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E-Commerce Adoption Trends in Bulgarian Agriculture

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Abstract. *The digital transformation of agriculture is reshaping traditional business models, yet e-commerce adoption remains limited. This study examines the extent of e-commerce adoption among Bulgarian agricultural enterprises, leveraging data from 5,555 active companies registered with Bulgaria's National Revenue Agency and the Apis database. Notably, the study adopts a total universe approach, encompassing the entire population of active agricultural enterprises rather than relying on a representative sample. This comprehensive inclusion ensures that the findings accurately reflect the state of e-commerce adoption.*

The analysis reveals that only 108 firms operate online stores, indicating significant barriers to digitalization. Using a mixed-methods approach, the study employs descriptive statistics, hypothesis testing (ANOVA, Chi-Square), and qualitative insights from farmers' market vendors to assess financial performance, regional disparities, and structural challenges. The findings highlight a pronounced North-South digital divide, with southern businesses exhibiting higher e-commerce adoption rates. Statistical tests confirm that firm size, EU project participation, and access to funding significantly influence digital integration. However, financial performance indicators such as return on equity and revenue per employee show no immediate benefits from e-commerce adoption, suggesting that profitability is not the primary driver of digital transformation. Instead, engagement in EU-funded projects emerges as the most significant predictor of e-commerce adoption, underscoring the role of external support mechanisms.

Qualitative findings reveal that informal online sales channels, such as social media, direct messaging and phone communications, dominate the sector, further reflecting hesitancy toward formal e-commerce integration due to regulatory burdens and insufficient digital literacy. These results emphasize the need for targeted policy interventions, infrastructure investment, and tailored support programs to bridge the digital divide in agriculture. By identifying structural and behavioral barriers, this study contributes to the growing discourse on digitalization in rural economies and offers recommendations for fostering e-commerce adoption among agricultural enterprises.

Keywords: E-commerce adoption, Bulgarian agriculture, digitalization, regional disparities, financial performance, EU funding.

Introduction

Although e-commerce has emerged as a transformative force across industries, agriculture remains slow to adopt digitalization due to regulatory burdens, digital literacy gap, and its localized, relationship-based nature, relying on return customers and people living near different farmer's markets. However, trends like rising demand for organic products, direct-to-consumer (D2C) models, and sustainable sourcing are prompting agricultural businesses to reconsider their strategies. This expansion reflects broader European trends where digital trade is becoming a dominant force in retail and wholesale sectors.

Existing research on digitalization in European agriculture highlights a growing interest in technology adoption, particularly in countries such as Romania (Șerbănel, 2021; Andrei et al., 2023), where SMEs face IT infrastructure costs and cybersecurity challenges. Studies on Bulgarian agriculture (Nigohosyan et al., 2024) focus on innovation and EU funding but provide little insight

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into digital commerce. However, few empirical studies have analyzed e-commerce adoption in agricultural enterprises across Eastern Europe.

This study addresses the gap by analyzing financial, operational, and structural differences between 108 e-commerce adopters and 5,555 active agricultural firms registered with Bulgaria's National Revenue Agency (NRA)[1] and Apis database[2]. Unlike research relying on partial data or representative samples, this study includes the entire sector, ensuring a comprehensive view of digital adoption trends. It evaluates e-commerce adoption, regional disparities (North-South divide), and financial performance using descriptive statistics, ANOVA, Chi-Square tests, and financial ratio comparisons. Additionally, qualitative insights from farmers' market vendors explore barriers to digital expansion in the sector.

Literature review

E-commerce is a key driver of digitalization across industries, including agriculture. However, e-commerce adoption alone does not constitute digital transformation, though it represents an innovation for businesses. Some enterprises integrate e-commerce with broader operational changes, such as automated logistics, data-driven decision-making, and platform-based business models. This distinction is critical, as merely adopting an online sales channel does not equate to a fully digitized business model.

