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Assessing the Impact of Production Risk-Management Strategies on Crop Productivity: Exploring the Mediating Role of Agricultural Technology Adoption

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ABSTRACT: This study examines the relationship between production risk management strategies (PRMS), agricultural technology adaptation (ATA), and crop production (CP) in Ghana, emphasising the mediating function of ATA. This study aimed to analyse the influence of PRMS and ATA on CP, providing insights for improving agricultural productivity in the context of rising risks. A quantitative research design was utilised to collect primary data via structured surveys of key stakeholders in the agricultural sector. Structural Equation Modelling (SEM) was employed to examine the proposed relationships among the variables.

The results indicated that PRMS had a positive and significant effect on both CP and ATA, with ATA directly and significantly influencing CP. In addition, ATA serves as a partial mediator in the relationship between PRMS and CP, highlighting its essential function in converting effective risk management strategies into improved productivity. This research highlights the significant potential of incorporating ATA into agricultural practices to enhance the effectiveness of risk management strategies.

Policy implications indicate the need for focused investments in risk management infrastructure and technology dissemination initiatives. Practical applications include the promotion of farmer-centred training initiatives and the development of region-specific technological solutions to tackle agricultural challenges. Policymakers and stakeholders should prioritise the diffusion of innovation and adoption of sustainable practices to enhance resilience within the agricultural sector. This study enhances theoretical models by identifying the ATA as a key intermediary in agricultural resilience frameworks, offering practical insights for enhancing productivity and sustainability.

KEYWORDS: Production Risk Management, Agricultural Technology Adaptation, Crop Production, Resilience, Sustainability

I. INTRODUCTION

Agriculture is a fundamental component of Ghana's economy and plays a crucial role in GDP, employment, and food security (Asare-Nuamah et al., 2023; Bawa, 2019). This sector encounters significant challenges related to production risks, such as unpredictable weather patterns, pest infestations, and declining soil fertility, which jeopardise crop productivity (Salifu & Salifu, 2024). The identified risks generate uncertainty for farmers, diminish their incomes, and impede agricultural development. Effective production risk management strategies are essential to address these challenges and maintain sustained productivity (Ferreira et al., 2022). Although there is an increasing body of research on risk management strategies in agriculture (Asravor & Sarpong, 2023; Ankrah et al., 2021; Sumani, 2018), there has been insufficient focus on their connection with crop productivity and the influence of agricultural technology adoption as a mediating variable. Addressing this gap is essential for developing evidence-based policies to improve productivity and strengthen the Ghanaian economy.

The agricultural sector in Ghana primarily comprises smallholder farmers, who contribute more than 80% of the total agricultural output (Ministry of Food and Agriculture (FAO, 2022). Farmers frequently depend on rainfed agriculture, rendering them particularly susceptible to climatic and environmental risks. Production risks, including droughts, floods, and pest outbreaks, disrupt agricultural activities and reduce crop yields (Nyantakyi-Frimpong et al., 2023; Addaney et al., 2021). Recent studies emphasise the significance of PRMS, such as crop diversification, irrigation, and the utilisation of resistant seed varieties, in reducing these risks (Sayavong, 2023; Egbeadumah et al., 2023; Tack & Yu, 2021; Birthal et al., 2021). The adoption and effectiveness of these strategies are inconsistent, particularly among resource-constrained smallholder farmers in Ghana.

The adoption of agricultural technology is increasingly being acknowledged as a transformative factor in contemporary farming practices. Technologies including precision farming, enhanced seed varieties, mechanisation, and climate-smart practices can significantly improve resilience and productivity (Kitole et al., 2024). Despite the global promise of these innovations, their adoption rate among Ghanaian farmers remains low, which is attributed to challenges such as limited access to credit, insufficient extension services, and high costs. Investigating the mediating role of technology adoption in the relationship between PRMS and crop productivity allows the identification of pathways to improve agricultural outcomes.

Ghana's substantial investment in agricultural policies and programmes, including the Planting for Food and Jobs initiative, has not resulted in optimal crop productivity (Prah et al., 2023). The ongoing production risks encountered by farmers indicate that the existing PRMS are either insufficient or ineffectively executed. However, the integration of agricultural technologies into these strategies is insufficient, thereby constraining their effectiveness. The lack of extensive research examining the relationship between PRMS, technology adoption, and crop productivity results in a knowledge gap that obstructs the formulation of targeted interventions in Ghana's agricultural sector.

