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Technological Innovations in Agricultural Firms in Bulgaria: What is the Role of EU Funds?

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Abstract. *The value chains that originate from agricultural production across the globe are of critical importance to achieving the Sustainable Development Goals. In the context of Bulgaria on the country level, the gross capital formation of agricutural firms has experienced an incredible increase of 95% because of buying machines and equioments during the years 2018 and 2022. Our research project focuses on analyzing the effects of governmental financial support on the growth and competitiveness of agricultural companies. For the study, data on firms that were financially aided to buy agricultural machinery between 2021 and 2023 was derived from the eufund.bg database. It was discovered that medium and large businesses are two to three times more likely to receive funding from the EU compared to the micro-enterprises. The study identified a significant North-South divide signaling a positive impact of funding to the less developed regions and in particular the Northwest region. Furthermore, the crucial role of the EU funding in enhancing the growth of the agricultural sector are emphasized by the study. The study identifies gaps in the efficacy of support programs and policy interventions in enhancing innovations in the agricultural sector. The study also offers insights on specific impacts on farm productivity, profitability, environmental sustainability, and socio-economic implications for the future studies.*

Keywords: agricultural sector, automation, growth, governmental funding projects, Bulgaria.

Introduction

The gross capital formation of Bulgarian agricultural firms rose from 381 million euros in 2018 to 594 million euros in 2022. The incredible increase of 95% of the gross capital formation during the period can be attributed to the acquisition of machines and equipment. The implementation of new technologies – be it autonomous tractors, smart irrigation systems, or the integration of drones and AI into the overall management of agricultural processes is an innovation. Agriculture is subject to serious transformation processes powered by technologies and regulation (i.e. the Green Deal). However, the Eurostat and the National Statistical Institutes do not include agricultural enterprises in the samples they study annually for the introduction of new technologies and products on the market. The mirroring study in Bulgaria, conducted by ARC Fund[1] for the annual reports Innovation.BG (for the latest see Georgieva et al., 2023) also did not include agricultural companies in the sample of their latest study in the summer of 2020. So, studies on agricultural innovation and automation specifically could be done mainly case by case if no large-scale survey is administrated.

Innovations in the whole agricultural value chain increasingly attract the attention of researchers, civic activists, and policymakers in addressing the Sustainable Development Goals. Surprisingly, most of the comparative studies in the innovation field, at least in the European context, do not include the agricultural sector eiher. Studies focus on the sector's capabilities to cope with new green and bio regulations, strong discrepancies in the way the European agricultural

[1] www.arcfund.net

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policy is implemented at the member state level, and lately – the impact of the Russian-Ukraine war on the internal market.

The Food and Agriculture Organization (FAO) of the United Nations has pioneered several global projects related to digital agriculture, e-agriculture, and climate-smart agriculture, which relies on proper digital measurement and smart automation, which saves resources and reduces greenhouse and farm emissions. Yet, we still do not have an international or European-wide system of benchmarking the progress of digital transformation in agriculture.

All countries are compelled to undergo a technical transition to investigate the best possibilities for boosting healthy agricultural production while preserving the ecological balance. Depending on the various advanced computer science and information technologies, the advantages in labor and resource, time, and quality have been outstanding in agricultural activities such as production, storage, and transportation. Therefore, the adoption of new technology has become a central issue for those who have not been upgraded at this exploring stage of agricultural technology transition.

This study is consequently comprised of four essential parts. The first section is the literature review. Herein, a robust analysis of foundational theories including the dissemination of innovation theory to establish the rate of uptake of the tremendous technological advancements within the agricultural sector is delved into. Moreover, the outstanding technological progressions in the management of the agricultural sphere are comprehensively discussed within the section. Subsequently, the study will move to the methodology section which looks into the procedures adopted for the study. More particularly, it discusses diverse aspects of the role of financial assistance emanating from the government in amplifying the Bulgarian agricultural sector in years 2021 and 2022. Third is the result section which presents the principal discoveries, particularly the expansion of the agricultural sector as occasioned by the diffusion of financial aid by the government. The paper concludes with a summary of the core aspects of the study and deliberations on the pathways for prospective research works.