In Bulgaria, e-commerce has grown steadily, driven by consumer adoption and regulatory advancements. The B2C e-commerce market was valued at €1.95 billion in 2023, projected to reach €2.34 billion in 2024 (BEA, 2024). This growth reflects wider European trends, where digital trade is expanding alongside increased ICT adoption (Șerbănel, 2021).

Despite agriculture contributing 5% to Bulgaria's Gross Value Added (GVA) and employing 6% of the workforce, the sector lags in digitalization due to infrastructure, regulatory, and financial constraints (Georgieva et al., 2024). Similar barriers exist in Romania, where SMEs struggle with IT adoption and cybersecurity (Rotaru et al., 2018). While EU-funded programs like CAP and Horizon 2020 have boosted asset accumulation and innovation, studies show they do not significantly improve profitability or employment, favoring large enterprises over smallholders (Nigohosyan et al., 2024; Sterie et al., 2024).

The technological landscape of Bulgarian agriculture has evolved with automation, precision farming, and digital marketplaces. From 2018 to 2022, agricultural firms increased capital investment by 95%, primarily in machinery and digital tools (Ma, 2024). However, funding remains uneven, favoring medium and large enterprises over micro-enterprises (Ma, 2024). This pattern mirrors Romania, where urban-rural digital divides, SME reluctance, and high IT costs hinder e-commerce adoption (Rotaru et al., 2018; Andrei et al., 2023). Additionally, limited financial incentives and training programs restrict small farmers' e-commerce participation, a challenge across the EU agricultural digitalization agenda (Șerbănel, 2021).

Environmental, Social, and Governance (ESG) practices are also shaping e-commerce adoption, as agribusinesses increasingly integrate sustainability frameworks into their operations (Georgieva & Georgieva, 2024).

Similar trends are evident in the European agricultural sector, where EU-funded projects emphasize circular economy principles, digital traceability, and supply chain optimization (Șerbănel, 2021; Sterie et al., 2024). The transition to digital platforms is further reinforced by

[1] Available at: https://portal.nra.bg/details/online-store-nrareg

[2] Available at: https://www.apis.bg/bg/

participation in global value chains, where traceability, sustainable packaging, and eco-friendly logistics strategies are becoming key competitive differentiators (Crasoveanu et al., 2023; Georgieva & Georgieva, 2024).

The adoption of AI-driven e-commerce platforms and blockchain-based supply chain management has also been proposed as a solution for enhancing transparency and reducing inefficiencies in agricultural trade (Sterie et al., 2024). Similar solutions are being integrated in Romanian and EU e-commerce ecosystems, focusing on real-time inventory tracking, predictive analytics, and AI-powered customer service solutions (Andrei et al., 2023).

Despite growth, Bulgaria's agriculture sector faces barriers to digitalization, including low digital literacy among farmers, inadequate rural ICT infrastructure, and market fragmentation. Romanian research identifies similar constraints, including fragmented logistics, slow SME digital transformation, and reliance on traditional business models (Rotaru et al., 2018; Andrei et al., 2023). Additional challenges include cybersecurity concerns, legal compliance, and online payment adoption hurdles, particularly for small and mid-sized agricultural enterprises (Crasoveanu et al., 2023).

Methodology

The methodology of this study employs a mixed-methods approach to analyze the adoption of e-commerce in Bulgaria's agricultural sector. By integrating quantitative and qualitative data collection and analysis, the research aims to provide a comprehensive understanding of the factors influencing the digitalization of agricultural enterprises. The study relies on two primary data sources: the National Revenue Agency (NRA) Public Register of Online Stores and the Apis Database. The NRA registry comprises 31,714 active records, representing 20,091 companies, offering verified data on businesses engaged in e-commerce. This dataset enables the identification of agricultural enterprises that have registered their online stores, allowing for analysis of formal digital commerce activities. Meanwhile, the Apis Database provides detailed financial and operational information on 9,109 companies within the agriculture, forestry, fisheries, and food and beverage production sectors.

