.6	49.5	19.4
Specialization in specific farm/business type	4.3	21.5	55.9	14	4.3
Relevance of digital tools to farm/business	4.3	11.8	48.4	32.3	3.2
Farmers age	14	35.5	24.7	16.1	9.7
Lack of knowledge and skills to run digital technologies	10.8	39.8	29	16.1	4.3
Lack of information on benefits	8.6	43	35.5	6.5	6.5
Poor data infrastructure (connectivity, internet)	6.5	25.8	20.4	31.2	16.1
Lack of adequate strategies to promote digitalization	3.2	18.3	44.1	28	6.5
Insufficient state subsidies for supporting investments in digital technology	6.5	10.8	38.7	31.2	12.9

Source: Authors processing

Other factors mentioned by German farmers included poor data infrastructure (47%), insufficient governmental subsidies (44%) to encourage investments in digital technology, and farm size. Compared to Finnish farmers, only 20% of them indicated a lack of knowledge and ability to operate digital technologies.

Table 3. Constraints to digital technology adoption in Albanian livestock farms

Constraints	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Farm size	2.7	5.4	29.7	43.2	18.9
Farm ownership (own compared to rented)	2.7	13.5	35.1	40.5	8.1
High investment costs	2.7	0	10.8	62.2	24.3
Lack of cooperation/farm associations	0	5.4	10.8	48.6	35.1
High costs of maintenance services	2.7	2.7	10.8	54.1	29.7
Low level of education	11.3	21.1	19.7	38	9.9
Specialization in specific farm/business type	5.4	16.2	24.3	40.5	13.5
Relevance of digital tools to farm/business	0	8.1	24.3	54.1	13.5
Farmers age	5.4	5.4	37.8	37.8	13.5
Lack of knowledge and skills to run digital technologies	2.7	5.4	8.1	51.4	32.4
Lack of information on benefits	2.7	8.1	27	45.9	16.2
Poor data infrastructure (connectivity, internet)	2.7	0	13.5	48.6	35.1
Lack of adequate strategies to promote digitalization	2.7	0	16.2	56.8	24.3
Insufficient state subsidies for supporting investments in digital technology	0	2.7	10.8	37.8	48.6

Source: Authors processing

Albania is in the process of entering the European Union, and implementing European policies on the digital plan of action is a priority. In this context, the use of digital technologies is crucial for the successful implementation of precision livestock farming in practice. As shown in Figure 3, the utilization of digital technology is still limited. Even though digital technologies have the potential to increase livestock production (an industry that has witnessed a decline in recent years), various barriers are hindering their adoption. Similar to farmers in Finland and Germany, Albanian

farmers also face significant hurdles due to the substantial investment and maintenance costs. In addition to financial barriers, they also highlight the lack of cooperation, poor infrastructure and limited knowledge further hindering their ability to adopt digital tools on their farms.

Governments play a crucial role in overcoming barriers to technology adoption. This involves providing accurate information about the costs and benefits of various technologies, offering incentives for innovation, promoting strategies for integrating digital technologies, investing in the skills and expertise of their workforce, and encouraging cooperation and collaboration between farmers and other stakeholders. According to Mendes et al. (2024), creating cooperative networks or farmer associations through the exchange of information and sharing of resources can help alleviate barriers related to costs, as well as the lack of knowledge and skills to operate digital technologies. Although the findings of several studies on the limitation factors to digital adoption are not uniform and vary across different regions of the world, notably some of them point out the role of government and policies and investments in research and development (Raimi et al., 2021), investments in human capital (Hoek & Miller, 2021), relevance to farm type (DEFRA, 2020), farm size (Tamirat et al., 2017), costs (da Silveira et al., 2023), training and knowledge on digital skills (Gaspar et al., 2021).

4. LIMITATIONS OF THE STUDY

Even though the findings of the study are very significant, it's important to note the limitations of the analyzed case studies. The technologies were selected based on literature research, focusing on technologies relevant to Finland, Germany, and Albania. However, due to the low level of digitalization in Albanian farms, some technologies may not be suitable for implementation. Moreover, it's essential to mention that the information on barriers and adoption factors comes only from the perspective of the farmers interviewed in each specific country. Therefore, views may be influenced by farmer bias and as a consequence, other barriers of adoption may need to be considered.

5. CONCLUSION

This study aims to assess the current adoption rates of specific technologies and prospects in livestock production within two European countries, Finland and Germany, as well as in Albania, which aspires to become a member of the European Union in the future. The analysis of the primary factors influencing adoption patterns provides insight into the potential for transforming the livestock sector.

The process of digitalization appears to be complex, posing challenges but also offering numerous opportunities for farmers and other stakeholders in the food industry. However, implementing digitalization in livestock farming in developing countries requires more time and effort compared to developed economies. Mapping the current adoption rates is a crucial step for policymakers, providing valuable evidence for understanding and addressing the challenges and potential benefits associated with the modernization in agriculture.

The adoption of digital technologies varies between Finnish and German farms. Some technologies are more prevalent in one country than the other. Online platforms (71%) and mobile apps (70%) are more widely used among German farmers, while FMIS (71%) and automated feeding systems (38%) are more common among Finnish farmers. Adoption rates for GPS and drones are low in both countries. Finnish farmers are more willing to invest in drones, sensors, and

GPS for the future, while German farmers plan to use automated feeding systems and robotics more extensively. Despite recent progress, farmers in both countries cannot be considered fully digitalized. In Albania, digital technology implementation is still in its early stages. The most commonly used technologies are mobile apps, online platforms, and automated milking systems. However, the findings suggest that large-scale farmers are increasingly willing to invest in these technologies in the future.

The investigation of adoption obstacles revealed that economic and financial resource constraints, inadequate data infrastructure, and farm size are important issues hindering investments in digitalization. The initial cost of investment and maintenance services was identified as significant barriers to digital adoption among farmers in all three countries. Based on the various circumstances and differences that exist between nations, Albanian farmers have identified several impediments to their willingness to digitize their farms. These include lack of knowledge and skills, absence of cooperation, government support, and advice. Therefore, policies in Albania should not only provide incentives to enhance the adoption level but also prioritize the promotion of suitable technologies and their benefits. Additionally, it is important to strengthen extension services to share knowledge with farmers and enhance their skills in utilizing these technologies effectively.

In the context of factors affecting technology adoption in Finland and Germany, farmers expressed differing views. Finnish farmers identified several factors, including lack of knowledge and skills, farmers' age, and the importance of digital tools as key influences on their willingness to invest more in digitalization. This indicates that skills and human capital are closely tied to the successful integration of digital adoption. On the other hand, German farmers reported the lack of strategies to promote innovation and insufficiency of subsidies as influencers of their decision to adopt digital tools. This brings out the necessity to rethink the issues surrounding the digitalization of the livestock sector.

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