This study is based on the necessity of enhancing the resilience and productivity of agriculture in Ghana. This study examined the impact of PRMS on crop productivity and the role of agricultural technology adoption in mediating this relationship, with the goal of providing actionable insights for policymakers, development partners, and farmers. This study aimed to identify the obstacles and facilitators of technology adoption in risk management, offering a framework for enhancing its incorporation into agricultural practices. The findings aim to support the attainment of Sustainable Development Goals (SDGs), specifically Goal 2 (Zero Hunger) and Goal 13 (Climate Action), through the promotion of sustainable agricultural practices in Ghana.

This study aims to evaluate the effect of PRMS on crop productivity, particularly by examining the mediating influence of agricultural technology adoption. This study examined the following research questions to achieve its objectives: What is the direct effect of PRMS on Ghana's crop productivity? To what extent does the adoption of agricultural technology mediate the relationship between PRMS and crop productivity?

Improving crop productivity via effective risk management strategies and technology adoption is essential to increase Ghana's agricultural output and promote overall economic growth. Enhanced productivity diminishes reliance on food imports, increases farmers' income, and fosters opportunities for agro-industrial development. Furthermore, the extensive implementation of agricultural technologies has the potential to stimulate innovation and create job opportunities in associated sectors, including agribusiness and technological services (World Bank, 2022). The findings of this study offer evidence-based recommendations for the expansion of effective PRMS and the promotion of technology use, thereby contributing to a resilient and prosperous agricultural sector in Ghana.

Existing literature highlights the essential function of PRMS in reducing production risks and protecting crop yields. Research conducted by Nyantakyi-Frimpong et al. (2023) and Addaney et al. (2021) indicated that strategies such as crop diversification and irrigation enhance resilience to climate shocks. Nevertheless, their research did not comprehensively examine the interaction between these strategies and technology adoption in relation to productivity outcomes. Kitole et al. (2024) highlights the transformative potential of agricultural technologies while identifying barriers including access to financing and training. This study addresses existing gaps by consolidating these themes into a unified framework, enhancing the comprehension of the mediating role of technology adoption in the PRMS-productivity relationship. This research enhances Ghana's agricultural transformation agenda by enabling farmers to manage risks more effectively, improve yields, and support the nation's economic goals.

II. Literature Review

2.1 Production Risk Management Strategies and Crop Productivity

Production risk management strategies are crucial for addressing unpredictable challenges in agriculture, especially in contexts such as Ghana, where climate variability and resource limitations are prevalent. PRMS include practices such as crop diversification, enhanced irrigation, pest and disease management, and soil fertility enhancement. Nyantakyi-Frimpong et al. (2023) asserted that crop diversification reduces the risk of complete crop failure by spreading risks among various crops, thereby improving farmers' resilience to unfavourable conditions. Irrigation systems mitigate water shortages resulting from inconsistent rainfall, which is a significant issue in rain-fed agriculture in Ghana.

The implementation of PRMS in Ghana is characterised by inconsistencies. Sayavong (2023) conducted a study indicating that, although numerous farmers recognise risk management strategies, their implementation is constrained by financial and logistical obstacles. Pest management frequently occurs with limited resources, leading to less-than optimal results. Furthermore, PRMS implementation often occurs in isolation, thereby reducing its overall effectiveness. Crop diversification may not achieve optimal outcomes without the implementation of complementary strategies such as enhancing soil fertility. Despite these limitations, PRMS can significantly enhance productivity in a comprehensive and systematic manner (Aduhene-Chinbuah et al., 2024).

2.*2 Production Risk Management Strategies and Agricultural Technology Adoption*

The connection between PRMS and the adoption of agricultural technology is significant but has not been sufficiently examined. The PRMS establishes a framework for risk mitigation while agricultural technologies improve their efficacy. Adopting drought-resistant seed varieties can enhance the effectiveness of irrigation practices, resulting in synergistic effects. Asravor and Sarpong (2023) assert that incorporating technological tools like precision farming into PRMS can enhance resource efficiency and reduce risks.