Importantly, this study encompasses the entire Bulgarian agricultural sector rather than a representative sample. By including all active agricultural enterprises identified through the combined NRA and Apis datasets, the analysis offers a complete and accurate depiction of the sector's engagement with e-commerce. This approach ensures that the findings reflect the full scope of digital adoption trends and challenges across Bulgaria's agricultural landscape. After a thorough data cleaning and validation process, 117 agricultural enterprises operating 175 e-shops were selected as the primary unit of analysis, representing the sector's engagement with digital commerce.

To ensure data reliability, firms without revenue and employees were excluded, along with those lacking VAT registration (threshold: €51,129) The filtering was needed as even if there is no data for revenue but there is a VAT registration, this is interpreted as a "live" company but their financial reports were not digitalized. After implementing these filtering criteria, 5,555 agricultural firms were identified as active. A prior study (Yalamov et al., 2021) analyzed 5,879 firms, suggesting that newer enterprises are more innovative and successful. This can also be observed within the current dataset, 108 enterprises own 161 e-shops, confirming operational online presence. The average establishment year for firms with e-shops is 2011, compared to 2008 for the total sample.

The analysis reveals that the vast majority of companies are micro-enterprises, accounting for over 80% of the total, while 32.8% are classified as empty shell companies, a particular phenomenon in Bulgaria. These entities typically represent very small firms with zero employees, where in some cases, founders might be insured at their day job at the national maximum, thereby avoiding having to pay for additional insurance from the micro company. Small enterprises constitute 16.1% of the total, followed by medium-sized firms at 2.4%, and large enterprises comprising only 0.2% of agricultural companies. The combination of official regulatory data from the NRA and industry-specific business insights from Apis ensures that the dataset covers both compliance-related and financial performance dimensions, offering a holistic perspective on digital adoption in agriculture.

A multi-level analytical approach is used to examine e-commerce trends, integrating descriptive, inferential, and qualitative analyses. Descriptive statistics summarize workforce size, revenue per employee, net profit margin, return on equity (ROE), and return on assets (ROA), with comparisons conducted in SPSS.

Additionally, interviews with farmers' market participants provide qualitative insights, complementing statistical findings with behavioral and structural perspectives on e-commerce adoption.

Limitations

Despite the study's use of authoritative databases and rigorous methods, several limitations must be acknowledged. Many small agricultural producers engage in informal e-commerce without registering with the National Revenue Agency (NRA), meaning the study may not fully capture the extent of digital trade in the sector. Additionally, agricultural production cycles influence digital engagement and financial performance, affecting the generalizability of findings across different timeframes.

Future research should incorporate longitudinal data to track digital adoption trends over time and expand field surveys to include informal e-commerce activities. Moreover, comparative studies across agricultural sub-sectors could provide deeper insights into sector-specific challenges and opportunities.

Results

In Bulgaria, e-commerce regulations require all online stores to register with the National Revenue Agency (NRA) to formalize digital trade and ensure tax compliance. Since December 2018, businesses accepting e-payments must register each platform separately, leading to 31,714 records but only 20,090 unique companies by 2024.

While registration increased recorded e-commerce businesses, agricultural enterprises, especially small farmers, face challenges. Many rely on cash transactions or use couriers to issue invoices and transfer payments, avoiding direct registration. Additionally, compliance with tax and accounting standards disproportionately burdens small producers, who often lack financial and technical resources (Ma, 2024). As a result, many operate informally or adopt hybrid models. Studies confirm that limited funding and training hinder digital adaptation, reinforcing reluctance to formalize online activities (Nigohosyan et al., 2024).

These trends are reflected in Figure 1, which shows fluctuations in agricultural e-commerce participation from 2018 to 2024.