Literature review

AI in agriculture

In recent years, technology has advanced in various sectors including big data, algorithms, and computational power. Artificial intelligence (AI) is among the impacted sectors with the change causing the prevalent use of AI in business to solve problems and enhance business value.

Spanaki et al. (2022) analyzed 205 papers in the research area of technology for agricultural operations.. The authors classify the agricultural operations into three types. The first is the type of physical agricultural technology applications, which emphasize the use of machinery and tools for agricultural operations that not only replace human labor tasks (e.g., robotic machinery, irrigation systems, etc.) but also present physical characteristics as agrotechnology "hardware". The second is the cyber-agricultural technologies. These applications are mainly related to platform software and are closely linked to data analysis and decision support systems for agricultural operations. Finally, the cyber-physical application area refers mainly to the use of intelligent agricultural machinery and/or farm robots, including hardware and software for data analysis and predictive/normative customized decision-making, advice, and recommendations. The authors demonstrate that AI-driven agricultural technologies based on AI that may disrupt farming operations and provide new ways of practicing agriculture are still in their early stages.

Spanaki et al. (2022) and Atanasov et al. (2022) postulate that technologies such as virtual simulations, innovative algorithms, and analytic platforms have been widely adopted in the agricultural sector. Among the notable advancements in agritech area are; the adoption of drip irrigation systems in dry regions, monitoring of the field conditions using wireless sensor networks, deployment of spraying techniques over vast agricultural lands and forests, and the successful implementation of autonomous harvesting practices.

Additionally, various studies underscore the ongoing enhancement of these technologies' sustained performance. However, literature specifically documenting the rapid advancements in Bulgaria remains scant. Therefore, there is a need to document the rapid advancement in Bulgaria.

Diffusion of innovation and influencing factors

According to the theory of diffusion and innovation (Rogers et al., 2014), the adoption of novel ideas, behaviors, or products in a social system occurs in five phases: awareness, interest, evaluation, trial, and adoption. The systematic process is demonstrated in the agricultural sector which has largely been characterized by a steady adoption of different technologies happening over the last ten years. It is as such crucial to study the factors that influence how new technologies are embraced in diverse regions and localities.

Agritech includes agricultural automation technology, computer vision and image recognition applied specifically in automating irrigation systems, weeding, crop monitoring for pest control management and others.

AI has become a crucial business tool and basic competence for all types of enterprises. Yet, SMEs face stronger challenges to adopt AI compared to large enterprises due to lack financial power. Small businesses do not have much money like big companies to keep pace with changing technological advancements such as implementing AI (Ghobakhloo & Ching, 2019; Masood & Sonntag, 2020).

Agricultural sector in Bulgaria

Bashev (2020) arguably conducted one of the first comprehensive studies on the digitalization of agriculture in Bulgaria. The findings of this study paint a rather pessimistic picture, suggesting that agricultural companies lack awareness of digital agriculture concepts and have an unclear understanding of the associated economic benefits.

Later follow-up research on experimental plots at the Agricultural Research Institute in Dobrudzha, Bulgaria, was published by Atanasov et al. (2022). Drones are used to enhance the diffusion of remote sensing in Bulgarian agriculture. Drones are also used to spray cultivated lands. According to in-depth interviews, drones are more efficient than informal light aviation, which operates without precise technology or even insurance. However, automated drone spraying and integration into a broader smart agriculture platform are still a ways off.

It's noteworthy that the onset of crisis periods, particularly around 2024, has catalyzed the instrumentalization of technological innovations in digital agriculture, as indicated by Bashev's observations.

In Bulgaria, agriculture has grown tremendously over the years due to massive innovation and technological advancement which has seen improved agricultural productivity, and optimized use of resources towards sustainable agricultural development.