Despite these potential benefits, barriers to technology adoption continue to exist in Ghana. Insufficient access to financing, restricted extension services, and inadequate infrastructure frequently hinder farmers from utilising technologies to enhance PRMS. The fragmented nature of Ghana’s agricultural policies is a significant obstacle. Numerous policies emphasise either risk management or technology adoption, with insufficient attempts to merge these two approaches. Ghana's Planting for Food and Jobs program integrates aspects of PRMS, yet it places a limited focus on the promotion of advanced agricultural technologies (Pauw, 2022). Addressing these gaps requires a comprehensive strategy that integrates technology adoption with PRMS to enhance productivity.

2.3 Agricultural Technology Adoption and Crop Productivity

The adoption of agricultural technology is acknowledged to be a significant factor that influences crop productivity. Technologies including enhanced seed varieties, mechanisation, and digital tools facilitate the optimisation of agricultural practices and the reduction of inefficiencies for farmers. Improved seed varieties can enhance yield and increase resilience to pests and diseases (Thomas et al. 2023). Mechanisation addresses labour shortages and reduces production costs, thereby enhancing productivity.

The relationship between technology adoption and productivity has been extensively documented in literature. A study by Nyantakyi-Frimpong et al. (2023) indicated that the implementation of precision agriculture tools in Ghana has resulted in notable enhancements in yields and resource efficiency. The rate of technology adoption is notably low, particularly among smallholder farmers. Financial constraints, limited awareness, and the high cost of technology are identified as the primary challenges (Okai et al., 2024). Cultural factors, including resistance to change and a preference for traditional farming methods, impede the adoption of agricultural technologies (Moomen et al., 2024).

Despite these challenges, the evidence indicates that the adoption of agricultural technology can effectively connect risk management and productivity. Integrating digital tools, such as weather forecasting applications, into PRMS allows farmers to enhance their planning and minimise losses. Technologies that improve soil health monitoring can support fertility management practices, resulting in increased yield. Thus, the adoption of agricultural technology serves as both a productivity enhancer and crucial mediator in the relationship between PRMS and crop productivity.

The relationship between PRMS, technology adoption, and crop productivity is significant for Ghana's agricultural sector. Agriculture plays a crucial role in the national economy and enhancing productivity through integrated strategies can lead to significant transformation. Research indicates that aligning PRMS with technology adoption may assist Ghanaian farmers in addressing issues associated with climate variability, pest infestations, and resource limitations (Nyantakyi-Frimpong et al., 2023; Pauw, 2022).

The literature indicates a significant gap in the understanding of the practical interactions of these factors. Many studies examine risk management and technology adoption separately, with insufficient consideration of their joint effects on productivity. Addressing this gap necessitates an integrated approach that promotes PRMS while incentivising technology adoption through targeted policies and investments. Current literature highlights the significance of PRMS and the adoption of agricultural technology as essential factors influencing crop productivity. The independent contribution of each factor to productivity enhancement is significant; however, their integration provides a more holistic approach for addressing the challenges encountered by farmers. Aligning the Public Resource Management System (PRMS) with agricultural technology adoption in Ghana can effectively address systemic barriers and maximise the agricultural sector's potential. Future research should examine the interactions between these factors to provide practical insights for policymakers and practitioners.

3. METHODOLOGY

The methodology section delineates the research design, sampling strategy, data collecting, and analytical processes employed to examine the correlation between production risk management strategies (PRMS) and crop productivity, with agricultural technology adoption serving as a mediating variable. This study employs a quantitative methodology, utilising a survey to gather primary data from agricultural producers. This methodology guarantees objective measurement and statistical analysis of the interrelationships among the variables according to the aims of the study (Creswell & Creswell, 2018).

3.1 Research Design

This study utilised a cross-sectional survey approach to collect data at a specific moment. This design is appropriate for investigating the relationships among PRMS, technology adoption, and agricultural yield in a methodical and organised fashion. Surveys enable standardised data collection, reduce biases, and enhance the generalisability of results within the study population (Fowler, 2014).

3.2 Population and Sampling

The target population for the study comprises smallholder farmers in Ghana, who are central to the agricultural sector yet disproportionately affected by production risks. A multi-stage sampling technique was employed to ensure representativeness. Initially, five key agricultural regions were purposively selected based on their contribution to national crop production and diversity in farming practices. Within these regions, the districts were stratified by agricultural intensity and exposure to production risks. Subsequently, simple random sampling was applied to select respondents from each stratum to ensure proportional representation. The sample size was determined using Cochran’s formula adjusted for an anticipated non-response rate to achieve statistical power and precision.

