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How Effective Public Policies Improve Farmers' Economic Welfare: The Serial Mediating Roles of Innovation Adoption and Productivity in Tobacco Farming

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Abstract

This study examines the causal mechanisms through which the effectiveness of public policy influences the economic welfare of tobacco farmers in Madura, Indonesia. Using survey data from tobacco farmers and applying structural equation modelling partial least squares (SEM-PLS), the study analyses the direct effects of policy effectiveness on innovation adoption, farmer productivity and economic welfare, as well as the mediating and serial mediating roles of innovation adoption and productivity. The findings demonstrate that public policy effectiveness significantly enhances innovation adoption, productivity and economic welfare. Innovation adoption improves productivity and welfare, while productivity directly strengthens welfare outcomes. Mediation analysis confirms that innovation adoption and productivity function as both individual and sequential mediators. This indicates that welfare gains are primarily achieved through policy-driven innovation uptake and productivity improvements, rather than through the direct effects of policy alone. Despite limitations relating to the cross-sectional nature of the data and the focus on economic welfare, the study provides valuable insights for the design of innovation-oriented agricultural interventions aimed at promoting sustainable welfare among smallholder farmers.

Keywords: public policy effectiveness; innovation adoption; farmer productivity; economic welfare; tobacco farmers

1. Introduction

In contemporary agricultural development literature, there is broad consensus that the economic welfare of smallholder farmers is influenced not only by production and market factors but also, critically, by the effectiveness of public policies that create enabling environments for innovation and productivity enhancement. (Ragasa et al., n.d.) argues that conducive public policies play a strategic role in shaping agricultural innovation processes and technology investment, ultimately contributing to productivity growth and income improvement among farmers in low- and middle-income countries (LMICs). Such policies encompass fiscal instruments, institutional frameworks, and integrated mechanisms linking research, technology dissemination, and farmers' local needs. Structural challenges faced by smallholder farmers frequently constrain their capacity to achieve sustainable economic welfare, particularly when access to technology, markets, and innovative knowledge remains limited. (Rodríguez-Espíndola et al., 2022) demonstrate that stronger market

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integration significantly correlates with higher income levels, poverty reduction, and household income diversification. This issue is especially salient in tobacco farming, where price volatility and unstable market access expose farmers to heightened income uncertainty. In Indonesia, small-scale agriculture including tobacco farming in Madura exhibits pronounced income fragility due to dependence on market conditions and production quality. This vulnerability is exacerbated by price uncertainty and limited capacity to adopt technical or institutional innovations, leading to stagnant productivity and adverse impacts on household welfare. (Crawford et al., 2024) show that improving farmer welfare in Indonesia requires a combination of policies addressing input subsidies, price stability, and incentives for productivity enhancement. Despite these insights, empirical evidence explicitly linking public policy effectiveness, innovation adoption, productivity, and economic welfare among tobacco farmers in Indonesia particularly in Madura—remains limited in international literature. Most existing studies focus on staple food crops or commodities such as coffee and cocoa, rather than tobacco, which operates within distinct market dynamics and value-chain structures. Consequently, there is a need for empirical research that systematically examines this causal chain to clarify how agricultural policies and institutional support translate into improved innovation capacity, productivity gains, and household economic welfare among tobacco farmers.

Prior studies report mixed findings regarding the relationship between innovation adoption and farmer welfare. (HABTEWOLD, 2021)) finds that adoption of comprehensive agricultural technology packages reduces poverty risk and improves multidimensional household welfare, indicating a positive welfare effect through reduced deprivation and enhanced household resources. Similarly, (Ganguly et al., 2017) reports that agricultural technological innovation improves productivity and production efficiency, contributing positively to farmers' income potential. However, other research highlights less consistent outcomes. (Parra-López et al., 2024) emphasizes that innovation effectiveness is highly contingent on structural barriers such as economic constraints, environmental conditions, and socio-cultural factors, implying that innovation does not automatically translate into welfare gains. A systematic review by (Abdul-Majid et al., 2024) further shows that while many studies report positive effects of technology adoption on productivity and income, outcomes vary depending on technology type and implementation context, resulting in mixed or indirect relationships between adoption and welfare. From a public policy perspective, (Ragasa et al., n.d.) underscores that a supportive policy environment—encompassing R&D support, fiscal instruments, and integrated innovation systems is a necessary condition for impactful innovation. Nevertheless, quantitative evidence at the commodity level that captures the indirect effects of public policy on farmer welfare through innovation adoption and productivity remains scarce. Overall, while innovation adoption and productivity are often positively associated with farmer welfare, the magnitude and consistency of these effects vary, and the systemic role of public policy effectiveness within a serial causal framework remains underexplored.

The novelty of this study lies in its examination of a serial mediation mechanism linking public policy effectiveness to farmers' economic welfare through innovation adoption and productivity within a single, integrated empirical model. Unlike prior studies that typically assess direct or partial effects of policy or innovation on welfare, this research elucidates the pathways through which public policy interventions succeed or fail in improving farmer welfare. In addition, the study offers contextual novelty by focusing on tobacco farmers in Madura, a region and commodity characterized by distinct socio-economic conditions, market structures, and policy environments. International literature remains limited in examining farmer welfare through the public policy effectiveness–innovation–productivity nexus in tobacco farming, particularly in developing-country contexts. By addressing this gap, the study extends the application of public policy and agricultural innovation theories to an underexplored empirical setting.

Based on these empirical phenomena and research gaps, this study aims to: (1) examine the effect of public policy effectiveness on innovation adoption among tobacco farmers in Madura; (2) assess the impact of public policy effectiveness on farmer productivity; (3) analyse the effect of innovation adoption on productivity; (4) examine the effects of innovation adoption and productivity on farmers'

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economic welfare; and (5) analyse the mediating roles of innovation adoption and productivity in the relationship between public policy effectiveness and economic welfare. This research is important because empirical evidence explaining how public policy effectiveness translates into improved household-level economic welfare among farmers remains limited. Despite the implementation of various agricultural policies and fiscal support programmes, including those targeting tobacco farming, their welfare impacts often appear inconsistent and difficult to explain causally. By employing a serial mediation approach, this study contributes to clarifying why improvements in innovation or productivity do not always result in enhanced economic welfare. From a policy perspective, the findings are expected to inform the design of more targeted, outcome-oriented policies capable of sustainably improving the economic welfare of tobacco farmers, particularly in economically vulnerable regions such as Madura.

