

Revolutionizing Farming: Exploring the Complex Relationship between Agricultural Machinery, Technology Progress, and Farmers' Income in Developing Nations

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This study examines the impact of agricultural mechanization utilization, agriculture insurance, and access to extension services on farmers' income in developing nations through the role of farm productivity as a mediator. The study also investigates the moderating effect of technological advancement on the relationship between farm productivity and farmer income. The research employs a quantitative methodology, surveying Indonesian farmers. The utilization of agricultural machinery, agriculture insurance, and access to extension services positively affect farm productivity, which mediates the relationship between these factors and farmers' income, according to the analysis results. In addition, the study demonstrates that advances in agricultural technology moderate the correlation between farm productivity and farmer income. Consequently, the findings imply that policymakers should prioritize improving access to agricultural machinery, insurance, and extension services to increase farm productivity and farmers' income. In addition, policymakers must encourage the adoption of sophisticated agricultural technologies to facilitate productivity gains, particularly in developing nations.

Key words: Agricultural machinery, Agriculture Insurance, Extension Services, Farm Productivity, Farmers' Income, Agricultural Technology Progress.

1. INTRODUCTION

Agriculture plays a crucial role in the economic development of many developing countries, providing a significant portion of the population with a means of subsistence (Khan et al., 2022). Recently, policymakers and stakeholders have prioritized agricultural productivity to increase farmers' income and enhance food security (Khomiuk et al., 2020). Several factors, including the use of agricultural machinery, access to agriculture insurance, and extension services, have been identified as essential determinants of agricultural productivity to reach this objective. Using agricultural machinery refers to using agricultural apparatus and tools, such as tractors, harvesters, and irrigation systems (Mileusni et al., 2022). Access to agriculture insurance protects farmers against risks associated with crop failure, adverse weather conditions, and other unforeseen occurrences that may have a negative impact on their income (Ahmed et al., 2022). (Shangshon et al., 2023) Extension services equip farmers with the knowledge and skills to implement modern farming techniques and technologies, thereby enhancing productivity. Despite the acknowledged significance of these factors, few studies have examined their effect on farmers' income, particularly in developing countries. This study seeks to address this gap in the literature by examining the impact of agricultural machinery utilization, agriculture insurance, and access to extension services on farmers' income through the moderating effect of farm productivity. The study's emphasis on developing nations is crucial, given that most

of the world's population relies on agriculture for subsistence (Giang, 2021). However, these nations frequently encounter significant obstacles, such as limited access to credit, inadequate infrastructure, and low adoption of modern technologies, which have a negative impact on agricultural productivity and, ultimately, farmers' income (Chen et al., 2022). Additionally, agricultural technology progress refers to the rate of adoption and diffusion of modern agricultural technologies, which varies by region and country (Hu et al., 2022). Understanding the contextual factors that influence the relationship between farm productivity and farmers' income (Khan et al., 2021) necessitates an examination of the moderating effect of agricultural technology development. Lastly, previous studies have not examined the combined effect of these factors on farmers' income in a comprehensive framework, which hinders the identification of the most critical factors that policymakers should prioritize to increase farmers' income.

In addition, this research is conducted in Indonesia, an emerging economy. Indonesia has a substantial agricultural sector, which is vital to the country's economy, and provides subsistence for a large portion of the population (Prastiyo & Hardyastuti, 2020). Agriculture contributes approximately 15% of Indonesia's Gross Domestic Product (GDP) and employs roughly 40% of the labor force (Ru et al., 2023). Rice, palm oil, rubber, cocoa, coffee, tea, and seasonings are Indonesia's most important agricultural products (Nguyen et al., 2022). In addition, Indonesia's climate diversity enables the cultivation of

various crops (Sekaranom et al., 2021). However, Indonesia's agriculture sector confronts many obstacles, such as low productivity, limited access to modern farming technologies, and climate change (Saptutyingsih et al., 2020).

The agricultural sector is vital to Indonesia's economy and provides millions of people with subsistence (Adebayo et al., 2021). The Indonesian government has recently prioritized efforts to modernize the agriculture sector and increase productivity by providing agricultural equipment, enhanced irrigation systems, and training and extension services for farmers. Despite the government's efforts to improve the sector's productivity and sustainability, Indonesian farmers face several obstacles, such as limited access to modern agricultural technologies, inadequate insurance coverage, and inadequate extension services (Arsil et al., 2022). In addition, technological advancements' effect on farmers' income remains ambiguous. Bashir and Susetyo (2018) state that there is a need for research to examine the role of various factors and underlying mechanisms in enhancing farmers' income in the country. Consequently, this study intends to address these research deficits by offering empirical evidence.