In crop management, Ondo Smart Farming Solutions is a game changer. It was awarded the Innovative Enterprise of the Year 2020 in the category of start-up. Ondo is all in one farming automation solution. Ondo monitors and controls irrigation and nutrition of plants, but also light,

humidity, temperature, pH, CO2, etc. Precise (often called also SMART) technologies could increase the resource efficiency – savings on water, energy, and reduction of human error. One example of the implementation of Ondo services is Nikol agro greenhouse in the Southwest planning region (town of Kresna). In this case, the savings on water are 25%, 20% on energy and fertilizers and human errors, and 35% less full-time equivalent of personnel. One of the reasons for relatively smaller ratios of savings is the micro-scale of application. Ondo is already exporting its services to neighboring countries like Republic of Northern Macedonia and Greece. Ondo's technology is suitable for field corps areas of 500 or more decades, but also vineyards and orchards.

Another automation device for crop management is designed by Robo-Weeder as a proof of concept. It is a 4WD robotic platform powered by solar panels for automatic detection of weeds vs useful plans. It received the award of high innovation achievement from the ARC Fund and EEN in 2022.

AgroVar is a start-up company specializing in decision and regenerative farming, AI, and big data in crop production and management. Although created in 2021 for less than three years it has already over 100 clients from various sub-fields of agriculture.

Within the same context, Bee Smart Technologies was successful in experimenting with IoT and AI in monitoring and managing honey production. It successfully raised investment through the BEAM market at the Bulgarian Stock Exchange.

Nasekomo has been awarded with High Innovation Achievement at the National Innovation Enterprise of the Year 2020 and is included as one of the top 50 innovative climate tech companies in Central and Eastern Europe (PWC, 2022). Both achievements take into consideration the process innovation, developed at the enterprise, and high-growth potential.

Various companies in Bulgaria serve as important innovation hubs in Asian countries, such as Bultech 2000, which is a market leader in automation and quality control technology for the dairy sector in India.

The research conducted by Yalamov et al. (2021) examined the innovation activities of firms in Bulgaria during the COVID-19 pandemic and validated Schumpeter's famous prediction that firms will tend to engage and invest in innovations during recessions. The finding of the paper was that academic engagement had an impact on the innovation intensity of enterprises. The largest impact comes from process changes, followed by innovations in products and marketing.

A survey[2] by the Bulgarian Modern Trade Association highlights the challenges and strengths of the Bulgarian business environment, including legislative issues and infrastructural advantages. Therefore, there is a need to explore the potential of Bulgarian agricultural firms within the framework of the macro. This research seeks to establish the effects government injections into projects have had on the expansion of the agricultural sector between 2021 and 2022. It does this by looking at how funds were allocated, employment trends, and investment strategies to gain insight into what drives the industry.

Research objectives

This study is a continuation of the research on how companies act in periods of crisis particularly during the onset of the Covid-19 pandemic in 2020. The expectation is for innovative agribusiness organizations to invest more in technology adoption and succeed even during this crisis (2021-2022).

[2] https://www.oecd.org/

The study is based on the hypothesis grant funding will lead to growth of companies. This article's focal point is to assess the impact of government funding on agricultural sector growth during the years of 2021 and 2022. It covers different aspects of agriculture management which includes allocation of funds, employment trends as well as investment initiatives. Through these areas of focus, the study brings out various dynamics in agribusinesses showing how smaller companies differ from larger ones in their approach towards enhancing farming practices.

Methodology

The data was derived from the national database efund.bg for EU funded projects. Our study focused on 412 firms that received funding for the purchase of agricultural machinery in years 2021 and 2022. We integrated project funding data with employment data and geographical location of companies from the Lacroda database.

We use the SME definition only based on the workforce employed. Micro and small entities (91.5% of all) were defined as those having less than fifty employees while medium-sized through large establishments had fifty or more workers representing only eight point five percent (8.5%). As for shell companies with no employees whatsoever being included within this sample setup, it accounted for twenty-nine percent (29%) thereof; such categorization enabled us to detect probable variations vis-à-vis how different-sized organizations would be affected by financing and their ability to optimally operate within the agricultural sector.