2. Literature Review

2.1. Public Policy Effectiveness

Public policy effectiveness is rooted in Public Policy Theory, which views policy as a governmental instrument to correct market failures, reduce inequality, and promote social welfare. A policy is considered effective when it achieves its substantive objectives through appropriate design, consistent implementation, and measurable impacts on target groups. In the agricultural sector, policy effectiveness is reflected in the government's ability to provide incentives, price protection, access to technology, and institutional support for smallholder farmers. This perspective is reinforced by Institutional Theory, which emphasizes that policies, regulations, and norms shape economic actors' behavior through incentive structures and institutional constraints. Recent empirical studies indicate that effective agricultural policies create an enabling institutional environment that encourages farmers to adopt innovations and improve farm performance (Adelle et al., 2021); (Saleh & Athari, 2023). In developing-country contexts, however, inconsistent or top-down policy implementation may weaken innovation incentives and ultimately reduce farmers' economic welfare. Public policy effectiveness refers to the extent to which public policies achieve their intended objectives and generate tangible outcomes for target groups. Dunn (2018) defines policy effectiveness as the degree to which policy interventions successfully address the problems they are designed to solve. Similarly, (Zolak Poljašević et al., 2025) emphasize that effective public policies are those that produce desired outcomes through appropriate policy design, suitable instruments, and consistent implementation. From an institutional perspective, (Roblek et al., 2019) argues that policy effectiveness is reflected in the alignment between policy goals, implementation processes, and actual impacts experienced by beneficiaries. The (Xu et al., 2024) further highlights that policy effectiveness is associated with governments' capacity to deliver measurable, relevant, and sustainable impacts on social welfare. Collectively, these perspectives underline that public policy effectiveness is not merely determined by policy formulation but by the ability of policies to translate objectives into observable improvements in economic and social conditions.

2.2. Innovation Adoption

Innovation adoption is grounded in **Diffusion of Innovation Theory** (Rogers), which explains how innovations spread and are adopted through cognitive and social processes. Innovation adoption among farmers is influenced not only by the characteristics of the innovation itself but also by policy support, access to information, and institutional capacity. Recent agricultural studies demonstrate that effective public policies accelerate innovation adoption through technology subsidies, training programs, and technical assistance. Nevertheless, several studies report that innovation adoption remains suboptimal due to limited farmer literacy, market risks, and price uncertainty (Ruzzante et al., 2021); (Chivasa et al., 2022). These findings highlight innovation adoption as a critical transmission mechanism linking public policy effectiveness to farmers' economic outcomes. Innovation adoption refers to the process through which individuals or

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organizations decide to accept and use new ideas, technologies, or practices in their activities. According to (Feeny & Rogers, 2003), innovation adoption is a multistage process involving knowledge, persuasion, decision, implementation, and confirmation of an innovation. (Damanpour, 2018) defines it as the adoption and implementation of ideas or technologies perceived as new by an individual or organization. In the agricultural context, (Rossi et al., 2024) conceptualize innovation adoption as farmers' decisions to apply new technologies to improve productivity and production efficiency. (Matarneh et al., 2024) further emphasize that innovation adoption represents the final stage of the diffusion process, where innovations are consistently integrated into routine practices. Collectively, these perspectives indicate that innovation adoption is not merely the availability of innovation, but the sustained use of new technologies or practices influenced by economic considerations, perceived benefits, and institutional support

2.3. Productivity

Productivity is theoretically anchored in Production Theory, which emphasizes efficiency in transforming inputs into outputs. In agriculture, productivity reflects farmers' ability to maximize yields through the efficient use of technology, skills, and farming practices. This concept is further elaborated by Farm Performance Theory, which positions productivity as a core indicator of farm-level performance. Empirical evidence suggests that agricultural innovation adoption has a positive effect on productivity; however, the magnitude of this effect depends heavily on implementation quality and sustained policy support (Islam et al., 2023); (Fertő & Bojnec, 2025). Accordingly, productivity functions as a performance-based mediator connecting innovation adoption with farmers' economic welfare. Productivity refers to the efficiency with which inputs are transformed into outputs within a production process. (Farrell et al., 2021) defines productivity as the ability of a production unit to achieve maximum output from a given set of inputs, emphasizing technical efficiency. (Putro & Takahashi, 2024) conceptualize productivity as the ratio between outputs produced and inputs utilized, reflecting overall production performance. From an economic perspective, (Samuelson, 1954) describe productivity as a key indicator of how effectively labor, capital, and other resources are used to generate goods and services. In the agricultural context, (Zhu et al., 2024) argue that productivity improvements arise from technological progress, enhanced skills, and more efficient input utilization. Collectively, these definitions highlight productivity as a central measure of performance and efficiency that underpins economic growth and welfare outcomes.

2.4. Economic Welfare

Economic welfare is grounded in Welfare Economics, which assesses well-being based on individuals' or households' capacity to generate income, meet basic needs, and achieve economic stability. In the agricultural context, economic welfare is commonly measured through farmers' income levels, purchasing power, and household economic resilience. This framework is strengthened by Sustainable Livelihoods Theory, which conceptualizes welfare as a multidimensional outcome shaped by access to productive assets, livelihood strategies, and the broader policy and institutional environment. Recent studies consistently show that improvements in agricultural productivity contribute positively to farmers' economic welfare, although the effect may be weakened by price volatility and unequal market structures (Scoones, 2015); (Dethier & Effenberger, 2012). Economic welfare refers to the level of well-being that individuals or households achieve through their economic conditions, particularly income, consumption, and economic security. (K. A. Khan et al., 2025) conceptualizes economic welfare as the component of social welfare that can be measured directly in monetary terms, such as income and consumption. (Samuelson, 1954) views economic welfare as a condition in which resource allocation maximizes individual utility and satisfaction. In the development context, (Mthanti & Ojah, 2018) define economic welfare as the ability of households to meet basic needs, improve income levels, and attain a decent standard of living. Specifically in agriculture, (Dethier & Effenberger, 2012) emphasize that farmers' economic welfare is reflected in income stability, purchasing power, and resilience to production and market

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risks. Overall, these perspectives indicate that economic welfare encompasses not only income generation but also economic security and sustainability of livelihoods.