3.2 Data Collection Instrument

A structured questionnaire served as the principal data collection instrument, partitioned into two portions: A and B. Section A collected demographic information. This part collected information on the respondents' age, gender, education, agricultural experience, and farm size. These variables offer insights into the dynamics of PRMS and technology adoption among various farmer profiles. Section B consisted of Likert-scale items. This section employed a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), to assess the study variables.

3.3 Data Collection Procedure

Data collection was executed through in-person surveys conducted by professional enumerators proficient in local languages. Farmers were informed about the study objectives, guaranteed confidentiality, and provided informed consent prior to participation. The in-person method diminishes non-response rates and improves data precision by elucidating unclear enquiries.

3.4 Data Analysis

The data analysis was performed using SPSS (version 26) and SmartPLS (version 4). Descriptive statistics were used to summarise demographic characteristics and variable distributions. Reliability was evaluated using Cronbach’s alpha to confirm internal consistency. Validity assessments, such as Confirmatory Factor Analysis (CFA), confirmed the construct validity of the instrument. The research questions were evaluated through Structural Equation Modelling (SEM) to investigate both direct and indirect relationships among variables, with a specific focus on the mediating role of agricultural technology adoption (Hair et al., 2019).

3.5 Ethical Considerations

The study complied with established ethical standards. This study was approved by the institutional review board. Participants were made aware of their rights, including the option for voluntary participation and the ability to withdraw without incurring penalties. Confidentiality and anonymity of data were upheld during the research process (Bell & Bryman, 2007). This methodological framework guarantees reliable, valid, and actionable findings, thereby contributing to evidence-based strategies to enhance agricultural productivity in Ghana.

IV. PRESENTATION OF THE RESULT

4.1 Descriptive Analysis

Table 4.1 presents a comprehensive descriptive statistical analysis of the respondents' demographic characteristics, encompassing variables such as age, sex, educational attainment, and farming experience. This analysis serves as a foundational step in understanding the sample composition and provides insights into the heterogeneity of the respondent population. By examining these demographic factors, the analysis revealed patterns that may influence respondents' perceptions and practices of risk management and crop productivity. Such demographic details are crucial for contextualising the findings and interpreting potential variations in the study's outcomes, as demographic differences can shape responses to risk-management strategies and their effectiveness in agricultural settings.

Table I. Descriptive Statistical Analysis Result -Demographic

		FREQUENCY	PERCENT
GENDER	Male	556	52.8
	Female	498	47.2
AGE GROUP	under 20	81	7.7
	21-30	264	25
	31-40	125	11.9
	41-50	243	23.1
	51-60	219	20.8
	above 60	122	11.6
EDUCATIONAL LEVEL	Primary education	270	25.6
	Secondary school education	195	18.5
	Tertiary education	370	35.1
	No formal education	219	20.8
YEAR OF EXPERIENCE	less than 5 years	268	25.4
	5-10 years	245	23.2
	11-20 years	268	25.4
	over 20 years	273	25.9

Source: *Authors Own Creation*

The study sample exhibited a gender distribution of 52.8% male and 47.2% female participants. Nearly equal representation improves the generalisability of the findings and allows for an examination of gender-specific agricultural practices and risk management strategies. The gender diversity present in the sample facilitates an examination of the variations in roles, decision-making, and resource access between genders, thereby enhancing the analysis of social dynamics within farming communities.

Age demographics indicated a varied distribution, with the largest proportion (25 %) belonging to the 21–30 age group. This indicates a notable presence of young farmers, suggesting opportunities for innovation and the adoption of technology in agriculture. The 41–50 age group (23.1%) and the 51–60 age group (20.8%) highlight the significant role of middle-aged and mature farmers, who contribute valuable experience, yet may encounter difficulties in adopting modern practices. The limited representation of individuals under 20 years of age (7.7%) underscores the necessity for initiatives aimed at engaging the youth in agriculture.

The participants' educational backgrounds varied, with 20.8% having no formal education, 35.1% possessing secondary school education, and 18.5% achieving tertiary education, making secondary education the most common level attained. This stratification highlights the differing abilities of farmers in implementing risk management strategies. Farmers with tertiary education are positioned to lead in innovation, whereas those with limited educational backgrounds may require customised, accessible training to address knowledge deficiencies.