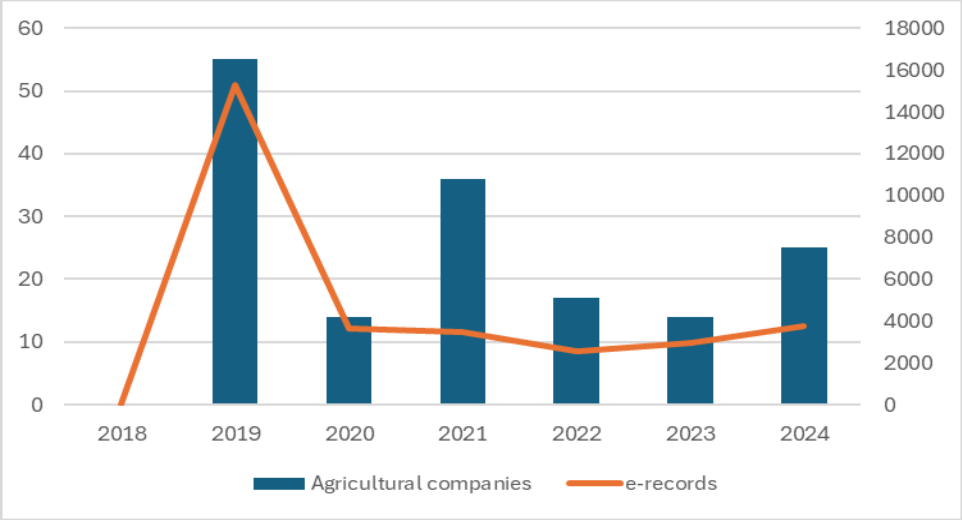

Figure 1. Trends in e-Commerce adoption

Source: Authors' own research.

The chart illustrates significant fluctuations in the number of active agricultural companies engaged in e-commerce and the overall trend in NRA registrations. The peak in 2019, where 55 agricultural companies were recorded alongside 15,302 total NRA e-registrations, aligns with new registration requirements, driving a surge in digital adoption. However, 2020 saw a sharp decline (14 companies, 3,646 NRA registrations), likely due to COVID-19-induced financial instability and supply chain disruptions.

Despite this downturn, some firms leveraged the crisis to innovate, as suggested by Yalamov (2021). By 2021, e-commerce engagement rebounded to 36 companies, even as total registrations stagnated, reflecting growing recognition of digitalization and the need for digital transformation as a resilience strategy. From 2022 to 2023, adoption stagnated (14–17 companies annually), hindered by financial constraints, compliance costs, and limited digital literacy. However, 2024 shows renewed interest, with 25 active firms and 3,777 NRA registrations, potentially driven by economic recovery and EU-funded digitalization programs (Ma, 2024).

The fluctuating trends in active agricultural companies and overall NRA registrations reveal the impact of policy interventions, economic disruptions, and technological advancements on digital adoption.

A more thorough look at the composition of the e-commerce adoption across Bulgaria's agricultural and food sectors shows the highest participation in categories such as bakery, canned foods, and meat products. While the bio/eco/organic sector stands out with strong digital diversification (27 store registrations for 12 companies), likely benefiting from delivery platforms. Primary producers (grains, nuts, dairy, pet food, beekeeping) have low adoption, relying on wholesalers and facing logistical barriers. Some sectors, such as canned/frozen foods and meat, operate multiple storefronts, while fishing, hemp, and baby food remain largely offline, possibly due to legal constraints, perishability, or niche demand. However, some innovative models exist, such as a hotel allowing guests to fish directly from their room's porch and hemp businesses diversifying from medical products to food and recreational use. The trends can be seen in the chart below.