3. Hypothesis Development

3.1. Public Policy Effectiveness and Innovation Adoption

Drawing on Public Policy Theory and Institutional Theory, effective public policies shape farmers' economic behaviour by reducing uncertainty and providing incentives, resources, and institutional support. In agriculture, policies such as input subsidies, extension services, and access to finance lower adoption barriers and accelerate innovation diffusion, consistent with Diffusion of Innovation Theory. Empirical evidence remains mixed. (Nguyen et al., 2021); (Ruzzante et al., 2021) report a positive effect of effective agricultural policies on innovation adoption, whereas (Chivasa et al., 2022) find that top-down and poorly contextualised policies may hinder adoption. These findings suggest that policy effectiveness, rather than policy presence, determines innovation uptake.

H1: *Public Policy Effectiveness positively influences Innovation Adoption among tobacco farmers in Madura.*

3.2. Public Policy Effectiveness and Productivity

According to Production Theory, effective policies enhance productivity by improving access to quality inputs, technology, and infrastructure. Institutionally, stable and predictable policies encourage efficiency-oriented production decisions. Empirical findings are inconclusive. (Shah et al., 2023) document a positive policy productivity relationship, while (Fertő & Bojnec, 2025) show insignificant effects when farmer capacity is limited. (Dethier & Effenberger, 2012) further highlight that certain policy interventions may weaken production incentives. This ambiguity warrants further empirical testing.

H2: *Public Policy Effectiveness positively influences the Productivity of tobacco farmers in Madura.*

3.3. Public Policy Effectiveness and Economic Welfare

From a Welfare Economics perspective, public policy aims to enhance economic welfare through income growth and risk reduction. For farmers, effective policies are expected to improve market access, price stability, and household welfare. However, empirical evidence is inconsistent. (Kien et al., 2023) find positive welfare effects, whereas (Dethier & Effenberger, 2012) show limited direct impacts due to price volatility and market distortions, suggesting the presence of indirect mechanisms.

H3: *Public Policy Effectiveness positively influences the Economic Welfare of tobacco farmers in Madura.*

3.4. Innovation Adoption and Productivity

Based on Diffusion of Innovation Theory and Production Theory, innovation adoption improves input efficiency, yields, and cost structures, thereby enhancing productivity. Most studies report positive effects (Chivasa et al., 2022); (A. J. Khan et al., 2022), although (Ruzzante et al., 2021) note that capital constraints and small-scale operations may limit productivity gains. Thus, the innovation–productivity relationship remains context-dependent.

H4: *Innovation Adoption positively influences the Productivity of tobacco farmers in Madura.*

3.5. Innovation Adoption and Economic Welfare

Within the Sustainable Livelihoods Framework, innovation adoption strengthens productive assets and income-generating capacity. Empirical findings vary. (Kien et al., 2023) show welfare improvements following innovation adoption, whereas (Dethier & Effenberger, 2012) argue that

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welfare gains may not materialise without favourable output prices, indicating a potentially indirect relationship.

H5: *Innovation Adoption positively influences the Economic Welfare of tobacco farmers in Madura.*

3.6. Productivity and Economic Welfare

According to Welfare Economics, productivity growth is a key determinant of income and purchasing power. In agriculture, higher productivity is expected to enhance household economic stability. While most studies find positive effects (Kien et al., 2023); (K. A. Khan et al., 2025), others emphasise that price volatility and market power may weaken welfare outcomes (Scoones, 2015); (Dethier & Effenberger, 2012), particularly for tobacco.

H6: Productivity positively influences the Economic Welfare of tobacco farmers in Madura.

3.7. Mediating Role of Innovation Adoption

From Institutional Theory and Diffusion of Innovation Theory, public policy affects productivity primarily through its capacity to stimulate innovation adoption. Without adoption, policy interventions yield limited performance improvements. Empirical evidence supports this mediation mechanism (Ruzzante et al., 2021); (Chivasa et al., 2022).

H7: *Innovation Adoption mediates the relationship between Public Policy Effectiveness and Productivity among tobacco farmers in Madura.*

3.8. Mediating Role of Productivity

Within Production Theory and Welfare Economics, innovation contributes to welfare mainly when it translates into productivity gains, positioning productivity as a key transmission channel. Previous studies confirm this role (Nguyen Thanh et al., 2024); (K. I. Khan et al., 2025).

H8: *Productivity mediates the relationship between Innovation Adoption and Economic Welfare among tobacco farmers in Madura.*

3.9. Sequential Mediation: Policy, Innovation, Productivity, and Welfare

According to Institutional Theory and the Capability Approach, effective public policies enhance farmers' capabilities by promoting innovation, which improves productivity and ultimately economic welfare. Innovation and productivity thus form a sequential pathway linking policy to welfare outcomes. Empirical studies confirm this mechanism (Schut et al., 2014); (Pietrobelli et al., 2021); (Altenburg, 2024); (FAO, 2022); (Gaitán-Cremaschi et al., 2022).

H9: *Innovation Adoption mediates the effect of Public Policy Effectiveness on Farmer Productivity.*

H10: *Innovation Adoption and Farmer Productivity sequentially mediate the effect of Public Policy Effectiveness on Economic Welfare.*

3.10. Innovation, Productivity, and Economic Welfare

From Human Capital Theory and Production Theory, innovation represents an investment that enhances efficiency and productivity, which subsequently improves welfare. Productivity therefore serves as the primary transmission mechanism. Empirical evidence consistently supports this pathway (Dethier & Effenberger, 2012); (Ogundari & Onyeaghala, 2021); (Díaz-Fúnez et al., 2021).

H11: *Farmer Productivity mediates the relationship between Innovation Adoption and Economic Welfare among tobacco farmers in Madura.*

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The conceptual model of this study is illustrated in Figure 1: Conceptual Framework.