The largest group of participants (25.9 %) had more than 20 years of farming experience, indicating a significant reservoir of practical knowledge within the sample. Conversely, individuals with less than five years of experience (25.4%) emphasised the opportunity to incorporate modern agricultural techniques. Farmers with 5–10 and 11–20 years of experience (23.2% and 25.4%, respectively) exhibit a significant equilibrium between traditional and contemporary practices, positioning them as essential for promoting innovation and facilitating knowledge transfer.

4.2 Measurement Model Analysis

The measurement model was thoroughly evaluated to confirm the reliability and validity of the constructs (Table 2). All item factor loadings were assessed with each surpassing the minimum acceptable threshold of 0.50, as suggested by Hair et al. (2010). Factor loadings exceeding 0.70 are generally favoured for reflective constructs (Vinzi et al., 2010); however, lower outer loadings (i.e. below 0.70) frequently occur in social science research, reflecting the intricate and multidimensional characteristics of behavioural data. A detailed analysis of the impact of such items on composite reliability (CR), content validity, and convergent validity is essential rather than their indiscriminate elimination. In accordance with Hair et al. (2021), items exhibiting outer loadings between 0.40 and 0.70 were deemed for removal solely if their exclusion enhanced Composite Reliability (CR) or Average Variance Extracted (AVE) beyond the established thresholds of 0.70 and 0.50, respectively.

In this study, PRM 3 demonstrated an outer loading of 0.312, which is considerably below the acceptable range. The inclusion adversely affected the reliability and validity of the PRM construct, yielding a Cronbach’s alpha of 0.700 and an AVE of 0.476, both below the recommended thresholds. The removal of PRM 3 resulted in a significant enhancement of these metrics, confirming the importance of its exclusion in preserving the construct's psychometric properties. Furthermore, an assessment of the confidence intervals for the outer loadings indicated that none encompassed zero, thereby reinforcing the reliability of the retained indicators. Consequently, one item was eliminated to enhance the measurement model for future analyses.

Reliability was evaluated using Cronbach’s alpha and composite reliability with all variables surpassing the suggested threshold of 0.70 (Wasko & Faraj, 2005). The results demonstrated that the constructs had internal consistency. Convergent validity was confirmed as the AVE for all constructs surpassed the minimum threshold of 0.50, indicating that the indicators effectively represented their corresponding latent variables. Discriminant validity was assessed using the Fornell-Larcker criterion and Heterotrait-Monotrait Ratio (HTMT). The square root of the Average Variance Extracted (AVE) for each construct exceeded the correlations among constructs, thereby satisfying the Fornell-Larcker criterion (Fornell & Larcker, 1981). HTMT values were below the conservative threshold of 0.85 (Henseler et al., 2015), indicating that the constructs are distinct. The results collectively demonstrate strong evidence of discriminant validity (Tables 3 and 4), confirming the suitability of the model for subsequent structural analyses.

Table II Construct reliability, validity, and Multicollinearity

Construct and Items	Factor Loading	Cronbach Alpha	Composite Reliability	AVE	VIF
ATA1	**0.778**	**0.817**	**0.873**	**0.578**	**1.631**
ATA2	**0.781**				**1.718**
ATA3	**0.717**				**1.453**
ATA4	**0.741**				**1.554**
ATA5	**0.783**				**1.711**
CP1	**0.729**	**0.811**	**0.869**	**0.570**	**1.433**
CP2	**0.774**				**1.622**
CP3	**0.753**				**1.603**
CP4	**0.767**				**1.728**
CP5	**0.750**				**1.600**
PRM1	**0.761**	**0.761**	**0.848**	**0.583**	**1.472**
PRM2	**0.764**				**1.503**
PRM4	**0.750**				**1.448**
PRM5	**0.779**				**1.507**

Source: *Authors Own Creation*

Table III. Discriminant validity Fornell-Larker criteria

	ATA	CP	PRMS
ATA	***0.760***		
CP	**0.650**	***0.755***	
PRMS	**0.689**	**0.595**	***0.763***

Source: *Authors Own Creation*

Table IV. Discriminant validity-HTMT

	ATA	CP	PRMS
ATA			
CP	**0.794**		
PRMS	**0.871**	**0.752**	

Source: *Authors Own Creation*

The next phase of the analysis examined the extent to which the independent variable affected and accounted for variance in the dependent variable. This assessment was essential to evaluate the explanatory capacity of the independent variables in relation to the model. The measurement model was designed to quantify the variance in the dependent variable, which can be attributed to the independent variable, offering insights into the strength and significance of relationships within the study framework.

