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Copra agribusiness efficiency and institutional dynamics in Buton Regency, Indonesia: A structural equation modeling approach

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ABSTRACT
Coconuts are among Indonesia's most important plantation commodities, yet copra farmers continue to face low bargaining power, weak institutions, and limited technology adoption. This study assesses the determinants of smallholder productivity and welfare in the copra value chain by integrating supply chain dynamics, market conditions, institutional capacity, and technology adoption. Research was conducted in Lawele Village, Buton Regency, using a mixed-methods design. Primary data were collected from 70 farmers and three collectors through surveys, interviews, and field observations. Analytical methods combined descriptive cost and flow analysis with Partial Least Squares Structural Equation Modeling (PLS-SEM). Results show that supply chain efficiency and market demand significantly influence farmer outcomes only when mediated by institutional strength and technology use. Institutions have the strongest effect on productivity and welfare, while technology adoption enhances quality and competitiveness when supported by stable demand and cooperative governance. These findings empirically support the Structure-Conduct-Performance (SCP) perspective by demonstrating that institutional arrangements and technology adoption function as critical transmission mechanisms between market structure and farmer welfare outcomes. This study also highlights the need for integrated policy interventions that prioritize institutional strengthening, cooperative-managed technology, and transparent market systems. The study suggests that policy implications, which are manifested through empowerment of rural cooperatives, facilitation of digital market access, and expansion of farmer training programs, are essential to enhance smallholder resilience.

Contribution/Originality: This study contributes to new empirical evidence of the copra agribusiness system in eastern Indonesia, where smallholder farmers have to deal with structural inefficiencies. It documents how institutional collaboration and technology use can enhance the welfare and competitiveness of the farmers. This study offers policy implications for strengthening cooperative governance, digital market access, and inclusive rural development.

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1. INTRODUCTION

Coconut farming has long been established as one of the key pillars of Indonesia's plantation economy, where most of the farming area is managed by smallholder households. This subsector attracts millions of Indonesian farmers, making coconuts an inseparable part of the rural economy since the late nineteenth century through livelihood production activities of copra, especially in eastern Indonesia (Alouw & Wulandari, 2020; Suhascaryo & Yudiantoro, 2021). For many years, many regions in Sulawesi have relied on copra production, where the commodity was perceived to be a "green gold" product, which represents the main economic value and cultural significance in sustaining local communities (Evita, Mappangara, & Akhmar, 2020). As the copra industry develops among rural communities, presently, the significance of coconut farming extends far beyond local boundaries (Elfahmi, Sutiarso, Purwadi, & Machfoedz, 2024), positioning Indonesia as a major player in the coconut industry.

Globally, Indonesia is one of the largest coconut producers, which contributes significantly to the supply of coconut oil (CNO) and its derivative products to international markets. Although global demand experiences cyclical fluctuations, the industry still plays a vital role in the export sector and is a strategic contributor of foreign exchange for Indonesia (Alouw & Wulandari, 2020; Mardesci, Santosa, Nazir, & Hadiguna, 2019). On the other hand, this sector has also faced increasing competition from other coconut-producing Asian countries (Jayasekhar, Chandran, Thamban, & Muralidharan, 2019; Sairam & Jayasekhar, 2018). In addition, the volatility of palm kernel oil (PKO) prices in the international market significantly affects the global demand for coconut oil, posing challenges to Indonesia's position and competitiveness (Pratama, Tooy, & Kim, 2024). Yet, at the national level, around 6.6 million farmers rely on the coconut commodity, making it a crucial source of income for rural communities (Alouw & Wulandari, 2020). Hence, beyond its macroeconomic role, improving efficiency and value distribution within the coconut value chain has become essential in sustaining rural livelihoods and enhancing global competitiveness.

Along the value chain, studies indicate that the largest share of value addition and costs is concentrated in the processing stages, particularly in coco-coir and coco-geonet production. This highlights the importance of enhancing efficiency and profitability through better utilization of downstream activities. Nevertheless, limited access to institutional markets has been identified as a major constraint to scaling coconut-based enterprises, restricting profitability and competitiveness. Addressing these constraints requires targeted promotion, market development, and coordinated inter-agency support (Bandupriya, Perera, Pereira, & Bourdeix, 2020; Johnson et al., 2024). Furthermore, recent work underscores the critical roles of various stakeholders, including farmers, cooperatives, and government institutions, in ensuring value-chain resilience. Collaborative approaches have been recommended to improve credit access, information flow, and market linkages, while also promoting circular economy strategies to mitigate coconut waste and enhance sustainability (Muriuki, Ayuya, & Oloo, 2024).