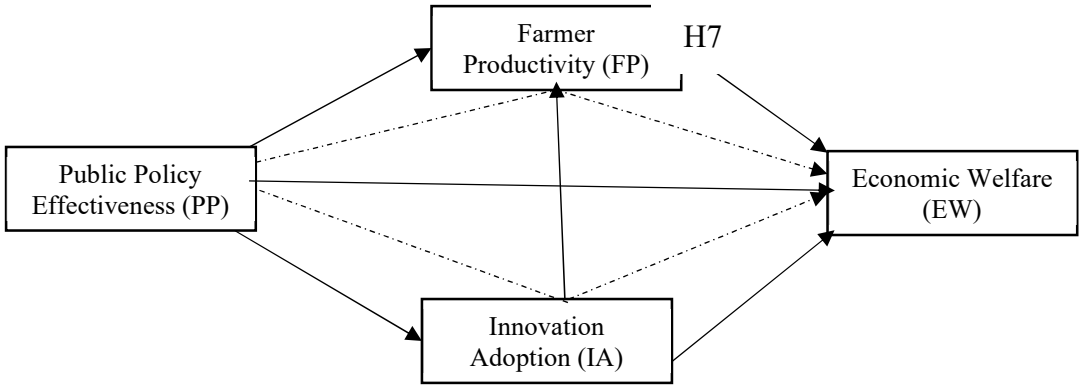

Figure 1. *Conceptual Framework.*

4. Research Methodology

4.1. Research Design

This study adopts a quantitative research design to examine the effect of public policy effectiveness on the economic welfare of tobacco farmers in Madura, with innovation adoption and productivity serving as intervening variables. A descriptive explanatory research design is employed to both describe the socio-economic and institutional conditions of tobacco farmers and to test the causal relationships among public policy effectiveness, innovation adoption, productivity, and economic welfare. The descriptive component aims to capture the characteristics of tobacco farming households, their exposure to agricultural policies, and their level of innovation adoption and productivity. Meanwhile, the explanatory component focuses on identifying causal mechanisms through which effective public policies influence farmers' welfare outcomes, either directly or indirectly through innovation and productivity pathways. The conceptual framework of this study is grounded in Public Policy Theory, Institutional Theory, Diffusion of Innovation Theory, Production Theory, and Welfare Economics, which collectively explain how policy effectiveness shapes farmers' behavioural responses, production performance, and economic outcomes. Public Policy Theory and Institutional Theory provide a foundation for understanding the role of government interventions in structuring incentives and constraints faced by farmers. Diffusion of Innovation Theory explains how policy support facilitates or inhibits the adoption of agricultural innovations, while Production Theory clarifies how innovation adoption translates into productivity improvements. Finally, Welfare Economics offers a framework for understanding how increased productivity contributes to improvements in farmers' economic welfare. To empirically test the proposed model, Structural Equation Modelling (SEM) is employed as the primary analytical technique. SEM is particularly suitable for this study as it allows for the simultaneous estimation of direct effects (e.g., public policy effectiveness on economic welfare), indirect effects (through innovation adoption and productivity), and mediating relationships within a single comprehensive model. This approach is well suited for analysing complex policy-driven empowerment processes in agricultural contexts, where welfare outcomes are influenced by multiple interrelated behavioural and performance-based mechanisms.

4.2. Research Approach

A quantitative research approach is employed to enable systematic data collection and objective statistical testing of the proposed hypotheses regarding the relationships among public policy effectiveness, innovation adoption, productivity, and economic welfare of tobacco farmers in Madura. This approach allows for precise measurement of the strength and significance of both direct and indirect effects, particularly the mediating roles of innovation adoption and productivity in

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linking policy effectiveness to farmers' economic welfare. The quantitative approach facilitates the use of latent variable modelling, enabling complex relationships among policy, behavioural, performance, and welfare constructs to be examined within a unified analytical framework. By applying this approach, the study is able to empirically assess how variations in perceived policy effectiveness influence farmers' adoption of agricultural innovations, subsequent productivity outcomes, and ultimately their economic welfare. The use of a sufficiently large and representative sample of tobacco farmers enhances the external validity of the findings and supports cautious generalisation to similar tobacco-producing regions with comparable institutional and policy environments. Furthermore, the quantitative approach ensures methodological rigour, objectivity, and replicability, providing a robust empirical foundation for evaluating the effectiveness of public policies aimed at promoting innovation-driven productivity and economic empowerment in the agricultural sector.

4.3. Data Collection and Sources

Primary data were collected through a structured questionnaire survey administered directly to tobacco farmers in Madura, who are actively engaged in tobacco cultivation and marketing. The survey targeted household heads or primary decision-makers in farming activities, as they possess the most comprehensive knowledge regarding policy exposure, innovation practices, production performance, and household economic conditions. The questionnaire employed a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5), to measure respondents' perceptions of public policy effectiveness, innovation adoption, productivity, and economic welfare. The items were designed to capture farmers' experiences with agricultural policies, their adoption of production and technological innovations, their perceived productivity outcomes, and their overall economic welfare. Prior to the main survey, a pilot test involving 30 tobacco farmers was conducted to evaluate the clarity, content validity, and reliability of the measurement instruments. Feedback from the pilot study was used to refine wording and ensure that all questionnaire items were understandable and contextually appropriate for tobacco farmers. Ethical considerations were strictly observed throughout the data collection process. Participation was entirely voluntary, respondents were informed about the purpose of the study, and anonymity and confidentiality of all responses were guaranteed. All data were used exclusively for academic research purposes. This study relies exclusively on primary data. The dataset includes respondents' demographic characteristics (such as age, education level, farming experience, and household size), farm characteristics (land size, length of tobacco cultivation, production volume, and income from tobacco farming), as well as perceptual measures of the core research variables. No secondary data were employed; therefore, all analyses and interpretations are based solely on empirical evidence obtained directly from tobacco farmers in Madura.