Adopting a temporal lens, we designated the year of funding receipt as 'T', with 'T+1' and 'T-1' representing the subsequent and preceding years, respectively. We used a linear approximation technique to ascertain turnover rates over the designated time span. This enabled us to trace different patterns in revenue generation after receiving the financial support.

This research sets off on an extremely ambitious journey in evaluating governmental support's tangible effects on the growth paths and competitiveness of agribusiness firms. Our study therefore seeks to reveal these dynamics so that policymakers can have relevant information while making decisions; investors too need this knowledge and other industry players who may want insights on what can be done better or differently. Underneath our inquiry lies an assumption that organizations show observable patterns of development after getting financial support.

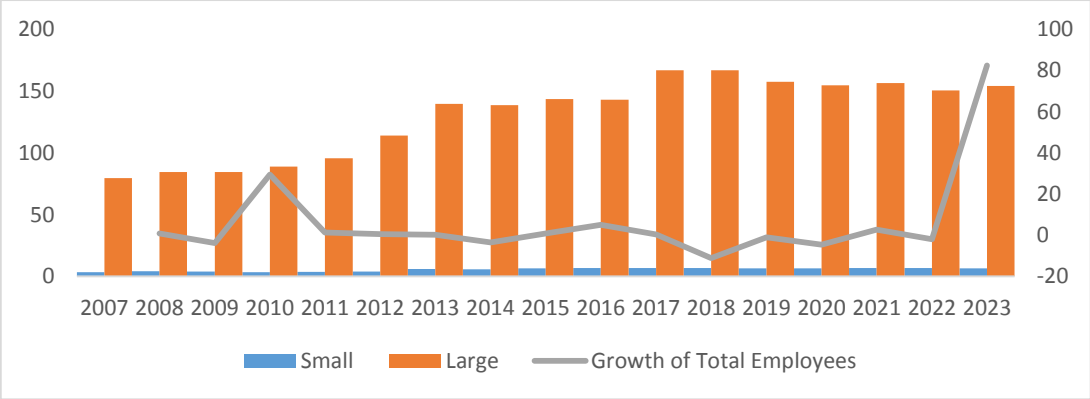
Results and discussions

As data suggests (Figure 1), there is an upward trajectory of employment levels in both small (less than 50 employees) and mid-sized and large companies (50 or more employees). There are just 10 large companies in agriculture in terms of employment in Bulgaria – they are Nedko Nedkov Ovcharovo LTD (Dobrich/Northeastern region), Elit 2096 LTD (Plovdiv, Southcentral region), Katarzyna Estate (registered in Sofia/Southwestern region, but vineyards are in Southcentral region, close to the Greek border next to Svilengrad) and Bata-2002 LTD (Southeastern region). There are around 130 more mid-sized companies in the sector, so the best employee threshold is 50 for relatively bigger companies.

Participation rate in EU projects is predictably higher in relatively bigger companies. For instance, 26% of mid-sized and large companies in the sector received financing under the program, subject to analysis. At the same time, just 10% of one-man show companies got funding. If we expand the sample to include all firms and self-employment agricultural producers, the success ratio falls to 5%. Yet, in agriculture, the relative support from EU programs and projects is much higher than in the other sectors.

For some years, there have been huge fluctuations in yearly total employees' growth whereby they sometimes increase too much before subsequently declining sharply later. For instance, 2009, 2010, and 2016 had high numbers while significantly low numbers were recorded during other times such as 2018 or 2020. It should however be noted that the growth realized currently is immensely high with an increase percentage being equal to 82.40% which implies that more people were employed this year than in the previous years.

