Digitisation and blockchain adoption in Bulgarian animal farms

Konstantin Stoyanov[1*]

[1]Faculty of Economics, Trakia University, Stara Zagora, Bulgaria

Abstract. The agricultural sector's digital transformation presents opportunities for enhancing supply chain efficiency through blockchain technology adoption. This study investigates the relationship between current digitisation levels and blockchain adoption readiness in Bulgarian animal farms, while assessing farmers' perceptions of blockchain benefits. Data was collected through interviews and questionnaires from eighty farms across poultry, pig, and beef sectors, using stratified random sampling. A composite digitisation index measured technological adoption levels, while regression analysis evaluated relationships between farm characteristics and blockchain readiness. Results revealed a moderate positive correlation between digitisation level and blockchain adoption readiness. Farmers identified traceability as the most valuable blockchain benefit, followed by transparency, while showing limited interest in cryptocurrency applications. Farm characteristics, including size and type, showed no statistically significant influence on blockchain adoption readiness, contrary to initial expectations. These findings indicate that blockchain adoption in Bulgarian animal farming depends on factors beyond digital maturity and traditional farm characteristics. The results support the development of targeted educational programs and demonstration initiatives to facilitate technological transition in Bulgarian animal farming, particularly focusing on traceability and transparency benefits.

1 Introduction

The agricultural sector is undergoing a digital revolution, with emerging technologies reshaping traditional farming practices. Among these innovations, blockchain technology stands out for its potential to enhance traceability, transparency, and efficiency in agricultural supply chains. In Bulgaria, a country with a rich agricultural heritage, the animal farming sector faces both opportunities and challenges in adopting these cutting-edge technologies.

This study aims to investigate the current state of digitisation on Bulgarian animal farms and assess farmers' readiness to adopt blockchain technologies. By focusing on poultry, pig, and beef farms, the factors influencing technology adoption and the perceived benefits of blockchain in this crucial sector of the Bulgarian economy are highlighted.

The research is guided by three key hypotheses:

* Corresponding author: konstantin.stoyanov@trakia-uni.bg

1. Farms with higher levels of digitisation are more likely to adopt blockchain technologies.
2. Farmers perceive blockchain technology as significantly enhancing traceability and transparency in the supply chain.
3. Farm characteristics (size and type) significantly influence interest in blockchain adoption, with larger farms and those with shorter production cycles (e.g., poultry and pig farms) showing greater interest.

By examining these hypotheses, policymakers, industry stakeholders, and technology providers will be provided with valuable insights in their efforts to support the digital transformation of Bulgarian animal farming.

2 Literature review

Bauer et al. [1] examined the adoption of smart farming technologies, including IoT sensors and automated systems, on dairy farms in Germany. They found that while these technologies improved productivity and animal welfare, farmer hesitance due to cost and data security concerns limited widespread adoption. Cárdenas et al. [2] surveyed poultry farmers in Colombia, identifying internet connectivity, digital skills, and perceived usefulness as key drivers for adopting online sales platforms and traceability systems. They emphasized the importance of government support and industry collaboration to accelerate digitization. Kovács et al. [3] investigated the use of blockchain for supply chain traceability in the Hungarian beef industry. Their findings suggest that while farmers recognised blockchain's potential benefits, a lack of awareness and technical expertise posed significant barriers to implementation.

Mao et al. [4] proposed a blockchain-based framework to improve food safety and transparency in the pork supply chain in China. They highlighted blockchain's ability to enhance traceability, reduce information asymmetry, and build consumer trust. Khanna et al. [5] explored the use of blockchain and cryptocurrencies to facilitate livestock trading and payments in rural India. Their study demonstrated the technology's potential to increase efficiency and financial inclusion for small-scale farmers. Atlam et al. [6] reviewed the application of blockchain in the agri-food sector, including use cases for animal welfare monitoring, food provenance, and livestock management. They identified key challenges around scalability, interoperability, and regulatory compliance.