Table V. Model Fit – R Square

	R-square	R-square adjusted
ATA	**0.475**	**0.474**
CP	**0.464**	**0.463**

Source: *Authors Own Creation*

The analysis produced an R2 value of 0.475 for Agriculture Technology Adaptation (ATA), suggesting that 47.5% of the variance in ATA is accounted for by Production Risk-Management Strategies (PRMS). The R2 value for Crop Production (CP) was 0.464, indicating that 46.4% of the variance in CP was due to the combined effects of PRMS and ATA. The results exceeded the recommended cutoff value of 0.10 (Falk & Miller, 1992), indicating a significant explanatory power of the model. The results highlight the effectiveness of the model in explaining variance in both ATA and CP (Table 5).

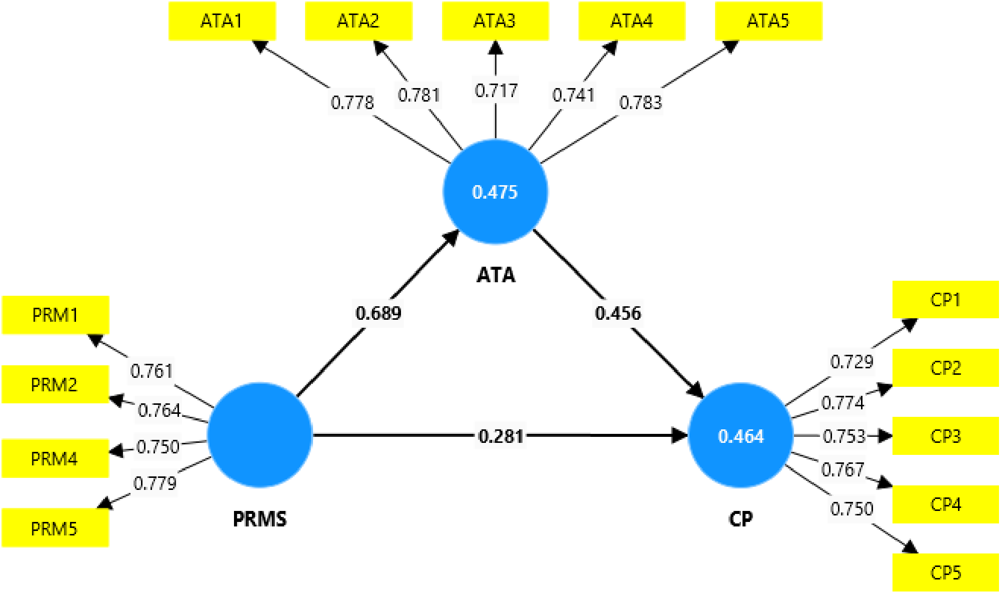

Figure: Measurement Model Analysis

4.3 Structure Assessment Model

4.3.1 Research Questions

Table 6 summarises the statistical outcomes for all research questions, providing a comprehensive overview of the results. The table presents the essential metrics, including regression coefficients, significance levels, and effect sizes for each relationship between the questions. The findings offer essential insights into the strength and direction of the relationships among the variables, facilitating a comprehensive evaluation of the study's theoretical propositions and their practical significance. This study systematically analysed these results, contributing to a deeper understanding of the underlying constructs and providing evidence to support or refute the proposed framework.

Table VI. Structure Model Result

	Beta Coefficient	Standard deviation	T statistics	P values
ATA -> CP	**0.456**	**0.036**	**12.590**	**0.000**
PRMS -> ATA	**0.689**	**0.019**	**36.988**	**0.000**
PRMS -> CP	**0.280**	**0.036**	**7.821**	**0.000**

Source: *Authors Own Creation*

This research examines the degree to which production risk management strategies (PRMS) have a positive and significant effect on crop production. The findings in Table 6 indicate a strong positive and statistically significant effect (β = 0.280, t = 7.821, p < 0.000), suggesting that PRMS significantly enhances crop production. This finding indicates that a 1% increase in PRMS correlates with a 28% increase in crop production, highlighting the essential function of proactive risk management in reducing uncertainties and maximising agricultural yields. The results are consistent with the theoretical expectations of risk minimisation frameworks in agriculture.