Figure 1. The average number of employees of small and large companies and the growth of total number of employees per year

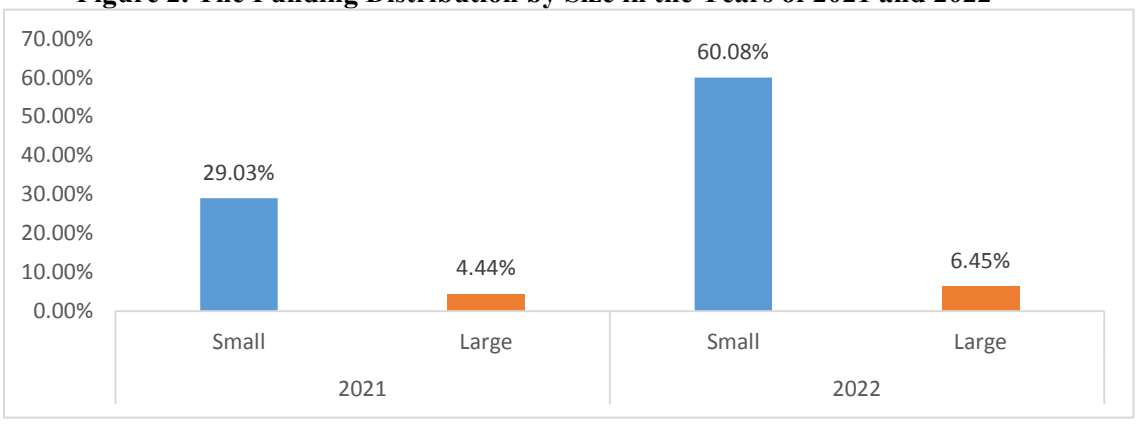


Source: Authors' own research results.

The data in Figure 2 reveals that both small and large enterprises gained access to funds in 2021 and 2022. A lot of growth was as such realized in the businesses:

The proportion of small firms that gained funding in 2021 (29.03%) was by far more than mid-sized and large firms (4.44%). Generally, 33.47% of enterprises were handed the funding. The huge disparity continued to 2022 as 60.08% of small firms compared to 6.45% of large firms received the funding. Overall, 66.53% of enterprises received the funding in that year. The data hence points to a rise in the number of organizations benefiting from the funding within the two years. Despite the existing disparity, both small and large enterprises benefited.

Figure 2. The Funding Distribution by Size in the Years of 2021 and 2022



Source: Authors' own research results.

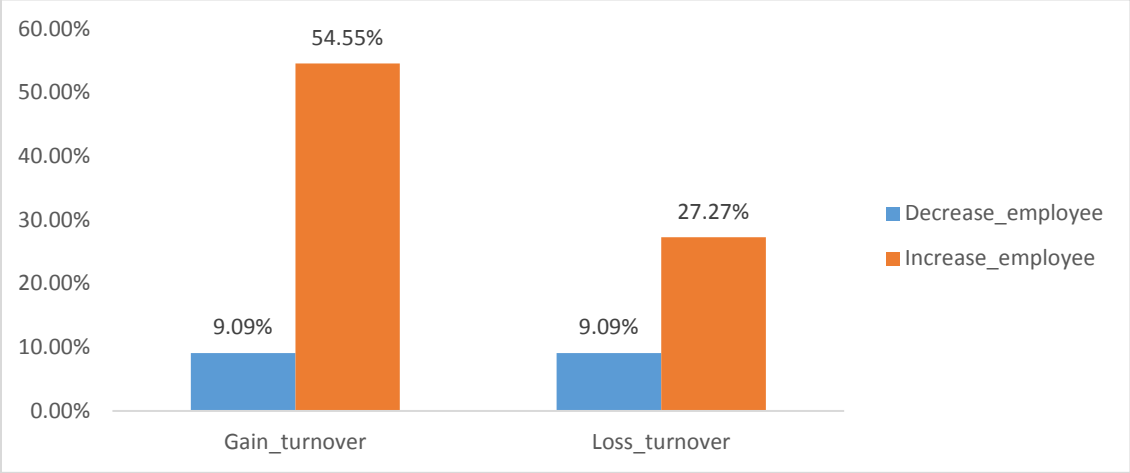
The data (as seen in Figure 3) provides information on the count of companies and the status of employee increase and decrease, as well as their impact on growth or turnover for the next year of investment.

