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AN EMPIRICAL ANALYSIS OF THE IMPORTANCE OF FARMERS' MOTIVATION AND AGRICULTURAL INNOVATION FOR THE DEVELOPMENT OF AGRICULTURAL HOLDINGS IN THE REPUBLIC OF NORTH MACEDONIA

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Abstract: *The aim of this study was to examine the impact of farmers' motivation and agricultural innovations on the development of agricultural holdings in the Republic of North Macedonia. The research was conducted on a sample of 426 farmers using a structured questionnaire and a five-point Likert scale, with data analyzed through descriptive statistics and regression analysis. The results indicate a high level of farmers' motivation and a significant presence of innovations in agricultural production. Additionally, the findings show that farms achieve stable business performance, maintain a good level of organization, and produce satisfactory-quality outputs. Regression analysis confirmed a statistically significant positive effect of both farmers' motivation and agricultural innovations on farm development, with innovations exerting a stronger influence, while motivation serves as an important supporting factor. These results demonstrate that the combination of human capital and the application of innovations form the foundation for improving efficiency, competitiveness, and sustainability in agricultural production. The findings carry important practical implications for the enhancement of agricultural development strategies in the Republic of North Macedonia.*

Keywords: *farmers' motivation, agricultural innovation, agricultural holding development*

JEL classification*: Q1, Q12, Q12, O30, O31*

INTRODUCTION

"Contemporary agriculture is undergoing intensive modernization and digital transformation aimed at increasing productivity, improving efficiency, and achieving sustainable development of agricultural holdings" . "In North Macedonia, the agricultural sector faces challenges such as lower productivity, limited investment in research and development, and slow adoption of innovations, negatively affecting sustainability and competitiveness" . The subject of this research is the factors influencing the development of agricultural holdings, with particular emphasis on farmers' motivation and innovation adoption. The objective of this research is to determine the extent to which farmers' motivation and innovation adoption contribute to the development of agricultural holdings in the Republic of North Macedonia. Research tasks include: analyzing farmers' motivation and its impact on business performance; examining the degree of innovation and modern technology adoption in agriculture; assessing the development level of holdings in terms of financial stability, organization, and sustainability; determining the relationship between motivation, innovation, and holding development; testing the hypotheses and quantifying the contribution of motivation and innovation to agricultural holding development. Research methods include a combination of quantitative and qualitative approaches. Data were collected through a structured survey of 426 farmers in North Macedonia, using a five-point Likert scale to measure attitudes. The analysis included descriptive statistics, regression analysis, and hypothesis testing to examine the role of motivation and innovation in agricultural holding development.

LITERATURE REVIEW

"When examining the sustainable development of agricultural holdings, it is essential to adopt a systemic perspective that integrates natural, economic, technological, and social factors shaping their overall functioning". "Natural conditions, including soil quality, availability of water resources, and the agroecological characteristics of a region, constitute the foundation of the production potential of each holding". "In addition, climatic characteristics - such as temperature regimes, precipitation distribution, and the frequency of extreme weather events - significantly affect the stability and productivity of agricultural production". "The demographic profile of the agricultural population, encompassing age structure, educational attainment, and labor engagement, is crucial for the adoption of new technologies and the improvement of production processes".

"The economic sustainability of agricultural holdings depends on ownership structure, technical equipment, and market access" . "Simultaneously, the institutional framework - including taxation policy, access to financial resources, educational initiatives, and support for innovation - exerts a strong influence on agricultural development and competitiveness" . Market stability, product price volatility, and credit availability further shape producers' investment decisions and the long-term sustainability of production.

"Beyond material and institutional determinants, psychological factors - particularly producers' motivation - play a pivotal role in achieving business performance in agricultural holdings" . "Motivation directly influences farmers' willingness to implement innovations, reorganize work processes, and expand production" . "Empirical studies indicate that education, resource availability, and the perceived benefits of innovation significantly determine farmers' readiness for modernization"

Producers' motivation also affects the development trajectory of holdings, their cooperation with other producers, and their integration into market systems. "Greater market concentration may facilitate the adoption of innovation due to improved access to capital and advanced technologies" . "Agricultural innovation encompasses improvements in production processes, work organization, and the application of new technologies, thereby enhancing efficiency and reducing production costs" .