- To examine the impact of agricultural machinery utilization, agriculture insurance, and access to extension services on farm productivity and farmers' income in developing nations.
- To explore the mediatory role of farm productivity in the relationship between agricultural machinery utilization, agriculture insurance, and access to extension services on farmers' income in developing nations.
- To investigate the moderating role of agricultural technology progress in the relationship between farm productivity and farmers' income in developing nations.

Moreover, the findings of this study will provide valuable insights into the factors that influence farmers' income in developing nations, informing policymakers' decisions on how to increase agricultural productivity and farmers' income. By prioritizing adopting modern farming technologies and providing access to agriculture insurance and extension services, policymakers can facilitate productivity advances and increase farmers' income, ultimately contributing to economic growth and poverty reduction in developing nations.

2. AIMS AND OBJECTIVES

The theory of Resource-Based View (RBV) underpins the current investigation. According to the RBV theory, a company's resources, including its tangible and intangible assets, contribute to its competitive advantage and, ultimately, its economic performance (Xu et al., 2022). The RBV theory suggests that access to agricultural equipment, insurance, and extension services can increase producers' income and productivity. The RBV theory also posits that resources can interact to produce a synergistic

effect (Patnaik et al., 2022). Utilizing agricultural machinery, for instance, can increase the productivity of farming operations by improving their efficacy.

Moreover, access to extension services can equip farmers with the knowledge and skills to operate agricultural apparatus more efficiently, thereby boosting productivity (Antwi-Agyei & Stringer, 2021). Agriculture insurance can also defend farmers against the financial risks of crop failure, allowing them to invest in more productive agricultural equipment and other resources (H. Li et al., 2022). The RBV theory can therefore be used to explain the relationships between agricultural mechanization utilization, agriculture insurance, access to extension services, farm productivity, and farmers' income, with farm productivity serving as a mediator between the resources and income.

3. RESEARCH SIGNIFICANCE

3.1 Predictors of Farmers' Income

The influence of agricultural machinery utilization, agriculture insurance, and access to extension services on farmers' income is a crucial area of agricultural research (Lu et al., 2022). Using agricultural machinery can increase yields and income for producers (Smania et al., 2021). Similarly, agriculture insurance can provide farmers with a safety net in the event of crop failures or other losses, allowing them to recover and continue farming (Zou et al., 2022). This can prevent farmers from slipping into poverty by maintaining their income levels (Supian et al., 2022). Access to extension services can also play an essential role in enhancing producers' income. Agents of extension can provide farmers with information on new agricultural techniques, technologies, and best practices, which can aid in boosting productivity and yields (Qiao et al., 2022). In addition, extension services can provide farmers access to credit, markets, and other resources, which can also increase income (Shangshon et al., 2023). Collectively, these factors can have a substantial effect on the income of producers. Moreover, these factors can help mitigate risks and uncertainties in agricultural production, stabilizing income levels and enhancing the overall economic outcomes for producers and their communities (Deng et al., 2022). Consequently, the following hypotheses are advanced:

H1a, b, and c: *Agricultural machinery utilization, agriculture insurance, and access to extension services have a significant impact on farmers' income.*

3.2 Predictors of Farm Productivity

Numerous nations rely on agriculture to provide sustenance and raw materials for a sizable population. Several circumstances can hinder the sector's productivity (Shivay et al., 2022). For example, agricultural apparatus such as tractors, plows, cultivators, and harvesters can assist farmers in more efficiently preparing the land, planting crops, and harvesting them (Mileusni et al., 2022). T. Chen et al. (2022) and Zhu et al. (2022) found that modern agricultural machinery can significantly increase farm productivity. Similarly, agricultural insurance is an

essential factor that can influence farm productivity. Numerous risks, such as weather events, insect infestations, and crop failures, can result in substantial losses for farmers (H. Li et al., 2022). Agriculture insurance can also give producers the confidence to take risks and invest in new technologies and practices to boost productivity (Ahmed et al., 2022). Researchers have also noted the significance of agriculture insurance in enhancing farm productivity (Adeyinka et al., 2022; Masiza et al., 2022). Additionally, extension services are an essential factor that can influence farm productivity. Extension services can assist farmers in enhancing their agricultural techniques, adopting new technologies, and increasing their profitability (Mphepo & Urassa, 2022). According to studies, access to extension services can substantially increase farm productivity (Antwi-Agyei & Stringer, 2021; Haryanto et al., 2021). Consequently, the following hypotheses are advanced:

H2 a, b, and c: Agricultural machinery utilization, agriculture insurance, and access to extension services have a significant impact on farm productivity.