Supply chain optimization represents another pressing concern. The design of networks aligned with local government policies can improve logistics, reduce distribution costs, and support agro-industrial development. Conceptual models validated by stakeholder insights demonstrate the potential for dynamic systems approaches to increase efficiency and effectiveness in coconut product chains (Meilizar, Hadiguna, Santosa, & Nofialdi, 2024). Moreover, performance measurement models for the coconut oil agro-industry covering inventory accuracy, delivery quality, and order fulfillment lead time offer pathways for continuous improvement and better business process management (Guenther, Guenther, Ringle, Zaefarian, & Cartwright, 2025; Zainol et al., 2023). Such approaches are crucial to strengthening supplier partnerships, improving demand forecasting, and sustaining competitiveness in global markets.

Despite these insights, relatively few studies have explicitly examined how supply chain efficiency and market dynamics interact with institutional capacity to shape productivity and welfare outcomes for smallholder farmers in underrepresented contexts such as Buton Regency in Southeast Sulawesi. Existing research tends to focus on technical efficiency, product innovation, or profitability analyses in isolated contexts (Jayasekhar et al., 2019; Ji, Vitale, Vitale, & Adam, 2023; Omar, Saili, Abdul Fatah, & Wan Noranida, 2023; Perera, 2020; Zmyślona, Sadowski, & Pawłowski, 2024). Yet, the mediating role of farmer institutions in translating market signals and supply chain improvements into tangible welfare outcomes remains empirically underexplored.

Against this backdrop, the present study develops and tests a structural model of the copra value chain in Lawele Village, Buton Regency. By integrating supply chain efficiency and market dynamics as exogenous drivers, institutional capacity as a mediating pathway, and productivity and welfare as farmer-level outcomes, the research aims to provide empirical evidence on causal linkages and practical leverage points for upgrading the copra value chain. This integrated approach is expected to contribute to the literature on sustainable coconut agribusiness while offering actionable insights for policy interventions that enhance cooperative governance, promote standardization, and improve transparency in market information systems.

Accordingly, this study seeks to answer two main research questions that guide the overall analysis. The first examines how institutional dynamics influence the efficiency of the copra value chain in Buton Regency, while the second explores the mediating role of technology adoption in enhancing smallholder productivity and welfare.

2. MATERIALS AND METHODS

2.1. Study Area

The research was conducted in Lawele Village, Lasalimu District, Buton Regency, Southeast Sulawesi Province, between August and November 2024. Lasalimu District covers an area of 245.02 km² and consists of 15 villages, with Lawele occupying approximately 22.95% of the total area (BPS Buton Regency, 2024). The village is located about 21 km from the district capital and 103 km from the regency capital, with limited accessibility that affects the distribution of agricultural products, particularly copra, which remains dependent on local intermediaries. Socio-economically, the community is dominated by coconut farmers who are highly dependent on the copra trade. Basic infrastructure, such as schools, health services, and housing, exists but is unevenly distributed. Most households rely on local water sources, village electricity networks, and firewood for cooking. Agroecologically, the region lies in lowland coastal zones with tropical rainfall patterns and soils suitable for coconut cultivation. The research location is presented in Figure 1 to illustrate the spatial distribution of the study site.