We further distinguish between companies with an increasing/stable number of employees and those with a decreasing number of employees.

More than half (54.55%) of the companies with growing employment experience growth in revenues as well. While among companies with decreasing employment only 9.09% experience growth in revenues.

Around a quarter of companies (27.27%) with growing employment experience a decrease in sales.

Figure 3. The ratio of large companies that Gain/Loss growth after the year of investment in 2021



Source: Authors' own research results.

These mid-sized and large companies used the project funding towards various initiatives aimed at improving livestock farming practices, including the acquisition of equipment, modernization of farms, and enhancement of bio-security measures. The size of the companies is crucial for the impact of technological innovations on agricultural enterprises' behavior and performance. Relatively smaller companies experienced faster growth over five years compared to companies bigger than 50 employees. Through the EU project funding, they increased operational efficiency and replaced some personnel. Relatively bigger companies increased their operational capacity instead through new machines and equipment, which led to hiring more employees and increased turnover. The detailed results are shown in Table 1.

Table 1. The growth in employment before and after the year of funding for small and large companies

Company size	Annual growth in employment before the project (5-year trend)	Growth in employment before the project (y-o-y)	Growth in employment after the project (y-o-y)
Companies with less than 50 employees	Positive (+3,19%)	Positive (+3%)	Negative (-0.5%)
Companies with 50 or more employees	Positive (+1,6%)	Positive (+2%)	Positive (+6%)

Source: Authors' own research results.

Comparing the total sample of agricultural enterprises (including self-employed agricultural producers) there is a diverging trend. The total employment in the agricultural sector decreased by 16% between 2017 and 2022. Against that, the companies that were successful in attracting investments through EU programs were able to stay stable in terms of employment and have positive financial results.

EU funds are better utilized by companies with 50 or more personnel since they can hire consultants or use the business heirs, who are usually studying in good universities in Bulgaria or abroad. This leads to an increased concentration of business, as shown also by other studies (Yalamov et al, 2021).

Some of the most successful companies are utilizing the EU funds persistently, not just with one project but also in clusters of companies via its supply-chain line, like Dobrev Trade LTD with the trademark Dobrev cheese[3]. One of the projects, for instance, is to support a small agricultural producer Toncho Tonev. Others – for automated dairy farms.

According to the agricultural census in Bulgaria, conducted in 2020, innovation is marginal in all farms in the six planning regions. Everywhere, less than 0.2% of the farms engage in innovative economic activity. The relatively strong region in terms of innovation seems to be the Southwest having the highest share of crop and livestock management innovation, as well as the processing of agricultural products. The detailed statistics are provided in Table 2.

Table 2 Percentage of innovative companies by planning region and type of innovation

Planning region	Crop management	Livestock management	Agricultural products processing	Other innovative technologies applied in agriculture
Bulgaria (total)	0,10%	0,09%	0,02%	0,06%
Northwest	0,11%	0,06%	0,01%	0,04%
Northcentral	0,16%	0,12%	0,01%	0,10%
Northeast	0,07%	0,05%	0,01%	0,06%
Southeast	0,08%	0,03%	0,02%	0,15%
Southwest	0,19%	0,13%	0,05%	0,04%
Southcentral	0,04%	0,12%	0,01%	0,04%

Source: Agricultural Census 2020, Ministry of Agriculture and Food, 2022.

Labor productivity in Bulgarian agriculture has increased three-fold in the last ten years and is reaching 71% of the labor productivity of Greece and Portugal (Yalamov et al, 2021). A great deal of the increase in labor productivity is due to technological upgrades and innovations, even though the agricultural census did not capture that. An additional argument that the agricultural census underestimated the innovation in agriculture is the increase of gross capital formation and EU projects in agriculture as well. These could be slight and individual for the company, but that notwithstanding, they count as innovation according to Eurostat's definition.