"Technological development in agriculture represents a continuous process of transforming traditional methods into modern systems, including mechanization, irrigation, fertilizer application, and digital tools, leading to increased productivity and operational efficiency" . "Innovation contributes to economic growth, poverty reduction, and employment generation, particularly in developing countries"

In European countries, "agriculture has undergone intensive modernization processes aimed at improving productivity and efficiency, involving the adoption of advanced technologies, enlargement of farm size, and improved production organization" . However, "the degree of modernization varies across countries, with transition economies facing additional challenges related to investment capacity and technological advancement" .

"The agricultural sector of North Macedonia represents a significant component of the national economy, particularly in terms of employment and exports; however, productivity remains lower compared to developed countries due to limited investment in research and development and slower innovation adoption" . Although modernization trends are evident, further improvements in technological capacity and institutional support for innovation are necessary.

Contemporary agriculture is undergoing transformation driven by digital technologies. "The application of information systems, automation, and data analytics enables more precise resource management and greater production efficiency" . This process, commonly referred to as the digital transformation of agriculture, has become a key element of sustainable development.

"Environmental sustainability requires the rational use of resources, reduction of negative environmental impacts, and adaptation to climate change" . "Climate change constitutes one of the most significant challenges, as it directly affects yields, product quality, and production stability" .

"Small agricultural holdings play a substantial role in global food production and represent a critical component of food security, particularly in developing countries" . "Productivity disparities between developed and developing countries highlight the necessity of broader implementation of innovation and advanced technologies" .

"The concept of smart agriculture encompasses the use of digital technologies, sensors, artificial intelligence, and data analytics to optimize production and enhance decision-making processes" . "Precision agriculture enables more efficient resource utilization and yield enhancement while reducing environmental impacts" . "The implementation of advanced technologies, including artificial intelligence, robotics, and the Internet of Things, significantly contributes to agricultural efficiency and sustainability" . However, "digitalization also entails risks, such as data security concerns and dependence on technological infrastructure, thereby necessitating appropriate risk management strategies" .

METHODOLOGY

The research sample consisted of 426 respondents from the territory of the Republic of North Macedonia. The theoretical research model, including the presentation of the study variables, is shown in Figure 1. Data were collected using a structured survey questionnaire in which respondents expressed their attitudes toward the stated claims. Attitudes were measured using a five-point Likert scale (1 - strongly disagree, 2 - disagree, 3 - neutral, 4 - agree, 5 - strongly agree).

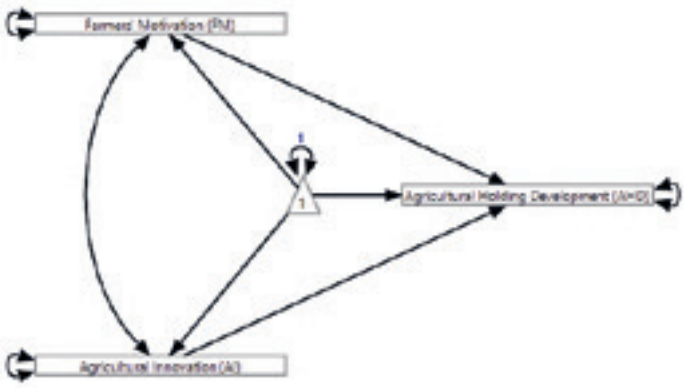
The study examines the mediating role of farmers' motivation and the implementation of innovation in agriculture, as well as their joint effect on the development of agricultural holdings. Through the analysis of quantitative and qualitative indicators, key factors that stimulate the sustainable growth of the sector were identified.

The independent variables in the study are: Farmers' Motivation (FM) and Agricultural Innovation (AI). The dependent variable is Agricultural Holding Development (AHD). The objective of the research is to determine whether farmers' motivation and the implementation of innovation significantly affect the development of agricultural holdings.

The general research hypotheses are formulated as follows:

- H_0: Farmers' motivation and agricultural innovation do not affect the development of agricultural holdings.
- H_1: Farmers' motivation and agricultural innovation affect the development of agricultural holdings.