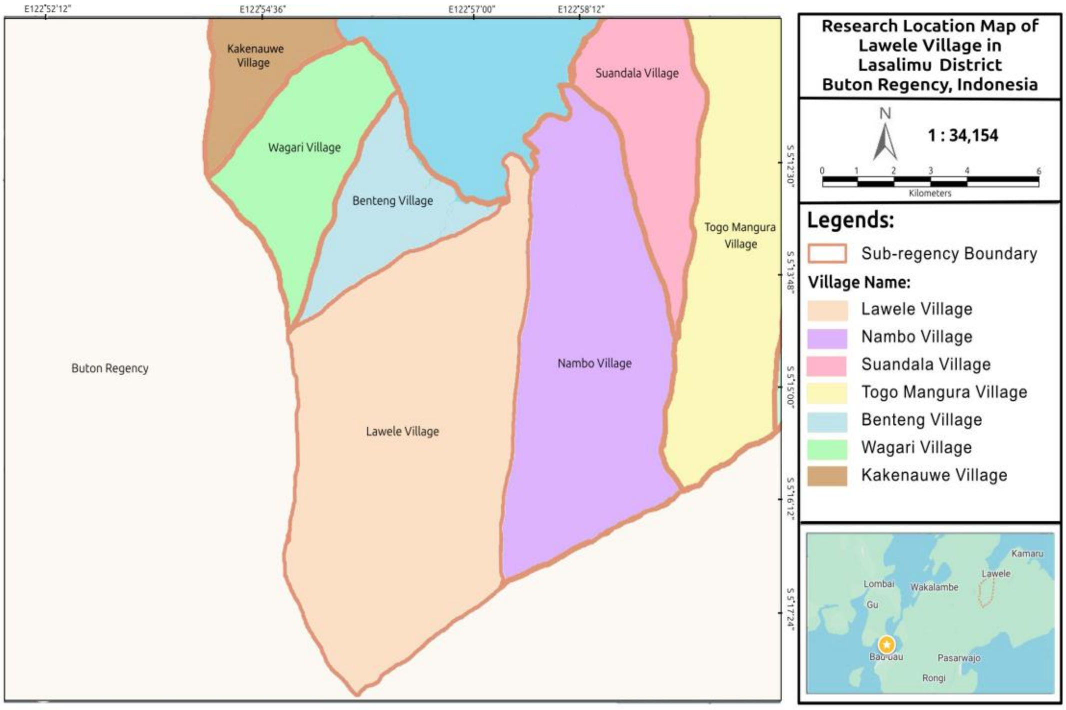

Figure 1. Research location map of Lawele Village, Lasalimu District, Buton Regency, Southeast Sulawesi, Indonesia.

2.2. Research Design and Data Collection

A mixed-methods design was employed to capture both quantitative and qualitative aspects of the copra value chain. Mixed-methods approaches are widely used in agricultural value-chain research because they enable the integration of structured survey data with contextual insights from qualitative inquiry (Smith, Cannata, & Haynes, 2016). Primary data were collected through standardized surveys of 70 copra farmers and three collectors, semi-structured in-depth interviews with key stakeholders such as cooperative leaders and traders, and direct field observations of production and distribution sites. Secondary data were obtained from official publications of the Indonesian Bureau of Statistics (BPS), local government reports, and relevant scientific literature to supplement primary findings.

2.3. Sampling

The study employed purposive sampling to ensure that respondents were active farmers and traders directly involved in copra production and marketing. This approach is commonly used in rural value-chain research to capture the perspectives of actors most relevant to the system under study (Ahmad & Wilkins, 2025; Andrade, 2020; Guarte & Barrios, 2006). The achieved sample size satisfies the general requirements for Partial Least Squares Structural Equation Modeling (PLS-SEM), which recommends a minimum sample of ten times the maximum number of structural paths directed at any construct (Arifin, 2025).

2.4. Analytical Framework

Supply chain analysis was conducted to assess efficiency and performance, focusing on three key flows: product, financial, and information. Product flow analysis traced how copra was harvested, processed, and distributed; financial flow analysis examined production and distribution costs; and information flow analysis assessed the transmission of price signals, market demand, and policy information. Similar frameworks have been employed in studies of smallholder commodity chains to highlight transaction costs and information asymmetries.

The behavior of supply chain actors was also analyzed to understand collaboration, trust, and bargaining power, which are recognized as crucial elements for improving institutional performance and market access. An economic cost analysis was conducted using a cost accounting framework where total cost (TC) is the sum of total fixed cost (TFC) and total variable cost (TVC). This approach enabled the identification of cost components most critical for farmer profitability and sustainability.

2.5. Structural Equation Modeling

To examine causal relationships, Structural Equation Modeling (SEM) was applied using Python-based Semopy software. Semopy provides a flexible, reproducible environment with syntax resembling mathematical notation, making it well-suited for empirical social science applications (Manhas, Manrai, & Manrai, 2012). Reflective measurement models were specified based on theoretical assumptions, consistent with the concept-proxy framework that ensures latent constructs are grounded in theory rather than statistical correlations alone (Guenther et al., 2025).

PLS-SEM was selected due to its suitability for prediction-oriented research, tolerance for non-normal data, and ability to handle complex models with moderate sample sizes. Following established guidelines, model assessment included convergent validity using average variance extracted (AVE), composite reliability, discriminant validity using the heterotrait-monotrait (HTMT) ratio, and bootstrapping with 5,000 resamples for significance testing (Roemer, Schuberth, & Henseler, 2021; Valentini & Damásio, 2016). Model fit was evaluated using the standardized root mean square residual (SRMR), while predictive relevance was assessed through Stone–Geisser's Q^2.

3. RESULTS AND DISCUSSION

3.1. Supply Chain Structure, Costs, and Feasibility

The copra value chain in Lawele Village is characterized by a complex interplay of production practices, cost structures, and market relationships that together determine the feasibility and profitability of farming activities. Understanding this structure is essential because it reveals not only how products, finances, and information flow across different actors but also where bottlenecks and inefficiencies reduce farmer welfare. By mapping these dynamics, it becomes possible to identify leverage points for improving efficiency, strengthening institutions, and enhancing the overall competitiveness of the sector.