Several key results can be derived from the analysis of the given information. To begin, there is a noticeable rise in companies that received funding throughout the years, especially in 2022 which indicates positive investment activity trends within agriculture. We observe an upward trend in employment by all sizes of companies. This indicates the overall expansion or enlargement in workforce size within this industry. Investments such as buying farm machinery as well as

[3] http://dobrev-cheese.com/

modernizing livestock farms point towards attempts made at improving farming methods, and enhancing bio-security measures while also boosting competitiveness levels locally and globally.

Table 3. The growth in different regions in Bulgaria before and after the funding

Regions in Bulgaria		5-year growth before project	y-o-y growth before the project	y-o-y growth after the project
Southwestern	Mean	12.4%	2.4%	0.6%
	N	116	116	116
	Std. Deviation	0.8635455	0.432195	0.4561316
Southeastern	Mean	17.2%	10.6%	-1.7%
	N	68	68	68
	Std. Deviation	0.9564152	0.6660889	0.5404745
South-central	Mean	23.4%	4.4%	-8.4%
	N	62	62	62
	Std. Deviation	0.7493601	0.6039699	0.5415396
Northwestern	Mean	23.1%	-8.6%	3.1%
	N	45	45	45
	Std. Deviation	0.7577358	0.5019917	0.5719309
Northeastern	Mean	14.1%	-5.9%	1.3%
	N	30	30	30
	Std. Deviation	0.4750774	0.5334009	0.5568203
North-central	Mean	7.8%	-0.2%	0.7%
	N	69	69	69
	Std. Deviation	0.8948632	0.4771543	0.5396361
Total	Mean	15.5%	1.8%	-0.9%
	N	390	390	390
	Std. Deviation	0.8311953	0.5306761	0.5196699

Source: Authors' own research results.

The data suggests a clear North-South divide, where agricultural companies in Northern Bulgaria increased the pace of employment growth after the implementation of EU projects. Just before the project, the average growth was negative in the North and after the project, it was positive with the highest difference observed in the Northwestern region, which is considered the poorest region in Bulgaria. The details are presented in Table 3.

The paper discusses significant technological advancements in agricultural firms in Bulgaria. However, there are possible areas for future research that can be conducted. More studies could for instance research the impacts of investment initiatives on farm productivity, profitability, and environmental sustainability. Identification of projects' ultimate beneficiaries, based on ownership information and related companies could lead to higher concentration of financial support. Furthermore, a comprehensive understanding of the role agriculture plays in regional

economies would also require a robust examination of socio-economic implications of employee dynamics including job creation, income generation, and rural development.

Conclusion

This research work aimed at analyzing the government's financial injections toward growth realization within agricultural sectors focusing mainly on two years: 2021 and 2022. It delves into different spheres of managing agriculture like money allocation, and employment trends among others.

We discovered that medium and large businesses are two to three times more likely to receive EU funds compared to micro-enterprises. Moreover, companies that have received EU funding demonstrated the ability to either increase their employment or slow down the decrease observed in the general agricultural population of firms. In particular, the mid-sized and large companies, which utilized the EU funds to enhance their operational capacity of the business, lead to the recruitment of new personnel, while micro and small companies predominantly tend to use EU funds to increase operational efficiency.

Moreover, our analysis points out the pronounced North-South divide as indicative of more favorable effects on underprivileged territories such as the Northwest. Similarly, it highlights how instrumental European Union funding is in promoting agricultural development while calling for more studies on its various impacts on environmental friendliness, profitability and social-economic aspects, and farm productivity among others. Also worth investigating could be the efficiency of regulatory interventions and support programs designed to foster resilience and innovation within agriculture. This is because such measures become increasingly important from now on too. In conclusion, this research provides valuable insights into agribusiness dynamics around patterns, initiatives, and their sustainability implications while at the same time deepening our understanding regarding complex interactions within this sector, hence underlining need-driven interventions towards equitable growth that can be sustained over time.

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