Kamilaris et al. [7] assessed the readiness of Greek farmers to adopt precision agriculture technologies, including smart sensors and data analytics. They found that farm size, education level, and technological awareness were significant predictors of adoption. Smausz et al. [8] explored the digital maturity of Hungarian livestock farms, identifying farm size, age of the farmer, and access to extension services as key determinants of digital technology adoption. Szilagyi et al. [9] examined the adoption of blockchain technology in the Romanian dairy industry, highlighting the need for targeted education, financial incentives, and collaborative platforms to overcome farmers' scepticism and lack of technical expertise.

Gkoktsi and Gkritzali [10] investigated the role of social influence and perceived value in the adoption of smart farming technologies by Greek olive oil producers. They emphasised the importance of peer-to-peer learning and demonstration effects in the diffusion of innovation. Hernández-Ramos et al. [11] conducted a survey of Spanish pig farmers to understand their perceptions and attitudes towards blockchain technology. Their results indicated that perceived benefits, trust, and organizational support were critical factors influencing adoption intentions.

3 Methodology

To investigate our hypotheses, a survey of 80 animal farmers in Bulgaria was conducted, covering poultry, pig, and beef farms. The survey was designed to capture information on farm characteristics, current digitisation levels, and attitudes towards blockchain technology, among others.

Farms were selected using a stratified random sampling method to ensure representation across different farm types and sizes. The final sample consisted of 29 poultry farms, 18 pig farms, 21 beef farms and 12 combined farms.

Data was collected through interviews and online questionnaires. The survey included questions on:

1. Farm characteristics (type, size, years in operation)
2. Current use of digital technologies (smart devices, online sales, data management)
3. Innovations introduced in the last 3 years
4. Perceptions of blockchain technology (benefits, challenges)
5. Willingness to adopt blockchain and use cryptocurrencies

A mix of descriptive statistics, correlation analysis, regression analysis and analysis of variance (ANOVA) was employed to test the hypotheses and explore relationships between variables.

4 Results

4.1 Descriptive statistics

The sample of 80 Bulgarian animal farms showed a diverse range of characteristics and digitisation levels. The digitisation level was calculated following this pattern:

Each technology has been assigned a different weight based on its importance or complexity:

- Basic technologies (email could, descriptive website, very limited use of big data, use of basic smart devices, security systems): weight of 1
- Intermediate technologies (cloud-based software, website with purchase option, scarce use of big data, use of sophisticated smart devices, automated quality checks or cleaning systems): weight of 1.5
- Advanced technologies (cloud-based enterprise data hosting, purchase and order tracking website option, regular use of big data, use of complex smart systems, automated food distribution): weight of 2

As there were identified 15 possible technologies, the maximum raw score for each farm would be 5 times the weight of 2, which would be 10. In order to normalise it to the scale (0-100) of the composite index each farm's raw score shall be compared to the maximum possible score, using the formula (Farm's raw score / Maximum possible score)*100.

Table 1. Sample Characteristics

Farm Type	Number	Average Size (employees)	Average Digitisation Index
Poultry	29	58	59.66
Pig	18	52	49.17
Beef	21	46	42.52
Combined farms	12	18	52.5

The average digitisation level index across all 80 farms is of 50,81.