Figure 1. Theoretical Research Model



Source: Authors' calculation

EMPIRICAL DATA

The majority of surveyed farmers are women (64.79%), while men account for (35.21%), indicating a significant role of women in agriculture within the observed sample. The most represented age group is 33 to 50 years (39.67%), suggesting that the majority of active producers are in their prime working age. Farmers aged 18 to 32 constitute (27.23%) of the sample, those between 51 and 65 years account for (29.34%), while respondents older than 65 represent only 3.76%.

Regarding educational attainment, most respondents possess primary or secondary education (59.39%), whereas (40.61%) have completed higher education (col-

lege or university degree). A higher level of education may facilitate the adoption of modern technologies and innovations, as more educated producers tend to accept new methods more readily and optimize production processes more effectively.

The analysis of work experience indicates that (35.45%) of farmers have up to 10 years of experience, (25.59%) between 11 and 20 years, (22.77%) between 21 and 30 years, and (16.20%) have more than 30 years of experience. These data suggest a balanced combination of young, moderately experienced, and highly experienced producers, which may influence both motivational dynamics and the readiness to implement innovations.

All information regarding the farmers' profile is presented in Table 1.

The demographic profile of the respondents suggests that farmers differ in terms of age and educational attainment, with relatively balanced levels of professional experience. This heterogeneity may represent a key factor in understanding their motivation for innovation and their capacity to improve and develop agricultural holdings.

Table 1. Farmers' Profile

Gender of the farmer	**N**	**Percentage**
man	150	35.21
woman	276	64.79
Age of farmers	**N**	**Percentage**
from 18 to 32 years old	116	27.23
from 33 to 50 years old	169	39.67
from 51 to 65 years old	125	29.34
over 65 years old	16	3.76
Level of education of farmers	**N**	**Percentage**
primary or secondary education	253	59.39
higher or higher education	173	40.61
Years of work experience in agriculture	**N**	**Percentage**
up to 10 years old	151	35.45
from 11 to 20 years old	109	25.59
from 21 to 30 years old	97	22.77
over 30 years old	69	16.20
Total	**426**	**100.00**

Source: Authors' calculation

Table 1 presents the statements and the distribution of respondents' attitudes regarding Farmers' Motivation (FM). The majority of respondents express a highly positive attitude toward agriculture, perceiving it as a source of pride, a stable source of income, and an opportunity for both personal and professional development. Farmers demonstrate a willingness to invest additional effort and financial resources into improving their holdings, while also benefiting from strong support from family and the local community. Although a certain degree of caution exists concerning the future of the sector, the overall trend indicates a high level of optimism, motivation, and commitment to agricultural activities.

Table 1. Statements for Farmers' Motivation (FM)

Farmers' Motivation (FM)	1	2	3	4	5
Agriculture gives me a sense of pride and satisfaction.	0	6	32	149	239
I believe he can provide enough money to live on.	3	1	44	145	233
I invest extra effort in successfully running the farm.	0	11	36	149	230
I plan to improve the farm through investments in the next three years.	3	4	26	176	217
I am convinced that agriculture in our country has a future.	1	7	62	165	191
I am motivated by the possibility of expanding the business to new markets.	0	4	37	158	227
I have strong support from my family and environment.	0	2	39	132	253

Source: Authors' calculation

The analysis of dominant values for Farmers' Motivation (FM) (Table 2) further illuminates respondents' attitudes. The findings indicate a high level of motivation and commitment to agriculture, a willingness to invest additional effort and financial resources, and a strong sense of support from family and the local community. These results suggest that farmers' motivation constitutes a key factor influencing their readiness to adopt innovations and improve agricultural holdings.