Field evidence indicates that Lawele's copra economy is dominated by individually owned, small-scale units employing an average of about seven workers. Processing remains traditional: coconuts are husked, split, and dried either by sun or by smoking to reduce moisture for preservation. Because drying is highly dependent on weather, product quality is uneven and subject to penalties. This pattern mirrors prior studies showing that sun-drying can take 5–10 days and often results in mold and aflatoxin risks, whereas biomass or mechanical dryers shorten drying time and improve quality but require capital and collective management (Gunawan, Trihastuti, & Mulyana, 2021). Nearly 80% of farmers reported lacking modern drying equipment, thereby perpetuating high variability and limiting access to price premiums.

The organization of the chain follows a sequential structure in which farmers sell dried copra to small collectors, who consolidate and resell to a large collector, before shipments are sent to Surabaya by container. The large collector can store up to approximately 50 t at once, while small collectors accumulate batches of around 3 t, of which only 60% typically remain saleable after two weeks due to storage losses. Patron–client ties are common, with working-capital advances binding farmers to particular small collectors. At the farm gate, prices average IDR 8,000–10,000 kg^{-1}, while transactions between small and large collectors range between IDR 10,000–12,000 kg^{-1} depending on quality and demand conditions. This flow of products from farmers to downstream actors is summarized in Figure 2, which highlights the three main stages of copra movement.

Figure 2. Copra supply chain product flow.

Among the three canonical flows in value chain analysis, product, financial, and information, the information flow proves weakest. Before discussing information, it is important to note how financial transactions operate. Payments are made primarily in cash: farmers receive IDR 8,000–10,000 kg^{-1} from small collectors, while small collectors in turn receive IDR 10,000–12,000 kg^{-1} from large collectors. Farmers often borrow advances from small collectors, obligating them to repay through copra sales. This creates dependency and reduces their flexibility in choosing buyers. The circulation of money along the chain is shown in Figure 3, where the financial flow moves in the opposite direction to the product flow.

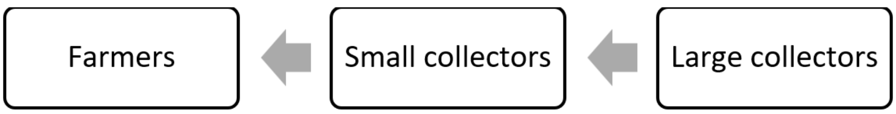

Figure 3. Copra supply chain financial flow.

Information, in contrast, moves less efficiently. Large collectors communicate demand volumes and quality requirements to small collectors, but farmers usually receive only delayed or incomplete signals about market prices and buyer expectations. About 60% of collectors set prices without transparent benchmarks, reinforcing farmers' weak bargaining position. This dynamic is illustrated in Figure 4, which shows that information flow is bidirectional yet remains dominated by collectors.

Figure 4. Copra supply chain information flow.

Such asymmetric structures are consistent with oligopsonistic conditions in many Indonesian agricultural markets, where a few buyers dominate numerous small producers and exercise unilateral control over pricing. This finding aligns with the value-chain framework that stresses how inefficiencies emerge when product, financial, and information flows are poorly coordinated (Zainol et al., 2023).

The cost structure of copra production in Lawele further clarifies the challenges and opportunities faced by smallholders. Tables below summarize fixed and variable costs, total expenditures, revenues, and incomes, with currency expressed in IDR and physical units in accordance with SI standards.

Table 1. Fixed costs of copra processing equipment (Monthly depreciation).

No.	Equipment type	Quantity (unit)	Cost (IDR unit^{-1})	Economic lifespan (year)	Depreciation (IDR month^{-1})
1	Crowbar	1	60,000	2	2,500.00
2	Machete	2	50,000	2	4,166.67
3	Coconut scoop	2	35,000	2	2,916.67
4	Wheelbarrow	1	280,000	2	11,666.70
Total		6	425,000	8	21,250.00

Table 1 presents the fixed costs associated with copra processing equipment, calculated based on monthly depreciation values. The table shows that basic tools such as machetes and wheelbarrows make up most of the fixed costs, averaging IDR 21,250 per month. Since equipment is relatively inexpensive and long-lasting, fixed costs are not a major burden for farmers, confirming that profitability largely depends on variable cost efficiency.

Table 2. Variable costs of copra processing per production cycle (≈3 months).

No.	Variable cost type	Cost (IDR cycle^{-1})
1	Raw materials (Whole nuts)	2,614,745
2	Kerosene	10,000
3	Matches	1,000
4	Labour	495,956
Total variable cost		3,121,701

The composition of variable costs incurred during one copra processing cycle is detailed in Table 2, highlighting the relative contribution of each cost component. Raw materials account for 83.8% of variable costs, labor contributes 15.9%, and fuel inputs are negligible. This dominance of raw material costs, typical in commodity processing, suggests that improvements in quality-linked pricing can have a stronger effect on margins than small reductions in other expenses (Ji et al., 2023).