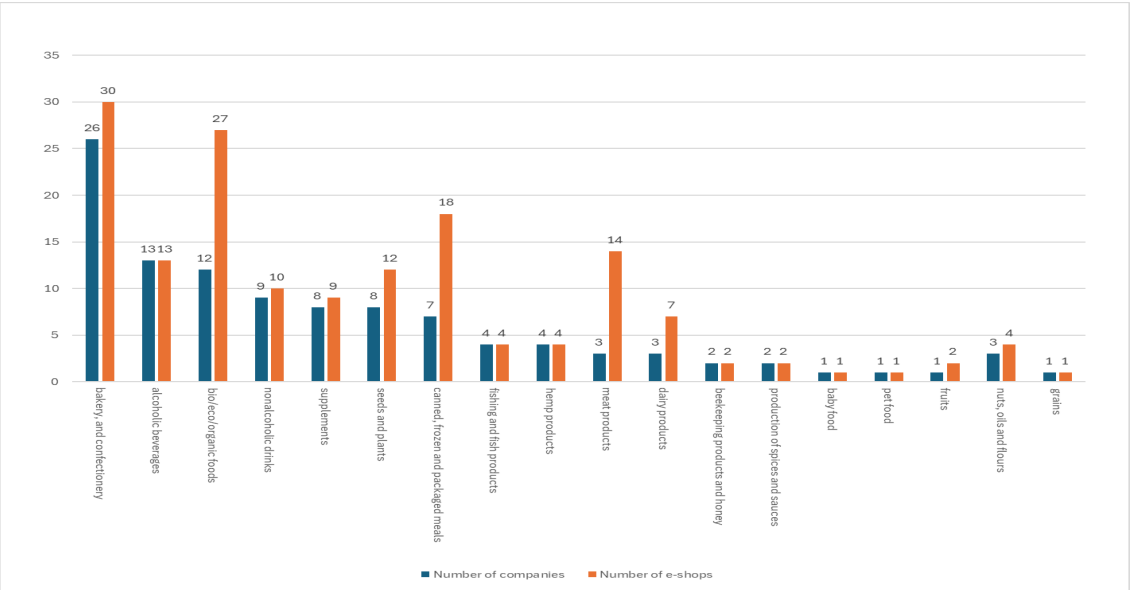

Figure 2. Product categories

Source: Authors' own research.

Overall, processed and packaged food sectors are leading e-commerce adoption, while primary producers and perishable goods sectors lag behind. The results suggest that logistical, regulatory, and financial barriers hinder broader digital transformation, emphasizing the need for targeted policy interventions and digital support programs.

Regional Distribution of E-Shops in Bulgaria

Table 1 presents a regional comparison of e-commerce adoption, revealing a statistically significant digital divide between northern and southern Bulgaria. Of 5,555 active businesses, only 108 (1.9%) operate an e-shop, with e-commerce adoption concentrated in the south.

The northern region, comprising 2,582 businesses, has only 35 e-shops (32.4%), while the southern region (2,973 businesses) accounts for 73 e-shops (67.6%). Despite hosting 46.5% of all businesses, the north lags in digital integration, whereas the south dominates e-commerce adoption with nearly two-thirds of all e-shops. These findings underscore a digital divide between the two regions, with businesses in the south being more inclined to integrate online sales channels into their operations. In-depth interviews suggested that north-south divide also reflects the B2B compared to B2C divide as well, which partially explains why the southern businesses more often adopt e-commerce.

Table 1: Chi-Square Test Results

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.769a	1	0.003		
Continuity Correctionb	8.202	1	0.004		
Likelihood Ratio	9.009	1	0.003		
Fisher's Exact Test				0.003	0.002
N of Valid Cases	5555				

Source: Authors' own research.

Statistical tests confirm that this disparity is not due to chance. The Pearson Chi-Square test ($\chi^2 = 8.769$, $p = 0.003$), Continuity Correction ($\chi^2 = 8.202$, $p = 0.004$), and Likelihood Ratio ($\chi^2 = 9.009$, $p = 0.003$) reinforce the significance of regional differences. Fisher's Exact Test ($p = 0.003$ two-sided, $p = 0.002$ one-sided) further confirms that e-commerce adoption is disproportionately higher in the south. These findings highlight the need for targeted digital support in northern Bulgaria to reduce the e-commerce gap.

These regional disparities in e-commerce adoption are further reflected in firm characteristics, particularly in EU project involvement and workforce size, as shown in Table 2.

Table 2. Descriptive statistics

	e-shops	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Number of projects	No	5447	0.22	0.651	0.009	0.2	0.23	0	9
	Yes	108	0.55	1.027	0.099	0.35	0.74	0	5
	Total	5555	0.22	0.662	0.009	0.2	0.24	0	9
Number of employees	No	3741	10.98	27.878	0.456	10.09	11.87	0	687
	Yes	108	19.91	48.784	4.694	10.6	29.21	0	405
	Total	3849	11.23	28.7	0.463	10.32	12.14	0	687

Source: Authors' own research.