4.4. Population, Sample, and Sampling Technique

The population of this study comprises all tobacco farmers operating in Madura Island, East Java Province, Indonesia, including farmers engaged in tobacco cultivation as their primary source of livelihood. Tobacco farmers in Madura represent a strategically important yet economically vulnerable group, as their income and welfare are highly dependent on agricultural policies, market structures, and production performance. Therefore, this population provides a relevant unit of analysis for examining how public policy effectiveness influences economic welfare through innovation adoption and productivity pathways. The study employs a total sample of 320 tobacco farmers, consisting of household heads or primary decision-makers in tobacco farming activities. These respondents possess sufficient knowledge regarding agricultural policies, innovation practices, production processes, and household economic conditions, enabling reliable assessment of the proposed research variables. The determination of sample size follows established Structural Equation Modelling (SEM) guidelines, which recommend a minimum sample size of ten observations per indicator to ensure stable parameter estimation and adequate statistical power (Sarstedt et al.,

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2021); (Kline, 2018). With 32 indicators included in the research model, a minimum sample size of 320 respondents (32 × 10) is considered methodologically appropriate for testing direct and indirect relationships within a complex mediation framework.

To ensure representativeness, the sample was distributed proportionally across the four administrative districts of Madura Island, namely Bangkalan, Sampang, Pamekasan, and Sumenep, based on the relative concentration of tobacco farmers and the scale of tobacco cultivation in each district. This proportional allocation allows the study to capture geographical and institutional variations in policy exposure, innovation adoption, and productivity levels among tobacco farmers. Specifically, 80 respondents were drawn from Bangkalan Regency, reflecting its role as an entry point for agricultural markets and policy dissemination in western Madura. 75 respondents were allocated to Sampang Regency, which is characterised by small-scale tobacco farming and relatively high economic vulnerability. 85 respondents were selected from Pamekasan Regency, recognised as a major tobacco-producing area with active farmer groups and extension activities. Finally, 80 respondents were drawn from Sumenep Regency, which has the largest land area and a substantial number of tobacco farmers operating in both mainland and island sub-regions. This distribution is intended to provide a comprehensive representation of tobacco farming conditions across Madura Island. A purposive sampling technique was employed, with respondents required to meet specific inclusion criteria aligned with the research objectives. First, participants had to be active tobacco farmers who had been engaged in tobacco cultivation for a minimum of two consecutive production cycles, ensuring adequate experience in evaluating policy impacts, innovation adoption, and productivity outcomes. Second, respondents were required to have direct involvement in decision-making related to farming practices and input utilisation. Third, participants needed to demonstrate a basic understanding of agricultural policies, production processes, and household economic conditions. Finally, only farmers who participated voluntarily and completed the questionnaire in full were included in the final sample, thereby ensuring the reliability and validity of the collected data.

4.5. Data Analysis

Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) with SmartPLS software. PLS-SEM was selected due to its suitability for predictive-oriented research, theory development, and the examination of complex mediation relationships, particularly in agricultural and public policy studies involving smallholder farmers, where data often do not fully meet multivariate normality assumptions and sample heterogeneity is common. PLS-SEM is especially appropriate for this study because the proposed model integrates policy-related constructs (public policy effectiveness), behavioural mechanisms (innovation adoption), performance outcomes (productivity), and welfare outcomes (economic welfare) within a single analytical framework. This approach allows for simultaneous estimation of direct and indirect effects, thereby capturing the policy–innovation–productivity–welfare pathways experienced by tobacco farmers in Madura. The measurement model was evaluated to ensure construct validity and reliability. Convergent validity was assessed using the Average Variance Extracted (AVE), with all constructs exceeding the recommended threshold of 0.50, indicating that the indicators adequately captured their respective latent variables. Discriminant validity was examined using both the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio, confirming that each construct was empirically distinct. Internal consistency reliability was assessed through Cronbach's alpha, rho_A, and composite reliability, all of which exceeded the recommended minimum value of 0.70, indicating satisfactory reliability. The structural model was evaluated by analysing standardised path coefficients, t-statistics, and p-values obtained through a bootstrapping procedure with a large number of resamples. The model's explanatory and predictive power were assessed using the coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). The mediating roles of innovation adoption and productivity in the relationship between public policy effectiveness and economic welfare were examined through indirect effect analysis, following recommended procedures for

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mediation testing in PLS-SEM. To minimise the potential influence of common method variance (CMV), both procedural and statistical remedies were applied. Procedurally, respondents were assured of anonymity and confidentiality, and measurement items for different constructs were clearly separated within the questionnaire. Statistically, full collinearity testing was conducted, and all variance inflation factor (VIF) values were below the recommended threshold, indicating that CMV did not pose a significant concern in this study.

5. Empirical analysis

5.1. Characteristics Respondents

Table 1 describes the structural characteristics of tobacco-farming households in Madura, which are predominantly male-led, experience-based, and asset-intensive micro-enterprises. Of the 320 respondents, 97.4% are male, reflecting male dominance in production decisions and programme participation, with limited female inclusion. The age profile indicates an ageing farmer population, with 57.5% aged above 53 years, highlighting weak intergenerational succession and the continued importance of social assistance in sustaining livelihoods. Educational attainment is generally low, constraining financial management and innovation adoption, thereby underscoring the relevance of financial literacy as a moderating factor. Most respondents possess over ten years of farming experience, suggesting strong path dependency, while high asset ownership (88.7%) coexists with persistent vulnerability due to price volatility and production risks. Overall, these characteristics support the study's framework linking social assistance and empowerment to economic self-reliance and poverty reduction.

Table 1. Respondent Profile.

Category	Information	N	%
Gender	Man	**312**	97.4
	Woman	**8**	2.6
	Total	**320**	**100.0**
Age	21–34 years	**57**	17.9
	35–52 years	**79**	24.6
	>53 years	**184**	57.5
	Total	**320**	**100.0**
Education	Primary	**117**	36.5
	Secondary	**44**	13.7
	Bachelor	**54**	17.0
	Masters	**48**	15.0
	Doctorate	**0**	0.0
	Others	**102**	32.0
	Total	**320**	**100.0**
Length of Business	2–5 years	**59**	18.3
	≥5–10 years	**117**	36.5
	≥10 years	**144**	45.2
	Total	**320**	**100.0**
Asset Value	< IDR 50 million	**36**	11.3
	≥ IDR 50 million	**284**	88.7
	Total	**320**	**100.0**

Source: Data processed.