Table 2. Dominant Values for Farmers' Motivation (FM)

Statement	Dominant Values	Description
Agriculture gives me a sense of pride and satisfaction.	4=149, 5=293	Most respondents feel a strong sense of pride and satisfaction in engaging in agriculture, indicating a strong emotional connection to their work and farmer identity.
I believe he can provide enough money to live on.	4=145, 5=233	Most respondents believe agriculture can be a stable source of income, although a small number expressed some uncertainty (ratings 1–3).
I invest extra effort in successfully running the farm.	4=149, 5=230	Respondents show a very positive attitude toward extra engagement, demonstrating readiness to dedicate additional work to managing their holdings.
I plan to improve the farm through investments in the next three years.	4=176, 5=217	This statement records the highest level of commitment, highlighting respondents' strong willingness to plan and implement investments to enhance their agricultural holdings.
I am convinced that agriculture in our country has a future.	4=165, 5=191	Respondents show moderate yet positive optimism regarding the future of the agricultural sector; a slightly higher number of neutral responses (62 respondents rated 3) suggests some uncertainty regarding broader market and policy conditions.
I am motivated by the possibility of expanding the business to new markets.	4=158, 5=227	Respondents display a pronounced entrepreneurial spirit, recognizing opportunities for business growth and expansion.
I have strong support from my family and environment.	4=132, 5=253	This statement shows the strongest agreement, emphasizing the importance of family and community support in motivating farmers and fostering willingness for additional engagement.

Source: Authors' calculation

Table 3 presents the statements and the distribution of respondents' attitudes regarding Agricultural Innovation (AI). The results indicate that farmers actively implement modern technologies and methods across various segments of production, including mechanization, digital tools, agronomic practices, new crop varieties, marketing strategies, and collaboration with other stakeholders. The majority of respondents demonstrate a high level of willingness to improve production processes and effectively apply innovations.

Table 3. Statements for Agricultural Innovation (AI)

Agricultural Innovation (AI)	1	2	3	4	5
I use modern machinery and equipment in my daily work.	19	20	67	164	156
I implement digital tools for record keeping on the farm.	9	24	83	173	137
I am introducing modern agrotechnical measures into production.	33	38	72	228	55
I grow new cultures and varieties with better performance.	42	46	58	226	54
I use modern methods of marketing and selling agricultural products.	29	45	60	229	63
I regularly improve my skills in the field of new technologies and practices in agriculture.	16	31	50	261	68
In order to improve the business, I cooperate with other farms and institutions.	3	3	22	386	12

Source: Authors' calculation

The analysis of dominant values for Agricultural Innovation (AI) (Table 4) further clarifies farmers' attitudes. The results indicate that respondents in the studied sample actively implement innovations across various segments of production, ranging from technology and agronomic practices to marketing and collaboration. There is a high level of readiness to adopt modern methods, although some variability is observed in the implementation of specific measures, particularly regarding the introduction of new crops and agronomic practices. These data provide a basis for further linking farmers' motivation (FM) with the adoption of agricultural innovations (AI) in the context of agricultural holding development (AHD).

Table 4. Dominant Values for Agricultural Innovation (AI)

Statement	Dominant Values	Description
I use modern machinery and equipment in my daily work.	4=164, 5=156	Most respondents actively use modern mechanization, indicating a high level of technical innovation in daily work. A smaller number rated 1–3, which may reflect limited access to equipment or varying production scales.
I implement digital tools for record keeping on the farm.	4=173, 5=137	Respondents show a high level of adoption of modern agronomic practices, although a moderate number gave neutral or lower ratings, suggesting potential limitations in resources or knowledge.
I am introducing modern agrotechnical measures into production.	4=228, 5=55	Most respondents introduce new crops and varieties to increase yields and productivity, although a notable portion expressed neutral attitudes (ratings 1–3).

I grow new cultures and varieties with better performance.	4=226, 5=54	The majority of respondents employ modern marketing methods, demonstrating awareness of the importance of sales and market competitiveness.
I use modern methods of marketing and selling agricultural products.	4=229, 5=63	Respondents show a strong commitment to self-improvement and staying updated on new technologies and practices, enhancing their readiness to implement innovations.
I regularly improve my skills in the field of new technologies and practices in agriculture.	4=261, 5=68	Most respondents actively collaborate with other farms and relevant institutions, reflecting a well-developed network for knowledge exchange and innovation adoption.
In order to improve the business, I cooperate with other farms and institutions.	4=368, 5=12	Most respondents actively use modern mechanization, indicating a high level of technical innovation in daily work. A smaller number rated 1–3, which may reflect limited access to equipment or varying production scales.