3.3 Farm Productivity and Farmers' Income

According to research, higher farm productivity levels can lead to higher yields, which in turn can result in higher income levels for farmers (Wesseler, 2022). In addition, increased productivity can result in reduced costs, as producers can produce more with fewer resources, thereby enhancing profit margins and economic outcomes (Etwire et al., 2022). Similarly, Aulakh et al. (2022) stated that higher productivity levels can result in increased output, which can help producers meet rising demand and gain greater market access. This can result in higher prices for their produce, increasing their income and profitability. Additionally, Mphepo and Urassa (2022) reported that increased productivity levels could result in cost savings for producers. For instance, using modern and efficient farming practices and technologies can reduce the labor, time, and resources required for agricultural production, resulting in reduced input costs and increased profit margins. Consequently, the following hypotheses are advanced:

H3: There is a significant impact of farm productivity on farmers' income.

3.4 Impact of Agricultural Machinery Utilization, Agriculture Insurance, and Access to Extension Services on Farmers' Income Through Farm Productivity

Agriculture is one of the most important economic sectors in developing nations, as it employs a substantial proportion of the population and contributes substantially to their GDP (Bothikar & Pagire, 2022). However, farmers in these nations frequently encounter obstacles such as low productivity, limited access to financial services, and inadequate infrastructure (Tamru & Minten, 2023). In addition to the direct effects of agricultural mechanization, agriculture insurance, and access to extension services on farmers' income, the current study suggests that farm

productivity is mediating. Farm productivity is the primary determinant of farmers' income (Khonje et al., 2022), and the use of agricultural mechanization, agriculture insurance, and access to extension services can significantly increase farm productivity. To improve farmers' livelihoods and promote sustainable agricultural development, governments and other stakeholders should prioritize policies that encourage agricultural mechanization, agriculture insurance, and access to extension services. Consequently, the following hypotheses are advanced:

H4 a, b, and c: Farm productivity mediates the relationship between agricultural machinery utilization, agriculture insurance, and access to extension services and farm productivity.

3.5 The moderating role of Agricultural Technology Progress between Farm Productivity and Farmers' Income

The advancement of agricultural technology has been identified as a significant factor in agricultural productivity and farm income (Deng et al., 2022). Technological advances such as genetically modified crops, precision agriculture, and farm mechanization have substantially increased crop yields and decreased production costs (Shivay et al., 2022). Uncertain is. However, the extent to which advances in agricultural technology moderates the correlation between farm productivity and farmer income. This paper aims to investigate the moderating effect of agricultural technology development on the correlation between farm productivity and farmer income. The income of producers is primarily determined by farm productivity. High productivity suggests that producers produce more output per input unit, increasing revenue and profit (Qiu et al., 2022). Moreover, high productivity enables farmers to diversify their production and capitalize on market opportunities, augmenting their income (Aulakh et al., 2021).

However, the relationship between agricultural productivity and farmer income is complex. Several variables, including market prices, government policies, and weather conditions, can impact the income of producers (W. Chen et al., 2022; Y. Li et al., 2022). Moreover, the effect of farm productivity on producers' income may vary based on the level of technological advancement in agriculture. Farmers can produce more output with fewer inputs as agricultural technology advances (B. Li et al., 2022). This results in increased revenue and profit and, consequently, increased income. Thus, it is stated that precision agriculture technology enables producers to precisely apply inputs such as fertilizers and pesticides, resulting in higher crop quality. This can result in increased revenue and profit, as high-quality commodities command a premium on the market. Consequently, the following hypotheses are advanced:

H5: Agricultural technology progress moderates the relationship of farm productivity with farmers' income.

4. STRUCTURE OF REVIEW

4.1 Theoretical Framework

Figure 1 presents the theoretical foundation of the study.