The data reveal that companies with e-shops engage in more EU-funded projects (0.55 vs. 0.22 for non-digital firms) and have larger workforces (19.91 vs. 10.98 employees on average). The wider confidence intervals for digital firms suggest greater variability, likely due to differences in business scale and funding access. These findings indicate that e-commerce adopters are typically larger and more resource-equipped, reinforcing their ability to secure external financing and integrate digital solutions.

Table 3. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Number of projects	Based on Mean	44.079	1	5553	0
	Based on Median	26.58	1	5553	0
	Based on Median and with adjusted df	26.58	1	5342.771	0
	Based on trimmed mean	42.158	1	5553	0
Number of employees	Based on Mean	17.432	1	3847	0
	Based on Median	9.851	1	3847	0.002
	Based on Median and with adjusted df	9.851	1	3487.178	0.002
	Based on trimmed mean	12.014	1	3847	0.001

Source: Authors' own research

The Levene's test for homogeneity of variances indicates highly significant differences in variance between these groups ($p<0.001$), reinforcing the heterogeneity in the dataset. For both the number of EU projects and the number of employees, variance is substantially higher among

e-commerce adopters, suggesting a more diverse range of business structures and operational scales.

The ANOVA results (Table 4) confirm that the differences between groups are statistically significant, with an F-value of 26.580 ($p<0.001$) for the number of projects and an F-value of 10.178 ($p=0.001$) for the number of employees. This implies that e-commerce adoption is strongly associated with increased project involvement and larger workforce sizes, likely reflecting the broader market reach and operational complexity of those willing to branch into digital sales.

Table 4. ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Number of projects	Between Groups	11.599	1	11.599	26.58	0
	Within Groups	2423.165	5553	0.436		
	Total	2434.764	5554			
Number of employees	Between Groups	8363.516	1	8363.516	10.178	0.001
	Within Groups	3161234	3847	821.74		
	Total	3169597	3848			

Source: Authors' own research.

These findings carry important implications for digitalization strategies in the agricultural sector. The significantly larger workforce and project engagement among e-commerce adopters suggest that digitalization facilitates business expansion and diversification. This analysis underscores the transformative potential of e-commerce in enhancing business performance, reinforcing the urgency of fostering digital inclusion within Bulgaria's agricultural economy.

The relationship between business size and e-commerce adoption further illustrates the structural dynamics of digitalization in agriculture, as shown in Table 5.

Table 5. Structure of companies by number of employed

		e-shops		Total	Share of enterprises with e-shops
		No	Yes		
Large (over 250)	Share of the vertical	0.20%	1.90%	0.20%	18.18%
Medium (50-249)	Share of the vertical	2.30%	6.50%	2.40%	5.26%
Small (10-49)	Share of the vertical	15.80%	30.60%	16.10%	3.70%
Micro (1-9)	Share of the vertical	48.30%	60.20%	48.50%	2.41%
Empty Shell (0)	Share of the vertical	33.40%	0.90%	32.80%	0.05%
Total		100.00%	100.00%	100.00%	1.94%

Source: Authors' own research.

The analysis reveals that e-commerce adoption is low, with only 1.94% of firms operating e-shops. Large enterprises (over 250 employees) lead with an 18.18% adoption rate, despite making up just 0.20% of firms, likely due to greater resources and strategic focus.

Medium-sized firms (50-249 employees) show a 5.26% adoption rate, while small (10-49 employees) and micro-enterprises (1-9 employees), representing 16.10% and 48.50% of firms, have lower adoption rates (3.70% and 2.41%, respectively), hindered by limited resources and digital literacy.

A significant 32.80% of firms are empty shell companies, with minimal operations and an adoption rate of just 0.05%. Despite low individual adoption, micro-enterprises contribute 60.20% of e-shop adopters due to their sheer number.

Table 6. Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	74.531a	4	0
Likelihood Ratio	87.651	4	0
N of Valid Cases	5555		
a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is .21.			