The second research question aimed to assess the positive and statistically significant impact of PRMS on agricultural technology adoption (ATA). The analysis demonstrated a strong and statistically significant relationship (β = 0.689, t = 36.988, p < 0.000), underscoring the considerable impact of PRMS on the incorporation of technology in agricultural practices. The results indicate that a 1% increase in PRMS was associated with a 68.9% enhancement in ATA. This relationship demonstrates that an effective PRMS not only mitigates risks but also facilitates technological advancements, potentially enhancing efficiency and sustainability in agricultural systems.

The third research question assessed the effects of ATA on crop production. The findings indicated a positive and statistically significant effect (β = 0.456, t = 12.590, p < 0.000), suggesting that ATA has a significant impact on crop production outcomes. A 1% increase in the ATA is expected to lead to a 45.6% increase in crop production. This finding highlights the essential role of technology adoption in closing productivity gaps, improving resource utilisation, and tackling agricultural challenges. This highlights the relationship between innovative solutions and agricultural performance, emphasising the need for technological integration to enhance productivity levels.

The findings from all three research questions collectively underscore the essential role of PRMS and ATA in enhancing crop production. The statistically significant relationships among these constructs offer empirical support for strategic interventions that integrate risk management and technology adoption as complementary mechanisms to enhance agricultural output and ensure resilience to production challenges. The results have significant implications for policymakers and practitioners focused on improving agricultural sustainability and productivity.

Table VII. Mediation Analysis Result

Total effect		**Direct effect**						
Coefficient	**P Value**	**Coefficient**	**P Value**		**Coefficient**	**SD**	**T Value**	**P Value**
0.595	**0.000**	**0.280**	**0.000**	**PRMS > ATA > CP**	**0.315**	**0.027**	**11.815**	**0000**

This study investigates the mediating function of agricultural technology adaptation (ATA) in the relationship between production risk management strategies (PRMS) and crop production. The results presented in Table 4.7 indicate a substantial total effect of PRMS on crop productivity (β = 0.595, t = 26.526, p < 0.001), confirming the direct positive impact of effective risk management practices on agricultural output. This highlights the significance of risk-mitigation strategies in diminishing uncertainty and fostering an environment conducive to increased productivity.

The introduction of ATA as a mediating variable indicated that the direct effect of PRMS on crop productivity was still statistically significant, although it diminished ($\beta = 0.280$, $t = 7.821$, $p < 0.001$). The decrease in the direct effect suggests that some of the effects of PRMS on crop productivity are mediated by the ATA. The indirect effect of PRMS on crop productivity through ATA was statistically significant ($\beta = 0.315$, $t = 11.815$, $p < 0.001$), highlighting the essential intermediary role of ATA in the production process. These findings underscore the dual mechanisms by which PRMS improves crop productivity by reducing risks and indirectly by promoting the adoption of advanced agricultural technologies. The observed partial mediation suggests that PRMS contribute independently to crop production, but its effectiveness is notably enhanced when integrated with technological advancements. This indicates that the ATA functions as a catalyst, allowing farmers to convert well-structured risk management strategies into measurable enhancements in productivity.

This study emphasises the importance of combining risk management frameworks with innovation adoption theories to enhance understanding of agricultural productivity. The impact of risk management extends beyond risk mitigation. It also facilitates the adoption of innovations essential for addressing structural inefficiencies in agricultural systems. The results emphasise the significance of integrating technology-driven approaches with risk management strategies. Investments in technologies that mitigate specific production risks should be prioritised by policymakers and practitioners, along with efforts to raise awareness and provide training to facilitate technology adoption. Addressing risk management alongside technological innovation enables stakeholders to promote sustained agricultural growth and resilience amid evolving challenges.