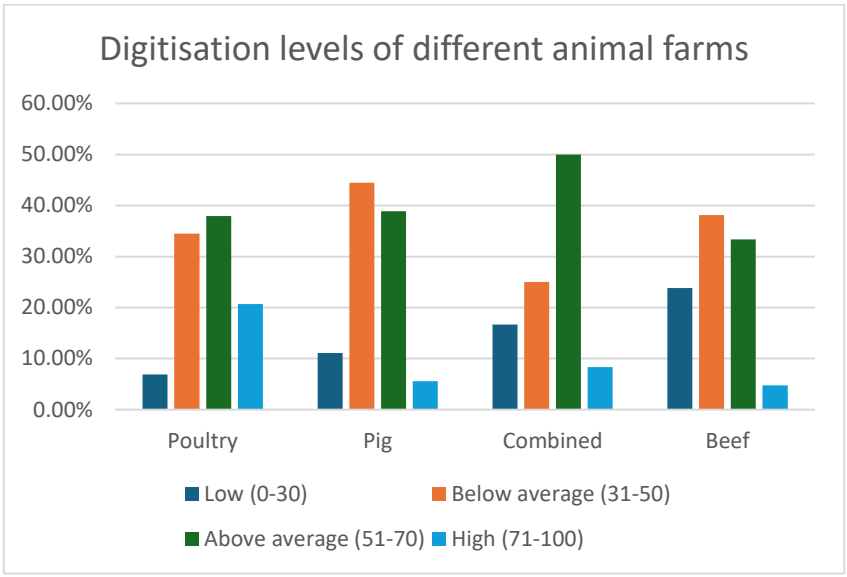

Fig. 1. Proportion of Farms at Different Digitisation Levels

The data reveals that poultry farms in this sample tend to be larger and have higher digitisation levels, followed by combined farms and pig farms, with beef farms generally less digitised.

4.2 Hypothesis Testing

H1: Farms with higher levels of digitisation are more likely to adopt blockchain technologies.

A relatively moderate positive correlation between digitisation level and blockchain adoption readiness is found ($r = 0{,}34$, $p < 0{,}002$). The scatter plot shows the relationship between Digitisation Level (X-axis) and Blockchain Adoption Readiness (Y-axis).

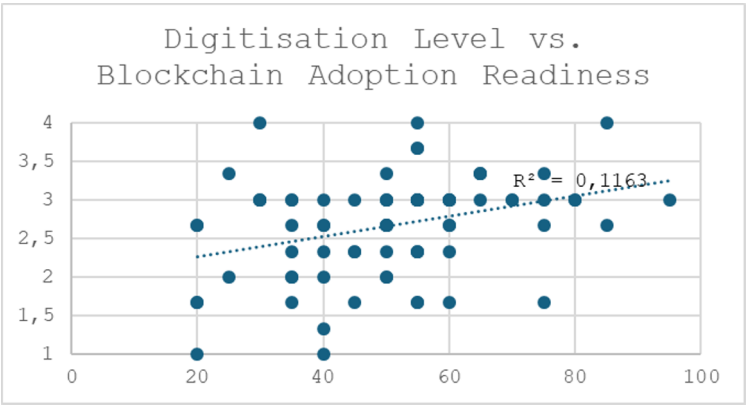

Fig.2. Digitisation Level vs. Blockchain Adoption Readiness

Note: Lower values on the Y-axis indicate higher blockchain adoption readiness

The R^2 value of 0.1163 indicates that about 11.63% of the variability in blockchain adoption readiness can be explained by the digitisation level. Points are scattered across the chart, showing considerable variation. Some vertical "stacking" of points occurs at certain X-values, indicating multiple farms with the same digitisation level but varying readiness. A few farms with low digitisation levels (0-20 range) show surprisingly high readiness for blockchain adoption.

The data does support the hypothesis "Farms with higher levels of digitisation are more likely to adopt blockchain technologies." As digitisation levels increase (moving right on the x-axis), there's a general trend towards lower y-values, which in this case means higher readiness. The relationship suggests that investing in general digitisation might prepare farms for more advanced technologies like blockchain. However, the weak R^2 value implies that digitisation alone doesn't guarantee blockchain readiness. Other factors (e.g., farm size, management attitudes, specific industry needs) likely play significant roles. The agricultural sector's path to blockchain adoption appears to be influenced by a complex interplay of factors beyond just digital maturity.

H2: Farmers perceive blockchain technology as significantly enhancing traceability and transparency in the supply chain.