Source: Authors' calculation

Table 5 presents the statements and the distribution of respondents' attitudes regarding Agricultural Holding Development (AHD). The results indicate that the majority of farmers achieve stable financial outcomes, utilize modern equipment, organize their operations systematically, and maintain attention to product quality and sustainable production practices.

Table 5. Statements for Agricultural Holding Development (AHD)

Agricultural Holding Development (AHD)	1	2	3	4	5
My farm generates stable and growing income year after year.	8	5	37	172	204
Production is competitive on the domestic and foreign markets.	28	31	71	210	86
The farm has modern equipment and infrastructure.	10	22	84	246	64
The operation of the farm is organized and planned.	10	22	74	214	106
The farm has access to financial resources for further development.	3	24	68	205	126
Product quality meets customer requirements.	2	19	71	212	122
The farm achieves good results in the conservation of natural resources and sustainable production.	11	26	89	219	81

Source: Authors' calculation

The analysis of dominant values regarding Agricultural Holding Development (AHD) (Table 6) indicates that the sampled farms achieve a high level of development in terms of financial sustainability, infrastructure, organizational practices, product quality, and environmental sustainability. Variability in competitiveness and access to resources may suggest the need for additional support and improvement in certain areas. These data provide a foundation for further analysis of the relationship between farmers' motivation (FM), the adoption of innovations (AI), and the development of agricultural holdings (AHD).

Table 6. Dominant Values for Agricultural Holding Development (AHD)

Statement	Dominant Values	Description
My farm generates stable and growing income year after year.	4=172, 5=204	The majority of respondents report stable and increasing income, indicating financial sustainability and effective farm management.
Production is competitive on the domestic and foreign markets.	4=210, 5=86	Respondents generally view their production as competitive, though greater variability in responses suggests differences in market position and product placement opportunities.
The farm has modern equipment and infrastructure.	4=246, 5=64	Most farms utilize modern machinery and infrastructure, contributing to more efficient operations and higher productivity.
The operation of the farm is organized and planned.	4=214, 5=106	Respondents demonstrate a high level of organization and planning, reflecting a systematic and professional approach to farm management.
The farm has access to financial resources for further development.	4=205, 5=126	The majority of respondents have access to financial resources, enabling additional investments and farm development, although a small portion reports lower scores.
Product quality meets customer requirements.	4=212, 5=122	Most farms deliver products of satisfactory quality, indicating good market adaptability and production standardization.
The farm achieves good results in the conservation of natural resources and sustainable production.	4=219, 5=81	Respondents show a strong commitment to environmental responsibility and sustainable practices, though a small group rated neutral or lower.

Source: Authors' calculation

Based on the data provided (tabel 7), the analysis of Farmer Motivation (FM) reveals a very high level of motivation, commitment, and positive attitude toward agricultural activities among the surveyed farmers. The mean values for the statements (range from 4.26 to 4.49 on a 1–5 scale), indicating that respondents generally strongly agree with the statements. The highest mean value is observed for "I have strong support from my family and environment" (M=4.493, SD=0.680, SE=0.033), highlighting the crucial role of family and community support in motivating farmers and sustaining their engagement in agricultural activities. Farmers also report a strong sense of pride and satisfaction from working in agriculture (M=4.458), as well as confidence that the sector can provide a stable income (M=4.418). High mean values are also recorded for statements related to personal effort and planning: "I invest extra effort in successfully running the farm" (M=4.404) and "I plan to improve the farm through investments in the next three years" (M=4.408), showing that farmers are willing to dedicate both time and resources to enhance the performance of their holdings.

Table 7. Descriptive Statistics for Farmers' Motivation (FM)

Statement	Mean	Stand. Deviation	Stand. Error
Agriculture gives me a sense of pride and satisfaction.	4.4577	0.6958	0.0337
I believe he can provide enough money to live on.	4.4178	0.7414	0.0359
I invest extra effort in successfully running the farm.	4.4038	0.7523	0.0365
I plan to improve the farm through investments in the next three years.	4.4084	0.7111	0.0345
I am convinced that agriculture in our country has a future.	4.2629	0.7830	0.0379
I am motivated by the possibility of expanding the business to new markets.	4.4272	0.6898	0.0334
I have strong support from my family and environment.	4.4930	0.6799	0.0329

Source: Authors' calculation

The relatively low standard deviations and standard errors suggest consistency in responses across the sample and the reliability of the data. These results confirm that farmer motivation is a strong driver for adopting innovations and achieving higher levels of agricultural holding development.