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5.2. Measurement Model Testing

Table 2. *Measurement Model Testing Convergent Validity, Composite Reliability and Cronbach's Alpha.*

Variable	λ	Cronbach's α	rho_A	CR	AVE
Economic Welfare		0.948	0.950	0.957	0.735
EW1	0.847				
EW2	0.881				
EW3	0.874				
EW4	0.821				
EW5	0.829				
EW6	0.903				
EW7	0.873				
EW8	0.825				
Farmer Productivity		0.937	0.940	0.948	0.695
FP1	0.772				
FP2	0.818				
FP3	0.847				
FP4	0.803				
FP5	0.828				
FP6	0.883				
FP7	0.855				
FP8	0.858				
Innovation Adoption		0.925	0.930	0.938	0.656
IA1	0.828				
IA2	0.830				

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IA3	0.868				
IA4	0.722				
IA5	0.794				
IA6	0.833				
IA7	0.820				
IA8	0.772				
Public Policy Effectiveness		0.934	0.936	0.945	0.684
PP1	0.832				
PP2	0.774				
PP3	0.828				
PP4	0.837				
PP5	0.834				
PP6	0.833				
PP7	0.875				
PP8	0.802				

Source: Data processed.

Table 2 reports the measurement model assessment, covering indicator reliability, internal consistency, and convergent validity. All indicator loadings exceed the recommended threshold of 0.70, ranging from 0.722 to 0.903, confirming adequate indicator reliability without the need for item removal. Internal consistency reliability is strongly supported, with Cronbach's alpha values between 0.925 and 0.948, composite reliability ranging from 0.938 to 0.957, and rho_A values above 0.93, all surpassing accepted criteria. Convergent validity is also established, as average variance extracted (AVE) values range from 0.656 to 0.735, exceeding the minimum threshold of 0.50. Overall, the results demonstrate robust psychometric properties, indicating that the constructs of Public Policy Effectiveness, Innovation Adoption, Farmer Productivity, and Economic Welfare are measured reliably and validly, supporting subsequent structural model analysis and hypothesis testing.

Table 3 presents the discriminant validity assessment using the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio. The Fornell–Larcker results show that the square roots of AVE for all constructs—Economic Welfare (0.857), Farmer Productivity (0.834), Innovation Adoption (0.810), and Public Policy Effectiveness (0.827)—exceed their respective inter-construct correlations, indicating that each construct shares more variance with its indicators than with other constructs. HTMT analysis further confirms discriminant validity, as all values are well below the conservative

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threshold of 0.90. The highest HTMT value is observed between Farmer Productivity and Economic Welfare (0.652), while the remaining values range from 0.316 to 0.580. Overall, both criteria consistently demonstrate satisfactory discriminant validity, confirming that all constructs are conceptually and empirically distinct and suitable for structural model estimation.

Table 3. *Discriminant Validity.*

Variable	Economic Welfare	Farmer Productivity	Innovation Adoption	Public Policy Effectiveness
Fornell–Larcker criterion				
Economic Welfare	0.857			
Farmer Productivity	0.618	0.834		
Innovation Adoption	0.542	0.489	0.810	
Public Policy Effectiveness	0.502	0.545	0.301	0.827
HTMT 0.90 Criterion				
Economic Welfare				
Farmer Productivity	0.652			
Innovation Adoption	0.573	0.516		
Public Policy Effectiveness	0.530	0.580	0.316	

Source: Data processed.

5.3. Inner Model Assessment and Hypothesis Testing

The results of the structural model testing are presented in Figure 2.

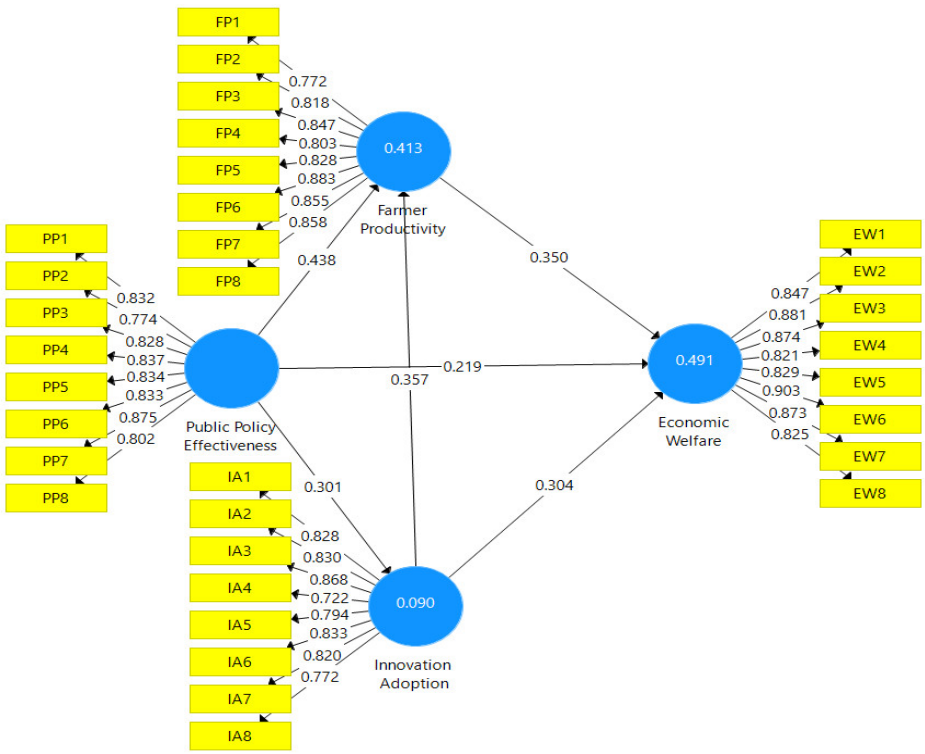

Figure 2. Structural Model.

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Figure 2 presents the structural model results, including standardized path coefficients and explained variance (R^2). Public Policy Effectiveness positively affects Farmer Productivity ($\beta = 0.438$) and Innovation Adoption ($\beta = 0.301$), indicating that policy support improves farm performance, although its influence on innovation uptake remains modest. Innovation Adoption enhances Farmer Productivity ($\beta = 0.357$) and directly contributes to Economic Welfare ($\beta = 0.304$), suggesting benefits beyond productivity gains. Farmer Productivity emerges as a key determinant of Economic Welfare ($\beta = 0.350$), while Public Policy Effectiveness retains a direct effect on welfare ($\beta = 0.219$), indicating partial mediation. The model explains a moderate proportion of variance in Farmer Productivity ($R^2 = 0.413$) and a substantial share of Economic Welfare ($R^2 = 0.491$), confirming a sequential mechanism linking policy effectiveness, innovation, productivity, and welfare outcomes.