Source: Authors' own research.

The Pearson Chi-Square test ($\chi^2 = 74.531$, $p < 0.001$) and the Likelihood Ratio test ($\chi^2 = 87.651$, $p < 0.001$) in Table 6 confirm that company size significantly influences e-commerce adoption, ruling out random variation. While 20% of cases have expected counts below five, this does not affect the overall validity but suggests a more detailed dataset could refine the analysis.

These findings underscore the need for targeted support for micro and small enterprises, which show strong digital potential but may require financial or technical assistance to optimize their e-commerce operations. The low engagement of large firms and empty shell companies suggests that while e-commerce is an effective growth strategy for agile businesses, structural barriers may prevent its widespread adoption across all enterprise sizes.

E-Commerce Adoption and Financial Performance in Bulgarian Agricultural Enterprises

We found no significant impact of e-commerce adoption on profitability, efficiency, or liquidity. Firms without e-shops have an average ROE and ROA of 5.32 but exhibit high financial volatility (SD = 407.20), while e-commerce firms report slightly negative ROE and ROA (-1.81), likely due to early-stage investment costs. However, t-tests ($p = 0.864$) confirm no statistical difference between the two groups.

Liquidity remains unchanged, with both groups maintaining a current ratio of 1.00. Revenue per employee is higher for traditional firms (€70,312 vs. €64,508) but with greater unpredictability (SD = €170,364 vs. €87,784). Similarly, the profit-to-operating revenue ratio is -40.67% for non-e-commerce firms vs. -1.35% for digital adopters, yet statistical tests ($p = 0.799$) show no significant difference.

While profit per employee remains similar (€6,655 vs. €6,481), e-commerce firms demonstrate better financial control with a less negative net profit margin (-1.35% vs. -40.67%). However, the lack of statistical significance across key financial indicators suggests that e-commerce alone does not drive financial success. Instead, long-term benefits may emerge through enhanced stability and market positioning, warranting further research on external factors such as digital infrastructure, training, and consumer demand.

Logistic Regression Results

The logistic regression analysis based on a dataset of 5,555 companies, with 2,779 companies (50%) included in the analysis and 2,776 companies (50%) excluded due to missing data. Initially, all companies were included, but after applying exclusion criteria—specifically removing companies founded after 2023 due to incomplete data, the dataset shrank to 5,094 companies. This adjustment excluded 45.4% of the cases.

Next, filtering out companies without employee data resulted in a final dataset of 3,849 companies, or 72.2% of the sample. The final dataset used for the logistic regression contained only those companies with both financial and employee data.

For the e-commerce adoption model, the initial classification table revealed that the model predicted all companies as non-e-shops, with an overall classification accuracy of 97.1%. However, the model failed to detect any e-shop companies, yielding 0% sensitivity for predicting e-shops. This significant class imbalance, with most companies not having e-shops, caused a skewed result despite the high accuracy.

Similarly, in the EU project participation model, the classification table showed an overall accuracy of 76.9%, but the model again failed to identify any companies with projects (0% sensitivity), as it classified all companies as not having projects. This indicates a severe class imbalance and the need for improved predictive techniques.

Overall, both models exhibited high accuracy due to the dominance of the majority class (non-e-shops and companies without projects), but they were ineffective at detecting the minority class (e-shops and companies with projects).

Qualitative Findings

Our market research reveals that only 1 in 10 farmers in Bulgaria have an online presence (website or social media), primarily used to inform returning customers about stock, presence at market locations, and offering the option for product reservations. However, online payments are rarely accepted, as most transactions are cash-based upon collection, exempting them from National Revenue Agency (NRA) registration. The majority of farmers rely on traditional cash transactions upon collection of goods, which means they are not required to register with the National Revenue Agency (NRA) for online sales. This practice reflects a strong preference for maintaining established customer relationships and the convenience of informal payment systems. Even farmers offering delivery services prefer phone-based order placement with cash on delivery, reflecting a cautious approach to digital tools while maintaining traditional customer interactions. A key reason for this preference for cash transactions is the avoidance of tax reporting obligations. While official courier services are required to report payments transferred to sellers, many farmers bypass these systems by performing their own deliveries, ensuring that transactions remain informal and unregistered. This minimizes tax liabilities but also contributes to limited financial transparency and exclusion from formal funding opportunities.