Table 3. Total cost of copra processing per production cycle.

No.	Description	Cost (IDR cycle^{-1})
1	Total fixed cost	21,250
2	Total variable cost	3,121,701
3	**Total cost (TC)**	3,142,951

Table 3 summarizes the total cost structure of copra processing per production cycle by combining fixed and variable costs. The sum of fixed and variable costs shows that copra production requires about IDR 3.14 million per cycle. This translates to roughly IDR 3,143 per kilogram, which serves as the benchmark for evaluating profitability against selling prices.

Table 4. Revenue and income of copra farming per season.

No.	Description	Amount
1	Production volume	1,000 kg season^{-1}
2	Selling price	IDR 10,000 kg^{-1}
3	Total revenue (TR)	IDR 10,000,000
4	Total cost (TC)	IDR 3,142,951
5	**Income (TR – TC)**	IDR 6,857,049 season^{-1}

The seasonal revenue and income profile of copra farming is illustrated in Table 4, covering production volume, total revenue, costs, and net income. The revenue and cost calculation shows that farmers earn approximately IDR

6.86 million per season. Despite appearing profitable, this income is highly vulnerable to price fluctuations and quality penalties imposed by collectors.

Table 5. Feasibility of copra farming (R/C ratio).

Metric	Value
Total revenue (IDR)	10,000,000
Total cost (IDR)	3,142,951
R/C ratio (TR ÷ TC)	3.18

Table 5 presents the feasibility analysis of copra farming based on the revenue–cost (R/C) ratio indicates a ratio of 3.18, which suggests the activity is feasible according to standard criteria (Omar et al., 2023). With production costs averaging approximately IDR 3,143 kg^{-1}, farmers achieve a gross margin of about IDR 6,857 kg^{-1}. Although private profitability is apparent, these margins are influenced by structural constraints such as opaque grading systems, high transportation costs, and reliance on intermediaries. As a result, household-level profitability coexists with systemic value capture by collectors, a paradox also observed in long and buyer-dominated supply chains (Gunawan et al., 2021).

The results collectively highlight three persistent challenges. First, quality volatility continues to suppress farm-gate prices: most farmers depend on weather-dependent drying, and small collectors report losses of up to 40% during storage, making rejection and discounting common. Although modern drying technologies could reduce these risks, incentives remain weak due to the lack of transparent grading and credible price premia (Elfahmi et al., 2024). Second, the persistent price gap between farm-gate sales (IDR 8,000–10,000 kg^{-1}) and collector sales (IDR 10,000–12,000 kg^{-1}) indicates asymmetric bargaining power, consistent with oligopsony dynamics. Even when R/C > 1, producers capture only a fraction of the potential value compared to shorter, more transparent supply chains (Gunawan et al., 2021). Third, the overwhelming share of raw materials in the cost structure suggests that small improvements in realized prices, achieved through reliable moisture standards and better product grading, could significantly increase incomes.

These findings underscore the need for institutional arrangements such as collective grading depots with calibrated moisture meters, posted discount schedules, and payment schemes tied to quality. Without such interventions, Lawele will continue exporting semi-processed copra while forfeiting opportunities for local value addition, in contrast to the Philippines, where value is increasingly captured in coco-coir and geonet processing nodes. Investments in dryers alone are insufficient unless embedded within stronger institutional and market systems. When chains are shortened and standards enforced collectively, both efficiency and producer prices improve, confirming predictions from classic marketing analyses (Jayasekhar et al., 2019).

Taken together, these findings argue for a sequencing of interventions: strengthening institutional governance to define grading rules and manage collective assets; enhancing access to timely and transparent market information to close the farm–factory price gap; and deploying appropriate technologies, such as 1–3 t batch dryers, through cooperatives to ensure that premia are reliably transmitted to producers. This combination sets the stage for the structural model presented in the next section, which demonstrates quantitatively that the largest mediated effects of market dynamics on farmer welfare operate through institutions rather than technology alone.

3.2. Institutional and Technological Determinants of Farmer Welfare

The Structural Equation Modeling (SEM) results provide strong evidence that supply chain efficiency and market dynamics are significant determinants of institutional capacity and technology adoption, which in turn directly shape farmer productivity and welfare. In other words, improvements in how products flow through the chain and how demand signals are transmitted will not automatically translate into better outcomes unless they are mediated by stronger farmer organizations and access to technology. The structural model is presented in Figure 5.