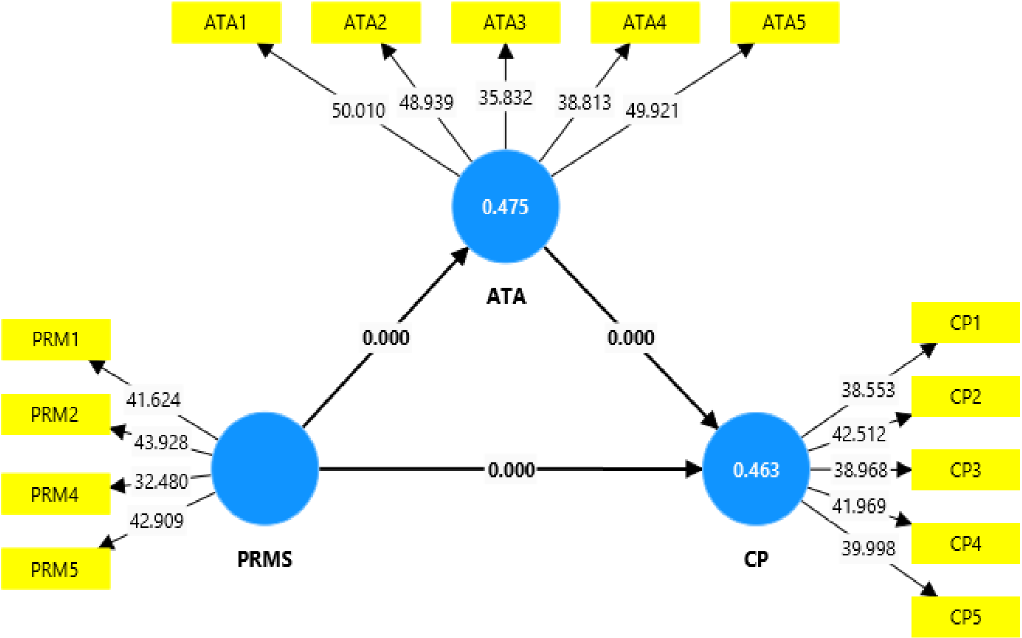

Figure: Structure Assessment Model

V. DISCUSSION AND CONCLUSION

This study offers important insights into the interrelated functions of production risk management strategies (PRMS) and agricultural technology adaptation (ATA) in improving crop productivity. The findings confirm the substantial and significant impact of PRMS on crop production, indicating that effective risk-mitigation strategies improve agricultural output by stabilising production conditions and minimising vulnerabilities. This is consistent with previous studies, including that of Antle and Capalbo (2001), who highlighted the significance of proactive risk management in promoting agricultural sustainability. This study reveals that PRMS promotes ATA, highlighting the complementary relationship between risk reduction and technology adoption. This finding aligns with that of Feder et al. (1985), who posited that secure production conditions facilitate the adoption of innovative agricultural practices.

The substantial impact of ATA on crop production underscores its importance as a primary factor for enhancing productivity. The ATA enhances sustainable agricultural intensification through efficient resource utilisation, reduction of post-harvest losses, and increased resilience to climatic variability. This corroborates the findings of Pretty et al. (2011), who indicate that the adoption of technology enhances productivity and promotes environmental conservation. Mediation analysis identified

ATA as a significant intermediary in the relationship between PRMS and crop production, highlighting the interplay between risk management and technology in attaining agricultural development objectives.

However, the findings of this study differ from those of Just and Pope (2002), who contend that the influence of risk management on productivity is constrained in the absence of significant infrastructural and institutional support. While the relationship between ATA and crop production has been validated, studies, such as Fuglie and Rada (2013), indicate that its impact is context-dependent, exhibiting variations in technology efficacy across diverse agro-ecological zones and socioeconomic conditions.

This study highlights the necessity of an integrated approach that merges PRMS and ATA to improve agricultural productivity. Policymakers and agricultural stakeholders must prioritise the establishment of enabling environments that facilitate risk mitigation and promote technology adoption. Future research could investigate contextual factors that could affect the effectiveness of these strategies, including access to credit, market conditions, and extension services. Stakeholders can enhance the sustainable transformation of the agricultural sector by addressing the deficiencies in risk management and technology adoption.

Theoretical Contribution

This study enhances the theoretical comprehension at the intersection of production risk management strategies, agricultural technology adaptation, and crop productivity. This study illustrates the mediating role of ATA, thereby enhancing the resource-based view (RBV) and innovation diffusion theories. This highlights the interaction between internal capabilities, such as PRMS, and external enablers, such as ATA, in improving productivity. The findings bridge a gap in the agricultural risk literature by empirically validating the ATA as a crucial intermediary in agricultural resilience frameworks. This study examines the relationship between risk management and innovation, and contributes to sustainability models by highlighting the transformative potential of adaptive agricultural systems.

Policy Implication

The results indicate that policymakers ought to prioritise investments in agricultural risk management infrastructure and facilitate technology adoption via subsidies, training, and extension services. Incorporating the ATA into national agricultural strategies may enhance the effectiveness of PRMS, promote resilience to climate variability, and improve productivity. Targeted interventions, including localised and accessible credit programs, are crucial for achieving equitable and scalable results in various farming communities.

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