This limited use of e-commerce tools suggests several underlying challenges. These include a lack of technical knowledge, skepticism about the security and reliability of online payments, and a preference for maintaining personal relationships with customers. Additionally, the absence of NRA registration for many farmers signals a need for clearer regulatory frameworks and incentives to support the transition toward digital operations. Addressing these challenges through targeted education, subsidies for digital tools, and simplified regulatory requirements could enhance the adoption of comprehensive e-commerce solutions within the agricultural sector. This would allow farmers to expand their customer base, streamline operations, and increase revenue opportunities while maintaining their traditional values and customer relationships.

Discussion

This study provides key insights into e-commerce adoption in Bulgaria's agricultural sector, revealing low participation despite the broader digital transformation. Only 108 out of 5,555 active

agricultural firms have registered e-shops, highlighting structural and behavioral barriers to digital integration.

A regional divide is evident, with higher e-commerce adoption in the south due to better logistics, infrastructure, and market access ($p = 0.003$). Firm size and EU-funded projects also influence adoption, as micro and small enterprises are more engaged in digital trade, while larger firms lag due to supply chain complexities. Businesses involved in EU projects are more likely to adopt e-commerce, suggesting that structured funding supports digital transformation.

However, financial performance indicators (ROE, ROA, revenue per employee, net profit margin) show no significant link to e-commerce adoption. While e-commerce firms experience lower financial volatility, immediate profitability gains are not guaranteed.

Qualitative findings reveal that many farmers rely on informal digital engagement (social media, phone transactions) rather than full e-commerce, driven by regulatory concerns, a gap in the digital literacy, and consumer preferences. The logistic regression model further confirms that traditional financial metrics poorly predict e-commerce adoption, with EU project participation ($p = 0.044$) being the only significant factor.

Conclusion

This study contributes to the growing discourse on digitalization in agriculture by offering empirical evidence on the current state of e-commerce adoption in Bulgaria. The results highlight the fragmented and regionally uneven nature of e-commerce adoption, with rural areas, micro-enterprises, and firms lacking external funding facing significant barriers to online commerce. While the financial benefits of e-commerce adoption are not immediately evident, the findings suggest that digital engagement fosters operational stability and market expansion potential.

The regional digital divide, compounded by infrastructural limitations and logistical constraints, calls for targeted policy interventions to bridge the gap. Improving digital infrastructure, offering financial incentives for e-commerce adoption, and providing training programs for agricultural entrepreneurs could accelerate digitalization in the sector.

The study also underscores the role of EU-funded projects in promoting e-commerce adoption. Firms participating in structured funding and support programs are more likely to engage in digital trade as their production capacity is often increased, suggesting that integrating e-commerce training and technology adoption incentives into EU initiatives could yield positive results. However, while EU funding has been instrumental in supporting innovation, many SMEs remain excluded due to complex application processes, lack of awareness, and administrative burdens. Addressing these gaps in funding accessibility could accelerate the integration of e-commerce in the agricultural sector across Bulgaria and other EU member states.

Future research should explore longitudinal trends in e-commerce adoption to assess whether continued digital investment leads to sustained profitability and market growth. Additionally, incorporating qualitative insights from non-adopters could offer a deeper understanding of behavioral and institutional constraints. Comparative studies across different agricultural sub-sectors may also provide valuable insights into sector-specific barriers and opportunities.

In conclusion, while the digitalization of Bulgaria's agricultural sector remains in its early stages, the findings indicate a gradual shift towards hybrid digital engagement rather than full-scale e-commerce adoption. Addressing structural, educational, and financial barriers through targeted policy support and capacity-building initiatives could foster broader digital inclusion and sustainable economic growth in rural Bulgaria.

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