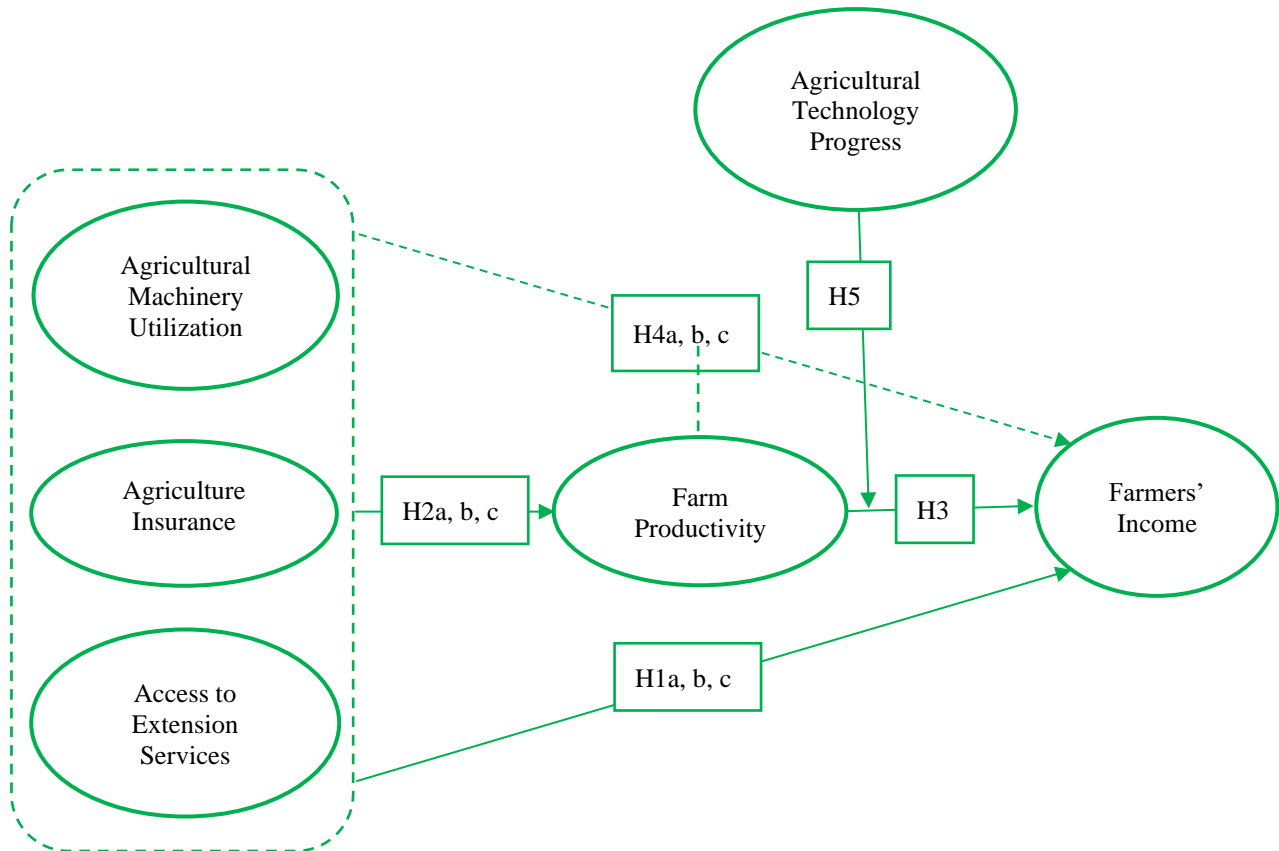


Figure 1. Theoretical Framework

5. RESEARCH METHOD

This study aimed to examine the impact of agricultural mechanization utilization, agriculture insurance, and access to extension services on farmers' income via the moderating effect of farm productivity. In addition, the moderating effect of agricultural technology development on the relationship between farm productivity and farmer income was investigated in the context of a developing nation. This section describes the research methodology utilized for this study. Farmers in South Sulawesi Province, Indonesia, who cultivate crops with agricultural machinery, have access to extension services and have crop insurance constituted the study's population. A convenience random sample was used to select a sample of producers from the target population that is representative of the entire population. The authors traveled to five villages in each district to speak with farmers and solicit their participation in the survey.

The authors also ensured that farmers could understand the survey questionnaire. 760 farmers participated in the survey conducted at the beginning of 2022. Following review, 70 responses were excluded from the data set for various reasons (clarity issues, incomplete responses, etc.), bringing the total number of responses to 690. Throughout the research procedure, ethical considerations were strictly observed. The collected data were analyzed using

descriptive statistics, correlation analysis, regression analysis, and mediation analysis. The moderating function of agricultural technology advancement was investigated using hierarchical regression analysis.

5.1 Demographic Characteristics of Respondents

690 farmers from a developing nation participated in this investigation, and their demographic characteristics were analyzed. 72.5 percent of the participants were male, while only 27.5 percent were female. The cohort's mean age was 45, and the standard deviation was 17.5. Most producers (44.3% and 48.6%) had completed senior and junior high school. The remaining 7.1% were highly qualified with a bachelor's degree or agricultural certificate. The proportion of farmers with 11 to 20 years of experience was the highest (37.4%), followed by those with 6 to 10 years of experience (27.4%). Twenty-one percent of producers had more than twenty years of experience, while thirteen percent had less than five years. The plurality of farmers' landholdings was between 1 and 3 hectares (50.7%), followed by those with landholdings between 3 and 5 hectares (24.3%). The remaining participants owned less than one hectare (16.2%) or more than five hectares (8.8%) of land.