Based on the data presented in (taable 8), the analysis of Agricultural Innovation (AI) indicates a moderately high level of adoption of modern technologies and innovative practices among the surveyed farmers. The mean values for the statements (range from 3.48 to 3.98 on a 1-5 scale), reflecting active implementation of innovations, albeit with some variation across different areas of farm operations. The highest mean values are observed for the statements "I use modern machinery and equipment in my daily work" (M=3.98, SD=1.056, SE=0.051) and "In order to improve the business, I cooperate with other farms and institutions" (M=3.94, SD=0.410, SE=0.020), highlighting a significant level of technical capacity and a well-developed network of collaboration among farmers. High mean values are also recorded for "I implement digital tools for record keeping on the farm" (M=3.95) and "I regularly improve my skills in the field of new technologies and practices in agriculture" (M=3.78), indicating that farmers actively invest in enhancing both administrative and technical processes.

Table 8. Descriptive Statistics for Agricultural Innovation (AI)

Statement	Mean	Stand. deviation	Stand. error
I use modern machinery and equipment in my daily work.	3.9812	1.0559	0.0512
I implement digital tools for record keeping on the farm.	3.9507	0.9652	0.0468
I am introducing modern agrotechnical measures into production.	3.5493	1.0732	0.0520
I grow new cultures and varieties with better performance.	3.4789	1.1462	0.0555
I use modern methods of marketing and selling agricultural products.	3.5915	1.0767	0.0522
I regularly improve my skills in the field of new technologies and practices in agriculture.	3.7840	0.9281	0.0450
In order to improve the business, I cooperate with other farms and institutions.	3.9413	0.4103	0.0199

Source: Authors' calculation

The results show that farmers actively adopt innovations, particularly in mechanization, digitalization, and collaboration, while innovations related to new crops, agrotechnical measures, and marketing are less consistently applied. Relatively low standard errors across most statements confirm the stability of responses and the reliability of the data, while the standard deviations indicate some variability in the adoption of specific innovations among farmers.

Based on the data presented in (table 9), the analysis of Agricultural Holding Development (AHD) highlights several key insights regarding the performance and potential of farms in the sample. The mean values for all statements (range from 3.69 to 4.31 on a 1–5 scale), indicating generally high levels of development. The highest mean value is recorded for the statement "My farm generates stable and growing income year after year" (M=4.31, SD=0.828, SE=0.040), which emphasizes that financial sustainability and consistent income are fundamental drivers of farm development and long-term stability.

Table 9. Descriptive Statistics for Agricultural Holding Development (AHD)

Statement	Mean	Stand. deviation	Stand. error
My farm generates stable and growing income year after year.	4.3122	0.8281	0.0401
Production is competitive on the domestic and foreign markets.	3.6923	1.0767	0.0522
The farm has modern equipment and infrastructure.	3.7793	0.8475	0.0411
The operation of the farm is organized and planned.	3.9014	0.9125	0.0442
The farm has access to financial resources for further development.	4.0023	0.8636	0.0418
Product quality meets customer requirements.	4.0164	0.8216	0.0398
The farm achieves good results in the conservation of natural resources and sustainable production.	3.7817	0.9110	0.0441

Source: Authors' calculation

The data demonstrate that the sample farms achieve a high level of development, particularly in financial stability, organizational management, product quality, and access to resources. At the same time, the slightly lower performance in competitiveness and sustainability indicates the need for continued improvement to strengthen market positioning and long-term ecological resilience. The relatively low standard errors across the statements further confirm the stability of responses and the reliability of these observations.