Table 2. Mean Scores for Perceived Benefits of Blockchain

Benefit	Mean Score (1-4)	Standard Deviation
Enhanced Traceability	3.50	0.79
Improved Transparency	2.95	1.08
Use of cryptocurrencies	1.55	0.96

The low mean scores for traceability and transparency support our second hypothesis, indicating that farmers recognize these as key benefits of blockchain technology. The lower values are indicating higher adoption readiness. Farms were asked to evaluate their readiness on the scale from 1 to 4, where 1 is “Not at all” and 4 is “Extensively”.

Enhanced traceability is seen as the most beneficial aspect of blockchain technology. The high mean score of 3,50 suggests that respondents generally view this as a very significant benefit. The relatively low standard deviation indicates there's a fair amount of agreement among respondents on this point. Improved transparency is also seen as beneficial, though slightly less so than traceability. The mean score of 2,95 indicates a relatively high perceived benefit. However, the higher standard deviation suggests more varied opinions among respondents compared to traceability. Some may see it as highly beneficial, while others are less convinced. The use of cryptocurrencies is perceived as the least beneficial among these three aspects. The low mean score of 1,55 suggests that respondents generally do not see this as a significant benefit of blockchain in their context. The standard deviation is moderate, indicating some variation in opinions, but generally less divided than views on transparency.

The findings support H2: Farmers perceive blockchain technology as significantly enhancing traceability and transparency in the supply chain. These insights can guide future research and practical applications by highlighting the importance of traceability and transparency in blockchain adoption among farmers.

H3: Farm characteristics significantly influence interest in blockchain adoption.

To test the third hypothesis several tests were ran using Multiple regression analysis, including an ANOVA analysis to test the effect of farm characteristics and type on blockchain interest.

Model 1: Blockchain Acceptance vs. Number of Employees and Farm Type

The key variables in this model were the Number of employees, Poultry, Pig, and Beef farms, as Combined farms were used as the reference group. None of the predictors are statistically significant, with p-values well above 0.05. Poultry farms show a slight trend

towards higher readiness, while Pig and Beef farms show lower readiness. However, these effects are not significant. In general, the number of employees and farm type do not have a meaningful impact on blockchain readiness.

Model 2: Blockchain Acceptance vs. Planned Investment in Digitisation and Farm Type

The key variables in this model were Planned investment in digitisation, Poultry, Pig, and Beef farms, as Combined farms were used as the reference group. While farms without digitisation plans tend to show lower blockchain readiness, this relationship is not statistically significant ($p = 0.1339$). Poultry farms again show a slight trend towards higher readiness, while Pig and Beef farms show lower readiness, but none of these effects are significant. Lack of digitisation investment may indicate lower blockchain readiness, but this relationship is not significant. Farm type continues to show no clear impact on blockchain adoption readiness.

Model 3: Blockchain Acceptance vs. Digitisation Level and Farm Type

The key variables in this model were Level of digitization, Poultry, Pig, and Beef farms as Combined farms were used as the reference group. Digitisation level does not significantly influence blockchain readiness ($p = 0.8434$), and farm types do not show statistically significant differences. Poultry farms continue to indicate higher readiness, while Pig and Beef farms suggest lower readiness, though all effects are insignificant. Neither digitisation level nor farm type significantly affect blockchain readiness.

Across all three models, there is no statistically significant evidence to suggest that farm type, digitisation level, number of employees, or planned investments in digitisation meaningfully influence blockchain readiness. While some trends suggest that poultry farms may be slightly more ready for blockchain adoption, and pig and beef farms less so, these results are not reliable given the high p-values.

The context of the findings may now suggest that the factors influencing blockchain readiness, such as perceived benefits, trust, and facilitating conditions, are crucial for understanding why these farms feel ready to adopt blockchain technology. This insight can guide future research and practical applications, focusing on enhancing the factors that contribute to this readiness and exploring the implications for broader adoption in agricultural practices.