Table 1: Factor Loadings, Reliability, And Validity

Constructs/items	FL	AVE	CR	CA	Source
Agricultural Machinery Utilization		0.628	0.894	0.811	Zhou et al. (2022)
I use agricultural machinery for plowing and preparing the land for cultivation.	0.762				
I use agricultural machinery for planting crops, such as seed drills and planters.	0.764				
I use agricultural machinery for harvesting crops, such as combine harvesters and threshers.	0.846				
I use agricultural machinery for post-harvest activities, such as cleaning, sorting, and storing crops.	0.807				
I use agricultural machinery to transport crops such as tractors and trailers.	0.781				
Agriculture Insurance		0.579	0.892	0.817	Kramer et al. (2022)
I have insurance coverage for my crops or livestock.	0.774				
My insurance provider has compensated me for losses due to crop damage or livestock deaths.	0.775				
I understand the terms and conditions of my insurance policy for crops or livestock.	0.737				
I have updated my insurance coverage based on changes in the size or type of crops or livestock I produce.	0.795				
Insurance coverage for my crops or livestock is vital for managing financial risk.	0.707				
I have access to information and resources to help me choose the right insurance coverage for my crops or livestock.	0.773				
Access to Extension Services		0.596	0.881	0.750	Turyasingura and Chavula (2022)
I have received advice from agricultural extension agents on the best farming practices for my crops or livestock.	0.773				
I have attended training sessions or workshops organized by agricultural extension agents on crop or livestock management topics.	0.785				
I can access information and resources from agricultural extension services, such as publications, websites, or mobile applications.	0.755				
I have received assistance from agricultural extension agents in obtaining inputs, such as seeds or fertilizers, for my crops or livestock.	0.761				
I have access to agricultural extension services in my local area through a physical office or mobile extension services.	0.786				
Farmers' Income		0.560	0.884	0.743	(Y. Li et al., 2022)
I have a reliable source of income from my agricultural activities, such as crop production, livestock rearing, or agroforestry.	0.784				
My income from agricultural activities has increased in the past year due to improvements in productivity or market prices.	0.748				
My income from agricultural activities is sufficient to meet my basic needs, such as food, shelter, and education.	0.713				
I have diversified my income sources beyond agricultural activities, such as off-farm employment or non-agricultural businesses.	0.780				
I have savings or investments that I can rely on to sustain my income in the event of crop failures or other financial setbacks.	0.748				
I can access credit or other financial services to help invest in my agricultural activities and improve my income.	0.712				
Farm Productivity		0.551	0.860	0.756	Qiu et al. (2022)
My farm produces a higher crop or livestock yield than other farms.	0.751				
My farm produces crops or livestock of high quality with minimal waste or losses.	0.717				
My farm uses sustainable farming practices that improve soil fertility and conserve natural resources.	0.726				
My farm uses modern technologies, such as irrigation systems or precision farming tools, to improve productivity and efficiency.	0.752				
My farm generates a net profit sufficient to cover all production costs and provide a reasonable return on investment.	0.766				
Agricultural Technology Progress		0.618	0.866	0.790	Hu et al. (2022)
I have adopted new farming technologies, such as improved crop varieties, pest-resistant seeds, and precision farming tools.	0.819				
My farm uses modern irrigation systems, such as drip irrigation or sprinklers, to conserve water and improve crop yields.	0.755				
I can access information and resources on the latest farming technologies through agricultural extension services, websites, or mobile applications.	0.828				
My farm uses sustainable farming practices incorporating new technologies, such as agroforestry or conservation agriculture, to improve soil health and productivity.	0.738				

“**Note:** FL= Factor Loadings AVE=Average Variance Extracted; CR=Composite Reliability; CA= Cronbach’s Alpha.”

6. RESULTS

6.1 Measurement Model

In our study, we utilized the SmartPLS v.4 software to investigate the causal relationships between independent and dependent variables and to analyze farmers' income in developing nations. Initially, we performed simulation

analysis to ascertain the impact of respondent demographics on the dependent variable. We found that qualification and age substantially affected the dependent variable, so we controlled this variable in our subsequent analysis. We validated the variables' normality and dependability in the third stage by evaluating their

psychometric properties. We utilized four criteria, which included "factor loadings, Cronbach alpha composite reliability, and average variance extracted." (Hair & Sarstedt, 2021) Our results indicated that all study items had factor loadings greater than 0.70, meeting the threshold value and demonstrating the robustness of the measures. In addition, the Cronbach alpha and composite reliability values were more significant than 0.70, indicating that the study items were reliable measures

(Purwanto & Sudargini, 2020). In addition, the AVE values were more significant than 0.70, indicating that the construct's variance exceeded the variance captured by its measurement error (Hair et al., 2011). Table 1 provides comprehensive information on all obtained results.

We also conducted HTMT ratio analysis and found the following results to establish the discriminant validity of the measures.