Table 4 reports the hypothesis testing results based on the bootstrapping procedure in the PLS-SEM analysis. All proposed hypotheses are empirically supported, confirming the robustness of the conceptual model. Public Policy Effectiveness has significant positive effects on Innovation Adoption (H1: $\beta = 0.301$, $p < 0.001$), Farmer Productivity (H2: $\beta = 0.438$, $p < 0.001$), and Economic Welfare (H3: $\beta = 0.219$, $p < 0.001$). Innovation Adoption positively influences Economic Welfare (H4: $\beta = 0.304$, $p < 0.001$) and Farmer Productivity (H6: $\beta = 0.357$, $p < 0.001$), while Farmer Productivity significantly enhances Economic Welfare (H5: $\beta = 0.350$, $p < 0.001$).

Table 4. Hypothesis Testing.

Path Coefficients	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Decision
Direct Effects						
Public Policy Effectiveness -> Innovation Adoption	0.301	0.303	0.055	5.466	0.000	H1, Significant
Public Policy Effectiveness -> Farmer Productivity	0.438	0.438	0.049	8.964	0.000	H2, Significant
Public Policy Effectiveness -> Economic Welfare	0.219	0.220	0.054	4.091	0.000	H3, Significant
Innovation Adoption -> Economic Welfare	0.304	0.304	0.054	5.638	0.000	H4, Significant
Farmer Productivity -> Economic Welfare	0.350	0.351	0.065	5.402	0.000	H5, Significant
Innovation Adoption -> Farmer Productivity	0.357	0.358	0.046	7.832	0.000	H6, Significant
Indirect Effects						
Public Policy Effectiveness -> Innovation	0.092	0.092	0.023	3.960	0.000	H7, Significant

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Adoption -> Economic Welfare						
Public Policy Effectiveness -> Farmer Productivity -> Economic Welfare	0.153	0.154	0.034	4.575	0.000	H8, Significant
Public Policy Effectiveness -> Innovation Adoption -> Farmer Productivity	0.107	0.108	0.024	4.390	0.000	H9, Significant
Public Policy Effectiveness -> Innovation Adoption -> Farmer Productivity -> Economic Welfare	0.038	0.038	0.011	3.412	0.001	H10, Significant
Innovation Adoption -> Farmer Productivity -> Economic Welfare	0.125	0.125	0.027	4.653	0.000	H11, Significant

Source: Data processed.

Mediation analysis further confirms the proposed indirect relationships. Innovation Adoption mediates the effect of Public Policy Effectiveness on Economic Welfare (H7: $\beta = 0.092$, $p < 0.001$) and on Farmer Productivity (H9: $\beta = 0.107$, $p < 0.001$). Farmer Productivity mediates the relationship between Public Policy Effectiveness and Economic Welfare (H8: $\beta = 0.153$, $p < 0.001$) as well as between Innovation Adoption and Economic Welfare (H11: $\beta = 0.125$, $p < 0.001$). A significant serial mediation effect is also identified, whereby Public Policy Effectiveness influences Economic Welfare through Innovation Adoption and Farmer Productivity sequentially (H10: $\beta = 0.038$, $p = 0.001$). Overall, the findings demonstrate that welfare improvements are driven by both direct policy effects and indirect pathways through innovation and productivity.

5.4. Coefficient of Determination, Effect Size, and Predictive Relevance

Table 5 reports the explanatory power (R^2), effect size (f^2), and predictive relevance (Q^2) of the structural model. Economic Welfare shows moderate explanatory power ($R^2 = 0.491$), with a medium effect size ($f^2 = 0.141$) and strong predictive relevance ($Q^2 = 0.245$). Farmer Productivity also exhibits moderate explanatory power ($R^2 = 0.413$), a medium effect size ($f^2 = 0.138$), and high predictive relevance ($Q^2 = 0.292$). In contrast, Innovation Adoption has a low R^2 value (0.090), indicating limited explanatory power, a small effect size ($f^2 = 0.066$), and modest but acceptable predictive relevance ($Q^2 = 0.082$). Overall, the model performs well in explaining and predicting economic welfare and productivity, while innovation adoption is influenced by additional factors beyond the current framework.

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Table 5. *Presents the outcomes for R^2, f^2, and Q^2.*

Variabel	**R^2**	f^2	**Q^2**
Economic Welfare	0.491	0.141	0.245
Farmer Productivity	0.413	0.138	0.292
Innovation Adoption	0.090	0.066	0.082

Source: Data processed.

6. Discussion

6.1. Direct Effects

The findings demonstrate that Public Policy Effectiveness exerts a significant positive influence on innovation adoption, farmer productivity, and economic welfare, confirming that agricultural policy functions as a critical institutional driver of rural economic transformation. Effective policies reduce structural constraints by improving access to technology, extension services, and market support, thereby increasing farmers' capacity and willingness to adopt innovations. This result aligns with Institutional Theory, which posits that formal rules and policy frameworks shape economic behaviour by creating incentives and reducing uncertainty. Consistent with recent empirical evidence, well-designed agricultural policies accelerate innovation diffusion and enhance farm-level performance, particularly in smallholder-dominated systems (Ruzzante et al., 2021); (Chivasa et al., 2022).

The positive and significant relationship between innovation adoption and farmer productivity indicates that technological and managerial innovations play a pivotal role in improving production efficiency. This finding supports Diffusion of Innovation Theory, which argues that adoption leads to performance gains when supported by adequate institutional and knowledge systems. In practice, innovation adoption enables farmers to optimise input use, adopt improved cultivation techniques, and mitigate production risks. Similar conclusions have been reported in recent studies showing that innovation adoption significantly enhances agricultural productivity, although the magnitude of the effect depends on policy coherence and implementation quality (Kassie et al., 2021); (Islam et al., 2023).