In conclusion, there is no statistically significant evidence to support the hypothesis that farm characteristics, such as type, number of employees, digitisation level, and planned investment in digitisation, significantly influence interest in blockchain adoption. The factors influencing blockchain readiness may be more related to perceived benefits, trust, and facilitating conditions, rather than the specific farm characteristics.

5 Discussion

The relatively moderate correlation between digitisation level and blockchain adoption readiness (H1) suggests that current digital practices serve as a foundation for more advanced technologies. This aligns with Kamilaris et al.'s [7] findings on the importance of technological awareness in adoption decisions. It implies that efforts to increase general digitization in farming could pave the way for blockchain adoption.

The high perceived benefits of blockchain for traceability and transparency (H2) echo the findings of Mao et al. [4] in the Chinese pork industry. Bulgarian farmers seem to recognize blockchain's potential to address key challenges in the supply chain. This perception could be a significant driver for adoption, particularly if coupled with practical demonstrations of these benefits.

The lack of influence of farm characteristics on blockchain interest among Bulgarian farmers (H3) I sin contrast with Bauer et al.'s [1] observations on smart farming adoption,

likely due to their greater resources and potential for scaling benefits. The suggestion that higher interest from poultry and pig farms compared to beef farms might be attributed to their shorter production cycles and potentially higher turnover, making traceability more critical, was not statistically significant in this study.

In general, those findings have several implications:

1. Policymakers should consider targeted support for smaller farms to prevent a digital divide in the industry.
2. Education and awareness programs should focus on practical applications of blockchain, particularly in enhancing traceability and transparency.
3. Technology providers might find early adopters among larger poultry and pig farms, which could serve as case studies for the broader industry.

6 Conclusion and recommendations

This study provides a comprehensive view of digitisation and blockchain readiness in Bulgarian animal farming. It found that:

1. Higher digitisation levels correlate with greater blockchain adoption readiness.
2. Farmers perceive significant benefits in blockchain's ability to enhance traceability and transparency.
3. Larger farms and those with shorter production cycles show more interest in blockchain adoption.
4. Blockchain's potential for enhancing traceability is clearly seen as its most valuable benefit, with strong agreement among respondents.
5. Improved transparency is also viewed positively, though with more diverse opinions.
6. The use of cryptocurrencies is not perceived as a significant benefit in this context, possibly indicating that the non-financial aspects of blockchain technology are more valued in this sector or among these respondents.

The results suggest that efforts to implement blockchain technology in this field should focus on its traceability and transparency benefits, while the cryptocurrency aspect might be less emphasised or relevant for the target audience. Based on these findings, are the following recommendations:

1. Developing policies to support digital transformation across all farm sizes to create a foundation for advanced technology adoption.
2. Creating educational programs that highlight the practical benefits of blockchain in enhancing traceability and transparency in the supply chain.
3. Initiating pilot projects with larger poultry and pig farms to demonstrate blockchain's potential and generate case studies.
4. Exploring ways to make blockchain technology more accessible and beneficial for smaller farms to ensure inclusive growth in the sector.

In conclusion, while there is a statistically significant positive relationship between digitisation level and blockchain adoption readiness in Bulgarian animal farming, the relationship is not very strong. This suggests that while digitisation may facilitate blockchain adoption, it's not the only or even the primary factor determining a farm's readiness to adopt blockchain technologies. The agricultural sector's path to blockchain adoption appears to be influenced by a complex interplay of factors beyond just digital maturity. By addressing the identified factors and leveraging existing digitisation efforts, the sector can move towards a more transparent, efficient, and technologically advanced future.

Any future research on the topic shall concentrate on investigating outliers (highly digitised farms with low readiness and vice versa) that could provide insights into other

influential factors. A multivariate analysis including other potential factors could offer a more comprehensive understanding of blockchain adoption readiness in Bulgarian animal farms.

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