RESULTS AND DISCUSSION

Table 10 presents the results of the regression analysis, including the ANOVA test, standardized coefficients, coefficient of determination, strength of relationships between variables, and hypothesis testing. The regression analysis demonstrates that the model is statistically significant, as confirmed by the ANOVA F-test value $F(2,423)=272.8808$, with a significance level of $p< 0.0001$. The model exhibits high statistical reliability, indicating that the independent variables-farmers' motivation (FM) and agricultural innovation (AI)-significantly contribute to explaining agricultural holding development (AHD). The coefficient of determination is $R^2=0.5636$, meaning that the model explains

56.36% of the variability in the dependent variable (AHD) based on farmers' motivation and innovation adoption. This value indicates a strong relationship between the observed variables and confirms the model's good predictive capacity. Standardized regression coefficients show that both independent variables have a positive and statistically significant impact on farm development. Agricultural Innovation (AI) has a greater effect (β=0.560) compared to Farmers' Motivation (FM) (β=0.294), highlighting that the application of modern technologies, new production methods, and collaboration with institutions represents a key factor in agricultural holding development. Farmers' motivation also exerts a significant positive effect by influencing their willingness to invest, improve production, and engage in long-term development planning.

Table 10. Regression Analysis

Variables	ANOVA	Standardized Beta Coefficient	Coefficient of Determination (%)	Strength of Relationship	Hypothesis
(FM), (AI) & (AHD)	[F(2,423)=272.8808, p<0.0001]	0.294157 0.560388	56.36	Strong	H_1: Accepted

Source: Authors' calculation

Based on the obtained results, the regression equation was formulated as follows (Equation 1):

$$(AHD) = 0.2047148 + 0.4031355 \cdot (FM) + 0.5178583 \cdot (AI) \quad (1)$$

Source: Authors' calculation

The equation indicates that increases in farmers' motivation and greater adoption of innovations lead to enhanced development of agricultural holdings, with innovations contributing more strongly.

The graphical representations of unstandardized and standardized coefficients (Figure 2, left and right) confirm that both independent variables (FM and AI) have a positive impact on the dependent variable (AHD), with innovations exhibiting the more dominant effect.

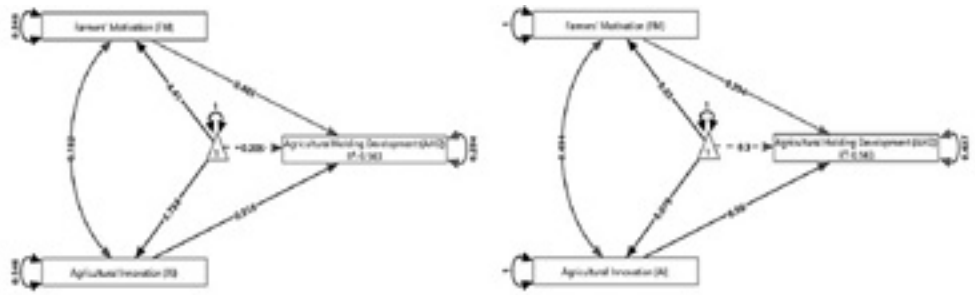


Figure 2. Unstandardized (left) and Standardized (right) Contribution Coefficients
Source: Authors' calculation

The scatter plot of actual versus predicted values (Figure 3) shows that most points are located close to the regression line, confirming the high accuracy of the model and the strong alignment between predicted and actual values.

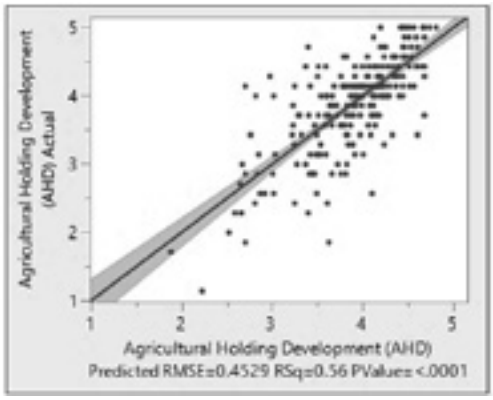


Figure 3. Multiple Linear Regression Equation Plot
Source: Authors' calculation

The graph (Figure 4) further confirms the positive relationship between farmers' motivation and agricultural holding development, as well as an even stronger relationship between innovation adoption and farm development. The results indicate that the implementation of agricultural innovations (Figure 4, right) exerts a more pronounced impact on development, while farmers' motivation (Figure 4, left) represents a crucial driving force that facilitates innovation adoption and overall business improvement.