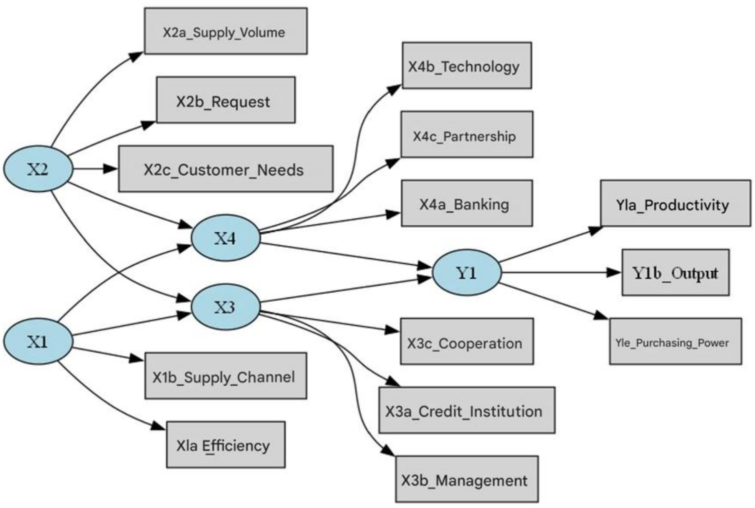

Figure 5. PLS-SEM path model of the copra value chain.

The estimated standardized path coefficients highlight these relationships clearly, indicating that supply chain efficiency and market dynamics significantly influence institutional capacity and technology adoption, which subsequently determine farmer productivity and welfare. The magnitude and statistical significance of these coefficients confirm the central mediating role of institutions and technology in transmitting efficiency gains and market signals into household-level outcomes.

Table 6. Standardized path coefficients and significance levels from the PLS-SEM model.

Path	Standardized coefficient (β)	Significance (p-value)	Interpretation
X1 → X3	0.32	0.002	Supply chain efficiency strengthens institutions
X2 → X3	0.41	<0.001	Market dynamics strongly enhance institutional capacity
X1 → X4	0.28	0.008	Efficient chains foster technology uptake
X2 → X4	0.37	<0.001	Market dynamics improve access to technology
X3 → Y1	0.45	<0.001	Institutional strength boosts productivity and welfare
X4 → Y1	0.39	<0.001	Technology adoption raises productivity and welfare

Table 6 presents the standardized path coefficients and significance levels derived from the PLS-SEM model describe the structural relationships among supply chain efficiency (X1), market dynamics (X2), institutional capacity (X3), technology adoption (X4), and farmer productivity and welfare (Y1). The results indicate that supply chain efficiency significantly strengthens institutional capacity ($\beta = 0.32$; $p = 0.002$) and fosters technology adoption ($\beta = 0.28$; $p = 0.008$), while market dynamics exert a stronger positive influence on both institutional capacity ($\beta = 0.41$; $p < 0.001$) and access to technology ($\beta = 0.37$; $p < 0.001$). Institutional capacity shows the largest direct effect on productivity and welfare ($\beta = 0.45$; $p < 0.001$), followed by technology adoption ($\beta = 0.39$; $p < 0.001$), confirming their mediating role in improving household outcomes. Together, supply chain efficiency (X1) and market dynamics (X2) explain 53% of the variance in institutional capacity ($R^2 = 0.53$) and 47% of the variance in technology adoption ($R^2 = 0.47$), while institutional and technological factors then jointly account for 68% of the variance in productivity and welfare ($R^2 = 0.68$), underscoring their central importance in the copra agribusiness system.

Indirect effects further underscore the mediating role of institutions and technology in linking upstream conditions to farmer welfare outcomes. Table 7 presents the indirect effects of supply chain efficiency (X1) and market dynamics (X2) on farmer welfare (Y1) through institutional capacity (X3) and technology adoption (X4).

Table 7. Indirect effects of supply chain efficiency (X1) and market dynamics (X2) on farmer welfare (Y1) via institutions (X3) and technology (X4).

Path	Indirect effect (β)	Interpretation
X1 → X3 → Y1	0.144	Efficiency raises welfare by strengthening institutions
X1 → X4 → Y1	0.109	Efficiency improves welfare through technology adoption
X2 → X3 → Y1	0.185	Market demand boosts welfare primarily via institutions
X2 → X4 → Y1	0.144	Market demand improves welfare through technology adoption

The table shows that supply chain efficiency improves welfare both by strengthening institutions ($\beta = 0.144$) and by facilitating technology adoption ($\beta = 0.109$), indicating that efficiency gains are transmitted through organizational and technological channels. Market dynamics generate even stronger indirect effects, particularly through institutional capacity (X2 → X3 → Y1; $\beta = 0.185$), followed by technology-mediated pathways ($\beta = 0.144$). The strongest mediated path is X2 → X3 → Y1, suggesting that vibrant market demands deliver the largest welfare improvements when supported by capable institutions. This finding highlights that favorable market conditions alone are insufficient and must be complemented by institutional mechanisms that enable farmers to capture and redistribute value within the copra value chain.