Farmer productivity is also found to have a direct and positive effect on economic welfare, suggesting that productivity gains translate into higher and more stable incomes, improved purchasing power, and greater household resilience. This relationship is consistent with Welfare Economics and Sustainable Livelihoods Theory, which emphasise productivity growth as a key pathway to improving rural welfare. Empirical evidence from developing countries confirms that increased agricultural productivity contributes to poverty reduction and welfare improvement, although the benefits may be moderated by market volatility and institutional constraints (Dethier & Effenberger, 2012).

Notably, the direct effect of public policy effectiveness on economic welfare indicates that policy interventions influence welfare outcomes not only through productivity enhancement but also via income stabilisation, social protection, and market regulation mechanisms. While some studies report limited policy impacts in contexts characterised by weak governance or fragmented implementation, the consistently significant effects observed in this study suggest that policy effectiveness rather than policy presence—is the determining factor shaping farmer behaviour and welfare outcomes. These findings imply that strengthening policy coherence, implementation capacity, and innovation-oriented support instruments is essential for achieving sustainable productivity growth and long-term economic welfare among farmers (Ruzzante et al., 2021); (Chivasa et al., 2022).

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6.2. Mediating Effects

The mediation analysis provides strong evidence that the impact of public policy effectiveness on farmers' economic welfare operates predominantly through indirect mechanisms, rather than solely through direct intervention. The significant mediating role of innovation adoption in the relationship between public policy effectiveness and economic welfare indicates that policy instruments translate into welfare gains only when they successfully stimulate behavioural change at the farm level. This finding is consistent with Institutional Theory and Diffusion of Innovation Theory, which posit that policies influence outcomes by reshaping incentives, reducing adoption risks, and facilitating learning processes. Empirical studies have similarly shown that policy support improves welfare primarily by accelerating innovation uptake rather than by direct income transfers alone (Ruzzante et al., 2021); (Kassie et al., 2021).

The mediating role of farmer productivity further reinforces the centrality of production efficiency as a transmission channel from policy to welfare. The significant indirect effect of public policy effectiveness on economic welfare through productivity suggests that productivity growth remains a fundamental prerequisite for sustainable welfare improvements. This result aligns with Production Theory and Welfare Economics, which emphasise productivity as the key mechanism linking institutional interventions to income and livelihood outcomes. Recent evidence from agricultural systems in developing countries confirms that productivity-enhancing policies are more effective in improving welfare than those focused solely on price or income support (Dethier & Effenberger, 2012); (Islam et al., 2023).

Importantly, the confirmed mediation of innovation adoption between public policy effectiveness and farmer productivity highlights innovation as a critical intermediate outcome of policy interventions. This finding suggests that policy effectiveness should be evaluated not merely by budget allocation or programme coverage, but by its capacity to induce technological and managerial change at the farm level. Studies by (Chivasa et al., 2022); (Ruzzante et al., 2021) similarly report that policies lacking innovation-oriented design fail to generate meaningful productivity gains, underscoring the behavioural nature of policy effectiveness.

The presence of a statistically significant serial mediation effect from public policy effectiveness to innovation adoption, then to farmer productivity, and ultimately to economic welfare provides robust support for a sequential development pathway. This pathway is consistent with the Capability Approach and Sustainable Livelihoods Theory, which conceptualise welfare as an outcome of accumulated productive capabilities rather than short-term assistance. Empirical evidence supports this logic, showing that innovation-driven productivity growth is the most reliable route to long-term welfare improvement among smallholder farmers, particularly in regions characterised by market imperfections and price volatility (Altenburg, 2024); (FAO, 2022).

Finally, the mediation of farmer productivity in the relationship between innovation adoption and economic welfare confirms that innovation alone does not automatically translate into welfare gains. Productivity improvement emerges as the critical conversion mechanism through which innovation generates economic benefits. This finding is consistent with recent studies demonstrating that innovation without measurable productivity gains has limited welfare impact, especially in commodity sectors with unstable output prices such as tobacco (Ogundari, 2021); (Bernardo, 2014). Overall, these results imply that effective agricultural policy should prioritise innovation-enabling environments and productivity-enhancing interventions to achieve durable welfare outcomes, rather than relying on direct policy support alone.

7. Conclusion

This study provides robust empirical evidence that public policy effectiveness plays a central role in improving the economic welfare of tobacco farmers in Madura through both direct and indirect mechanisms. The findings demonstrate that effective agricultural policies significantly enhance innovation adoption and farmer productivity, which subsequently contribute to higher

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levels of economic welfare. The confirmed presence of both simple and serial mediation effects indicates that policy interventions achieve their welfare outcomes primarily by stimulating behavioural change and performance improvement at the farm level rather than through direct income effects alone. These results reinforce the explanatory power of Institutional Theory and Diffusion of Innovation Theory in elucidating how policy-driven institutional support translates into productivity gains and welfare improvements, while also aligning with Welfare Economics in highlighting productivity as a key pathway to sustained economic well-being.

From a policy and practical standpoint, the results suggest that agricultural policies should move beyond short-term, input-oriented interventions toward innovation-centred and productivity-enhancing strategies. Policy instruments that strengthen extension services, facilitate access to technology, and reduce adoption risks are more likely to generate durable welfare gains for farmers. In the context of tobacco farming in Madura, integrated policy packages combining technical training, institutional support, and market access are particularly important given the sector's exposure to price volatility and structural constraints. These findings imply that policy effectiveness should be evaluated not only by implementation intensity but by its capacity to foster innovation uptake and productivity growth among smallholders.

This study contributes to the literature by empirically validating a sequential mediation framework linking public policy effectiveness, innovation adoption, farmer productivity, and economic welfare within a single analytical model. By integrating multiple grand theories into a unified empirical structure, the study offers a more nuanced understanding of how policy interventions operate in smallholder agricultural systems in developing regions. Nevertheless, several limitations should be acknowledged. The cross-sectional design restricts causal inference over time, and future research employing longitudinal data could provide deeper insights into dynamic policy effects. In addition, the focus on economic welfare excludes social and environmental dimensions that are increasingly relevant in sustainable agriculture debates. Finally, the context-specific nature of the study may limit generalisability, suggesting the need for comparative studies across commodities and regions with differing institutional environments.

Conflicts of Interests: None.

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