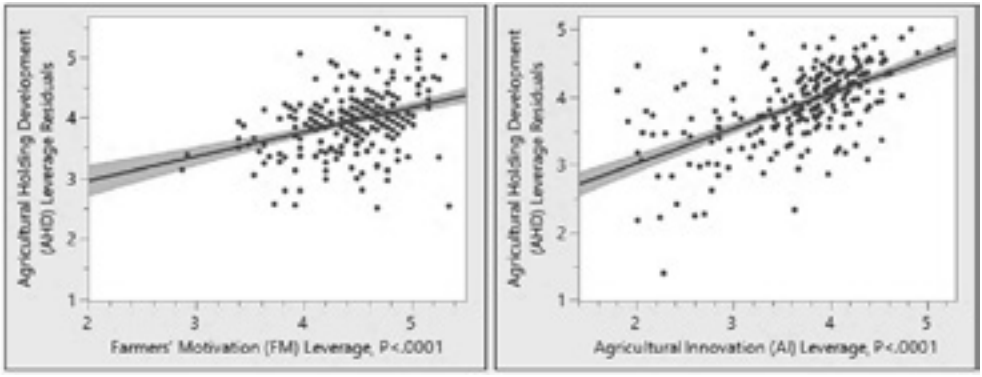


Figure 4. Regression Values Plot
Source*:* Authors' calculation

Based on the statistical and graphical results, the alternative hypothesis (H_1) is confirmed, indicating that farmers' motivation and agricultural innovations significantly influence the development of agricultural holdings. The model demonstrates a high level of reliability, and the results confirm that innovations are the key driver of development, while farmers' motivation serves as an essential foundation for their adoption and the long-term advancement of holdings.

CONCLUSION

Based on the results of the conducted research, it can be concluded that farmers' motivation, agricultural innovations, and the development of agricultural hold-

ings represent key determinants for improving business operations, competitiveness, and the sustainability of agricultural production. The findings indicate a high level of adoption of modern technologies and innovative practices among the surveyed farmers, as evidenced by the high mean values for most analyzed statements. Notably, the use of modern mechanization and equipment (M=3.98), application of digital tools (M=3.95), and collaboration with other farms and institutions (M=3.94) highlight a significant degree of technological and organizational modernization of holdings.

The results confirm that modern production and management approaches form a crucial foundation for enhancing efficiency and long-term development of agricultural holdings. Economic and development indicators are also high, with the highest mean recorded for the statement regarding stable and increasing farm income (M=4.31), reflecting a positive business trend and economic stability. High values were also observed for product quality (M=4.02), access to financial resources (M=4.00), and business organization (M=3.90), demonstrating that modern management and innovation practices strengthen market position and competitiveness. Relatively low standard errors across most statements indicate stability of responses and reliability of the results.

Regression analysis further confirms the importance of the analyzed factors for agricultural holding development. The model demonstrates high statistical significance and strong predictive power, with the coefficient of determination showing that a substantial portion of variability in farm development can be explained by the adoption of innovations and modern practices. Graphical representations, including contribution and scatter plots, confirm the positive relationship between innovation adoption and farm development, as well as a high level of alignment between predicted and actual values, reinforcing the validity and reliability of the model. The alternative hypothesis (H_1) is confirmed, indicating that farmers' motivation and agricultural innovations significantly influence the development of agricultural holdings.

The application of innovations, modern technologies, and improved organizational practices is a key factor in the development of agricultural holdings. Innovations enable increased productivity, more efficient resource use, enhanced product quality, and strengthened market competitiveness. Simultaneously, continuous farmer training, institutional collaboration, and access to financial resources further support business improvement and long-term farm development.

The results carry important practical and scientific implications for Republic of North Macedonia. They highlight the need to further promote the adoption of innovations, digitalization, and modernization in agriculture, as well as the importance of institutional support, education, and capacity building for farmers. Such measures can enhance sustainability, competitiveness, and overall agricultural sector development. Moreover, the findings provide a significant scientific basis for future research and the formulation of strategies aimed at advancing agricultural holdings through the integration of farmers' motivation, technological innovations, and modern management approaches.

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