Institutional dynamics are fundamental to welfare improvement. Stronger farmer cooperatives, producer organizations, and access to rural credit institutions enhance bargaining power, facilitate collective grading, and improve negotiations with buyers. These findings align with studies indicating that institutional voids diminish efficiency and perpetuate vulnerability (Muriuki et al., 2024). In Lawele, most farmers operate independently, with weak or inactive cooperatives, leaving them dependent on collectors and limiting their access to credit, information, or subsidies. This institutional weakness reflects challenges in Kenya's coconut sector, where (Muriuki et al., 2024) identified fragmented actors as barriers to adopting circular-economy practices. Conversely, in the Philippines, successful coco-geonet enterprises were built on partnerships that combined cooperative governance with stable market demand.

Technology adoption also plays a crucial role, albeit with slightly lower mediated effects than institutions. With a path coefficient of $\beta = 0.39$, technology adoption significantly enhances productivity and welfare. Yet, field data reveal that only about 10% of copra producers in Buton have adopted modern dryers or grading tools, leaving 90% reliant on traditional methods. This limits product quality, increases post-harvest losses, and reduces competitiveness. The SEM findings suggest that adoption is most likely where efficiency and demand conditions create incentives for investment, a pattern also observed in recent literature emphasizing that modern technology uptake in agribusiness requires reliable demand signals and stable distribution systems (Elfahmi et al., 2024). Regions such as South Sumatra and

North Kalimantan, which benefited from stronger government–industry partnerships, have achieved faster technology diffusion compared to Buton.

Taken together, these findings reinforce three insights. First, institutions are more decisive than technology in mediating welfare outcomes, as indicated by the stronger indirect effects. Second, technology remains essential but requires enabling conditions: investments in dryers or grading machines alone will not transform outcomes unless institutions ensure that quality improvements are rewarded through transparent price premia. Third, policy leverage lies in integration: strengthening farmer organizations, ensuring access to credit, and linking these to technology support will maximize the benefits of market demand and supply chain improvements.

This evidence aligns with the Structure-Conduct-Performance (SCP) paradigm, which posits that structural factors such as efficiency and demand influence institutional and technological conduct, ultimately determining economic performance (Manhas et al., 2012; Meilizar et al., 2024). By quantifying these relationships, SEM results not only validate theoretical frameworks but also identify areas for intervention: establishing strong institutions as the foundation, with technology adoption built upon them, to achieve sustainable improvements in productivity and welfare.

3.3. Synthesis, Implications, and Policy Directions

The results from both descriptive analysis and SEM modeling converge on a central insight: institutional and technological mechanisms are indispensable for translating structural efficiencies and market dynamics into tangible welfare outcomes for copra farmers. The descriptive findings in Lawele highlight persistent inefficiencies, such as product losses during storage, opaque grading, and oligopsonistic pricing, while the SEM results quantify how these inefficiencies are mediated through weak institutions and low technology adoption. Together, the evidence underscores that productivity gains and welfare improvements are not determined by single factors in isolation but by the interaction of structure, conduct, and performance across the value chain.

A first implication relates to institutional governance. With institutions explaining the largest mediated effects on welfare, the strengthening of cooperatives, producer associations, and credit institutions is critical. This includes the establishment of collective grading depots with transparent quality standards, as well as governance systems that reduce dependency on patron–client relations with collectors. Such reforms would not only increase farmers' bargaining power but also create credible channels for transmitting market signals, thereby enabling more equitable value capture. This mirrors evidence from Indonesia's coconut supply chain (Gunawan et al., 2021) and Kenya's coconut value chains (Muriuki et al., 2024), where institutional coordination proved decisive in overcoming fragmented and exploitative trade structures.

Another implication concerns technology adoption. While institutions exhibit stronger effects than technology in the model, modern processing methods remain crucial for long-term competitiveness. Traditional drying continues to compromise quality and price realization, and with raw materials accounting for over 80% of costs, small improvements in quality-linked price premiums can significantly increase net incomes. However, technology diffusion is unlikely without institutional support and stable demand conditions. Experiences in the Philippines and other Indonesian provinces (Gunawan et al., 2021) demonstrate that adoption accelerates when cooperatives or partnerships manage shared assets such as mechanical dryers, and when downstream buyers commit to price premiums for higher-grade products.

A third implication is the role of market information and transparency**.** The current system is characterized by delayed and opaque pricing, with 60% of farmers unaware of downstream factory prices. SEM results confirm that market dynamics exert a significant influence, but these benefits are only realized when institutional mechanisms make information accessible to producers. Policy interventions to establish real-time digital platforms for price reporting, supported by cooperatives and local governments, could help close the information gap and reduce transaction costs.