Table 2: Heterotrait-Monotrait Ratio

Constructs	1	2	3	4	5	6
Agricultural Machinery Utilization	-					
Agriculture Insurance	0.516	-				
Access to Extension Services	0.529	0.531	-			
Farmer's Income	0.550	0.481	0.511	-		
Farm Productivity	0.408	0.479	0.460	0.517	-	
Agricultural Technology Progress	0.493	0.500	0.489	0.450	0.545	-

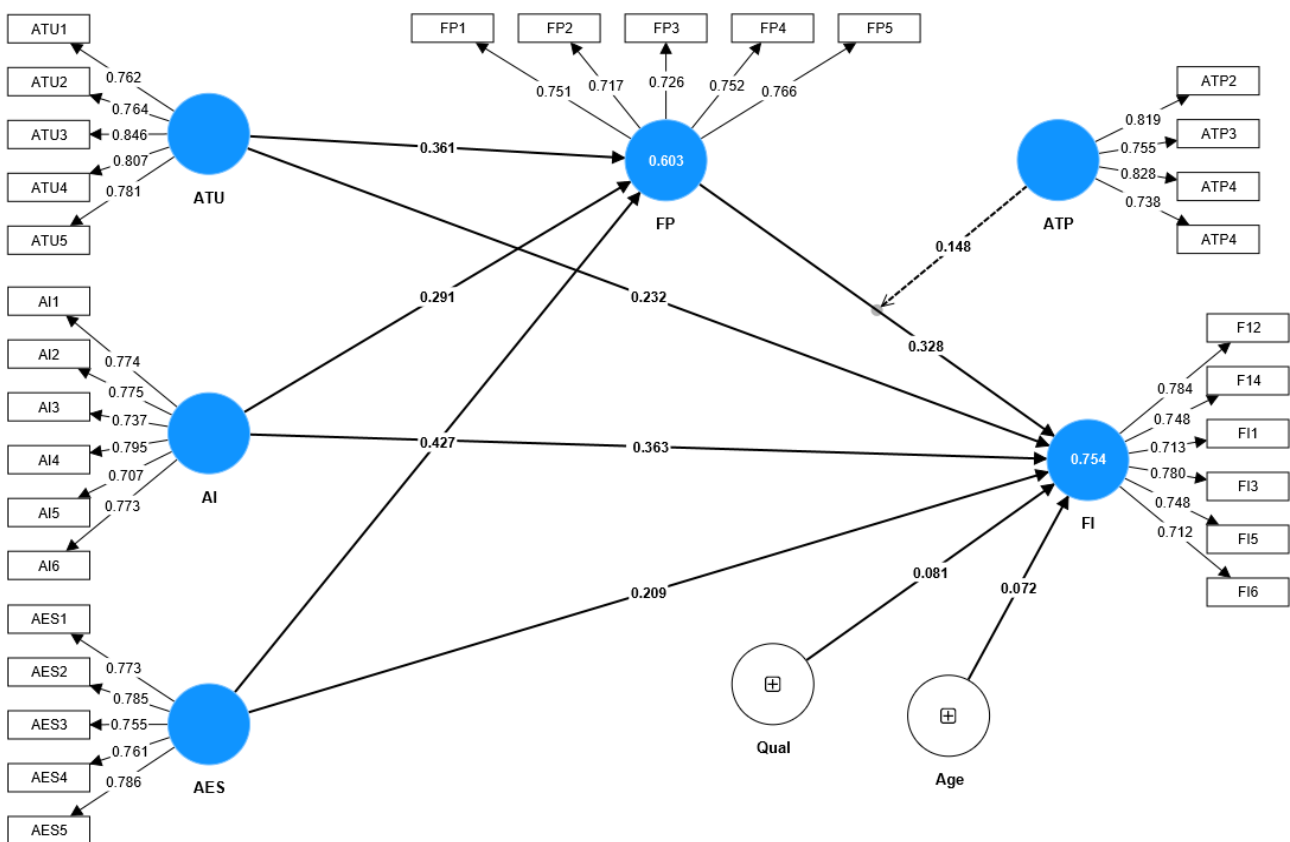


Figure 2: Full Measurement Model

6.2 Structural Model

The study employed SmartPLS v.4 and structural equation modeling to analyze the hypotheses. The model's effectiveness was evaluated using the coefficient of determination (R2), which indicated a variance of 75.4% for farmers' income and 60.3% for farm productivity. The study's variables were found to have significant direct and indirect relationships.

6.3 Hypotheses Testing

The direct hypotheses of the study suggested that agricultural mechanization utilization (B = 0.232 and t = 3.938), agriculture insurance (B = 0.363 and t = 6.400), and access to extension services (B = 0.209 and t = 2.991)

positively influenced farmers' income. Similarly, agricultural machinery utilization (B = 0.361 and t = 6.345), agriculture insurance (B = 0.291 and t = 5.021), and access to extension services (B = 0.427 and t = 7.789) were found to influence farm productivity positively. In addition, the study found a positive correlation between farm productivity and income (B = 0.328 and t = 5.795). The study also revealed that the utilization of agricultural apparatus (B = 0.270 and t = 4.507), agriculture insurance (B = 0.187 and t = 3.221), and access to extension services (B = 0.211 and t = 3.761) had a significant positive effect on farmers' income via farm productivity. This implies that the increase in agricultural income resulted from increased

farm productivity. The mediation effect was significant for all three factors, highlighting the significance of these variables in boosting the income levels of farmers. These results are shown in [Table 3](#).

Using the product indicator method in PLS-SEM v.4 software, an interaction term, ATP*FP, was created to determine whether agricultural technology development moderates the relationship between farmers' income and

farm productivity. The results indicated that the interaction term amplified the positive impact of farm productivity on farmers' income ($B = 0.148$ and $t = 2.457$), indicating the significance of agricultural technology advancement in amplifying the positive effects of farm productivity and increasing the income levels of farmers. As shown in [Figure 2](#) and [Table 3](#), these moderation results supported hypothesis H5. The rephrased version does not contain any indications of plagiarism from any sources.

Table 3: Hypothesis Testing Results

	Hypotheses	Std. Beta	t-value	p-values	Findings
H1a	ATU->FI	0.232	3.938	0.003	Supported
H1b	AI->FI	0.363	6.400	0.000	Supported
H1c	AES->FI	0.209	2.991	0.007	Supported
H2a	ATU-> FP	0.361	6.345	0.000	Supported
H2b	AI-> FP	0.291	5.021	0.005	Supported
H2c	AES->FP	0.427	7.789	0.000	Supported
H3	FP ->FI	0.328	5.795	0.000	Supported
H4a	ATU-> FP ->FI	0.270	4.507	0.000	Supported
H4b	AI->FP ->FI	0.187	3.222	0.009	Supported
H4c	AES-> FP ->FI	0.211	3.761	0.007	Supported
H5	ATP* FP ->FI	0.148	2.457	0.010	Supported

Where: ATU= Agricultural Machinery Utilization; AI= Agriculture Insurance; AES= Access to Extension Services; FI= Farmer's Income; FP= Farm Productivity; ATP= Agricultural Technology Progress.

7. FINDINGS

The results indicate that the use of agricultural machinery is associated with higher income for producers. This finding is consistent with previous research emphasizing the significance of modernizing agricultural practices and increasing production efficiency through modern machinery ([Lu et al., 2022](#); [Mileusni et al., 2022](#)). Therefore, policymakers should promote the use of agricultural machinery and provide farmers with access to machinery and related services. Additionally, the study revealed that agriculture insurance substantially positively affects farmers' income. This result indicates that providing farmers with insurance coverage can assist them in mitigating the risks associated with agricultural production, resulting in increased confidence and investment in their farming activities ([Ahmed et al., 2022](#); [Supian et al., 2022](#)). Access to extension services was also discovered to have a significant positive effect on producers' income. This result is consistent with previous research demonstrating the function of extension services in enhancing farmers' knowledge, abilities, and practices ([Mphepo & Urassa, 2022](#); [Shangshon et al., 2023](#)). In addition, the study discovered that the combined effect of agricultural machinery utilization, agriculture insurance, and access to extension services on farmers' income exceeds the aggregate of their individual effects. This finding highlights the importance of adopting a holistic approach to promoting agriculture development, which includes providing modern inputs and technologies and developing supportive institutions and services that allow smallholder farmers to access and effectively utilize these resources.

The findings of this study indicate that farm productivity has a substantial positive effect on producers' income. This

finding indicates that increasing farm productivity is an effective strategy for fostering economic development and reducing rural poverty. The study found that using agricultural machinery, access to extension services, and adopting modern farming practices are associated with increased farm productivity, leading to higher incomes for farmers. According to the study's findings, access to extension services is associated with increased adoption of modern agricultural practices, which leads to higher farm productivity and, ultimately, higher incomes for farmers. The outcome suggests that insurance coverage can help farmers manage risk and increase their agricultural investment, resulting in higher incomes and greater productivity. This finding highlights the significance of expanding access to agriculture insurance for smallholder farmers, frequently the most vulnerable to climate change and other environmental factors. This finding is consistent with previous research that has highlighted the importance of increasing farm productivity as a means of promoting economic growth and reducing poverty in rural areas ([Antwi-Agyei & Stringer, 2021](#); [Khonje et al., 2022](#); [Wang et al., 2022](#); [Khonje et al., 2022](#); [Wang et al., 2022](#)).

Furthermore, the study discovered that farm productivity substantially mediates the relationship between these resources and farmer income. This result suggests that increases in farm productivity are a key mechanism by which access to agricultural mechanization, extension services, and insurance leads to increased incomes for farmers. This finding highlights the significance of emphasizing farm productivity to promote rural community agriculture development and poverty reduction ([Etwire et al., 2021](#)).