Based on field observations, the distribution of marketing functions among producers, small collectors, and large collectors is highly uneven (Table 8). Producers perform nearly all functions except purchasing, while collectors capture value with fewer responsibilities. This unequal allocation of functions reinforces oligopsonistic patterns and leaves farmers with limited room for negotiation.

Table 8. Marketing institution functions.

No.	Function	Producer	Small collector	Large collector
1	Purchasing	x	√	√
2	Selling	√	√	√
3	Transportation	√	x	√
4	Storage	√	√	x
5	Processing	√	√	x
6	Standardization	√	√	x
7	Financing	√	√	√
8	Risk Management	√	√	x
9	Market Information	√	√	√

Note: √ = performs the function; x = does not perform the function.

This distribution illustrates that farmers bear the heaviest responsibilities while remaining disadvantaged in terms of bargaining power and value capture. It highlights the urgency of redistributing functions through cooperatives, standardization mechanisms, and policy reforms that ensure farmers' contributions are matched with equitable rewards.

Beyond these sectoral issues, the study contributes to broader debates on agribusiness transformation in developing contexts. It validates the Structure-Conduct-Performance (SCP) paradigm by empirically demonstrating that structural factors such as efficiency and demand influence performance outcomes indirectly through institutional and technological conduct. The findings also support the argument of Zainol et al. (2023) that upgrading pathways in value chains requires simultaneous improvements in product, process, functional, and inter-chain coordination. In Lawele, product and process upgrading (better drying, grading, storage) must go hand-in-hand with functional upgrading (collective bargaining and quality assurance by cooperatives) and inter-chain upgrading (linkages to processing industries beyond raw copra exports). Policy directions, therefore, need to be multi-layered. At the micro level, farmer groups and cooperatives should be strengthened to implement collective grading, storage, and marketing. At the meso level, partnerships between cooperatives, local governments, and financial institutions should facilitate technology adoption through subsidized loans and co-investment schemes. At the macro level**,** national policy should support competitive and transparent markets by regulating collector practices, promoting digital platforms for market information, and incentivizing direct farmer–industry linkages. Strategic sequencing is essential. Institutional reforms must come first to ensure that farmers can capture the benefits of subsequent investments. Technology adoption should follow, but be deployed through cooperative ownership and transparent governance. Finally, market reforms and infrastructure development should reinforce these gains, ensuring sustainability and competitiveness. This sequencing reflects the SEM results, which show that institutions are the primary mediators of welfare outcomes, while technology provides complementary but secondary effects. Taken together, these findings provide actionable recommendations for upgrading the copra value chain in Buton Regency. They point to a path where smallholder farmers, through stronger institutions and access to modern technology, can move from being price-takers in an oligopsonistic system to becoming active participants in more competitive and transparent markets. If implemented effectively, such reforms would not only raise farmer incomes and welfare but also enhance the resilience and sustainability of Indonesia's broader coconut sector.

4. CONCLUSION

This study provides empirical evidence on the determinants of productivity and welfare in the copra value chain of Lawele Village, Buton Regency, using a PLS-SEM framework complemented by descriptive supply chain analysis. The results demonstrate that supply chain efficiency and market dynamics do not directly translate into improved farmer outcomes unless mediated by institutional capacity and technology adoption. Institutions, in particular, emerge as the strongest driver, enhancing bargaining power, credit access, and coordination among farmers. Technology adoption also significantly improves productivity, but its impact is most effective when embedded in strong institutional arrangements and stable market conditions. The findings highlight three key insights. First, institutional governance is a prerequisite for effective value-chain upgrading, ensuring transparent grading, fairer pricing, and equitable distribution of benefits. Second, technological interventions such as mechanical dryers or grading tools are necessary but insufficient in isolation; their success depends on cooperative management and guaranteed market incentives. Third, policy strategies should integrate institutional strengthening, technology dissemination, and market transparency in a sequenced manner, beginning with governance reforms and followed by technological and infrastructural improvements.

From a theoretical perspective, this research reinforces the Structure-Conduct-Performance (SCP) paradigm by demonstrating that structural factors influence outcomes primarily through institutional and technological pathways. Practically, the study suggests actionable interventions such as establishing cooperative-managed processing units, implementing digital platforms for real-time price information, and fostering partnerships between farmers, government, and industry. Strengthening the copra value chain in Buton, therefore, requires an integrated approach that combines stronger institutions, wider technology adoption, and transparent market systems. Such measures will not only increase farmer incomes and welfare but also enhance the competitiveness and sustainability of Indonesia's coconut sector in the face of global market challenges. While the current study has shown evidence of the central roles of institutions and technology in improving small farmer outcomes, the results may not be fully generalizable to capture the diversity of copra production practices in Indonesia. Future studies can expand the geographical scope to compare the institutional effects across different coconut-producing regions.

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