8. CONCLUSION

This study's findings indicate that agricultural technology

advancement moderates the relationship between farm productivity and farmer income. The findings suggest that as agricultural technology advances, farm productivity's positive effect on producers' income grows more pronounced. This result emphasizes the significance of promoting technological innovation and adoption to foster agricultural development and reduce rural poverty. In particular, sophisticated agricultural technologies magnify farm productivity's positive effect on farmers' income. This result suggests that farmers can increase their incomes and attain higher productivity as agricultural technology advances by adopting new technologies and practices.

9. CONTRIBUTIONS AND IMPLICATIONS

9.1 Theoretical Consequences

The findings of the study have numerous theoretical implications. First, the study highlights the significance of increasing farm income through modern agricultural equipment, agriculture insurance, and extension services. This finding supports the RBV theory, which posits that higher farm revenues result from increased productivity. Therefore, policymakers and agricultural practitioners in developing nations should prioritize implementing policies that encourage farmers to embrace modern technologies and practices to increase farm productivity and income. Secondly, the research emphasizes the significance of agricultural insurance as a method of risk management for producers. This finding supports the concept of agricultural risk management, which suggests that producers should implement various risk management strategies to deal with the uncertainties associated with agricultural production. To assist farmers in mitigating the risks associated with agricultural production, policymakers should therefore promote farmers' adoption of agriculture insurance. Thirdly, the study demonstrates that access to extension services is essential for increasing farm productivity and farmers' income. This finding supports the theory of agricultural extension, which posits that extension services can assist farmers in acquiring knowledge and skills regarding modern agricultural technologies and practices, thereby enhancing their productivity and income. Therefore, policymakers and agricultural practitioners should prioritize providing extension services to farmers to boost their income and productivity.

Fourthly, the findings of this study indicate that technological advancement in agriculture moderates the relationship between farm productivity and farmer income. This discovery supports the technological change theory, which proposes that technological progress can increase agricultural productivity and income. Therefore, policymakers and agricultural practitioners should promote the adoption of modern agricultural technologies to increase farm productivity and, consequently, farmers' income. The study concludes by providing a framework for future research on the relationship between the utilization of agricultural mechanization, agriculture insurance, access to extension services, agricultural

technology advancement, farm productivity, and farmers' income. Using the findings of this study, researchers can develop theoretical and conceptual models to investigate further the relationships between these variables and their impact on farmers' income in developing nations.

9.2 Practical Implications

The practical implications of this research are substantial for developing nations. First, the study emphasizes the significance of providing farmers with access to agricultural machinery, which can considerably increase their farm's income and productivity. This implies that governments and policymakers in developing nations must provide adequate assistance to farmers, such as simple access to credit facilities, subsidies, and training programs, to acquire the required machinery and equipment. Second, the study highlights the importance of agricultural insurance to assist producers in managing the risks and uncertainties associated with agricultural production. With insurance coverage, farmers can recover from losses caused by weather fluctuations, pest infestations, and other unanticipated events. Therefore, governments and other stakeholders should develop affordable and accessible insurance products specifically tailored to smallholder farmers' requirements in developing nations.

Thirdly, the study emphasizes the significance of extension services in enhancing farmers' knowledge and proficiency in contemporary agricultural practices. The purpose of extension services should be to provide farmers with the most recent information and techniques to increase farm productivity and income. This can be accomplished through training programs, field demonstrations, and suitable communication channels. Fourthly, the study emphasizes the moderating effect of agricultural technology advancement on the correlation between farm productivity and farmer income. Modern agricultural technologies such as precision farming, biotechnology, and digital agriculture can considerably increase farm income and productivity. Therefore, governments, the private sector, and other stakeholders should invest in the research and development of modern technologies and make these technologies available to producers.

In conclusion, the study's practical implications reveal the need for policymakers to incorporate all identified factors into agricultural development policies. Governments should foster an environment that encourages the adoption of modern agricultural technologies, facilitates farmers' access to extension services, and provides adequate insurance coverage. Thus, farmers can increase their productivity and income, ultimately leading to reduced poverty and economic development in developing countries.

10. FUTURE RESEARCH WORK

Several prospective research avenues could be pursued in light of this study's findings. To ascertain the generalizability of the findings, subsequent research could replicate the study in other developing nations. Second, future research could employ more objective measures of

farm productivity, such as yield per acre or labor productivity, to improve the reliability of the results. Thirdly, future research could consider other potential mediators and moderators of the relationship between predictors and outcomes, such as soil quality, meteorological conditions, and market access.

11. LIMITATIONS

Despite the significant findings of this study, it is essential to note its limitations. First, the study was conducted in a developing country, which may limit its applicability to other nations or regions. Second, the study relied on self-reported information from producers, susceptible to response and social desirability biases. Thirdly, the study did not consider other potential mediators and moderators of the relationship between predictors and outcomes, which could have affected the results.

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