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Price Transmission Dynamics and Market Efficiency in Thailand's Cassava Value Chain

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ABSTRACT

Price transmission dynamics in Thailand's cassava value chain have significant implications for market efficiency and the economic stability of farmers. This research focuses on these dynamics, highlighting the limited diversification in recent years. Using vector error correction models (VECM) to analyze price transmission, the study examines the price relationships and adjustments within the cassava chain from farmgate to wholesale and export levels. The analysis is based on monthly price data from January 2003 to January 2023. The study finds strong long-term price correlations but slow adjustments, indicating market inefficiency. Farmgate prices are influenced by wholesale and export prices of cassava products, but not vice versa. This asymmetry causes farmers to face revenue volatility without affecting downstream prices. Additionally, export prices react to wholesale changes, but wholesale prices remain unaffected by other market levels. Factors such as the limited number of processors, trade dependency, and variability in starch quality may contribute to these pricing patterns. Recommendations for improving market efficiency include diversifying cassava products, expanding export markets, empowering farmers through value-added processing, and providing credit to manage surplus supplies.

Keywords: Cassava, Price Linkages, Price Transmission, Value Chain, Market Efficiency

Background and Significance of the Research Problem

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Cassava is a vital crop in Thailand's agricultural sector, serving as a key source of income for many households. In 2021, 587,754 cassava farm households cultivated 9.52% of the country's cropland, or 1,510,241 hectares (Office of Agricultural Economics, 2023). Approximately 27.2% of cassava roots are used domestically, mainly in the ethanol industry, while the remainder is processed and exported as chips, pellets (28.3%), native and modified starch (44.1%), and other products such as sago pearls and cassava pulp (0.4%) (Sowcharoensuk, 2023). The cassava supply chain involves several stages, from farmers to processors and exporters, with products serving both domestic and international markets.

Inefficiencies in price transmission within Thailand's cassava market, driven by an imbalanced structure of many upstream producers and fewer downstream processors and exporters, pose risks of unequal welfare distribution, particularly for small-scale farmers. The supply chain starts with farmers who cultivate cassava, followed by aggregators who transport the crop to processing companies. These companies transform cassava into value-added products, which are sold to traders and exporters for distribution (Kaplinsky et al., 2011; Piyachomkwan & Tanticharoen, 2011; Xanthavanij & Amornsawadwatana, 2019). Thailand's reliance on cassava exports, especially to China, further increases its vulnerability to external market shocks. China's growing demand for commodities like cassava has exposed Thai producers to price volatility and shifting market conditions (Kaplinsky et al., 2010). Global markets and regional trade dynamics shape price risks, with local market structures and policies significantly influencing price formation and transmission (Nguyen et al., 2023).

Analyzing price transmission within the cassava value chain is critical to understanding how price changes affect stakeholders. Asymmetric price transmission, where prices rise faster than they fall, can distort market efficiency and welfare distribution (Peltzman, 2000). Equally important is examining whether price transmission from upstream to downstream and vice versa is bidirectional or unidirectional, and whether the magnitude of price adjustments is consistent across different stages of the value chain. Such asymmetries may be exacerbated by market power, where dominant players like processors or exporters manipulate price adjustments to their advantage, leaving smaller actors like farmers at a disadvantage (Meyer & von Cramon-Taubadel, 2004). Additionally, product differentiation within the cassava market, particularly between starch and chips, could create distinct pricing dynamics, with products like starch commanding more stable demand and pricing power.

From an economic perspective, this study addresses several key issues. First, it will assess how efficiently price changes are transmitted from farmgate to wholesale and export markets, focusing on the degree of price integration and whether changes at higher levels are fully passed down to farmgate prices. Delays or incomplete transmission may reveal structural barriers that disproportionately affect small-scale farmers. Second, the study will investigate the market structure to identify potential imbalances in bargaining power, particularly between large processing firms, exporters, and small farmers. Lastly, it will explore how product differentiation, especially between cassava starch and chips, influences pricing pressures and market dynamics. By examining these factors, the study aims to provide insights into market efficiency and the role of market power in price transmission.

Despite cassava’s economic significance, research on price transmission within its value chain is limited compared to crops like rice and palm oil (Charoenrit et al., 2021; Chen & Saghaian, 2016; Chulaphan et al., 2012; Conforti, 2004; Fiamohe et al., 2015; John, 2013; Saleerut et al., 2020; Songsiengchai et al., 2020). Only two studies have examined price transmission in Thailand’s cassava value chain. Conforti (2004), using annual data, found nearly complete long-run transmission between cassava and the world reference price, but the result has limited implications since the reference price used was Thailand's cassava export price itself. Siriruk and Thongpang (2017), using monthly prices up to 2015, found significant transmission from farmgate to export starch prices, but no strong connection to cassava chip prices. This unexpected result was contrary to expectations, considering the substantial export share of cassava chips, particularly with the growing dependence on the Chinese market in recent years. Moreover, the competition for cassava roots between chip and starch production should theoretically strengthen price linkages. However, a significant gap remains in understanding cassava price transmission, as no prior studies have examined whether the transmission is bidirectional or unidirectional, or the relative speed of adjustment, both of which are critical for assessing market efficiency.

Research Objective

This research investigates the direction and speed of price adjustments within Thailand's cassava value chain to determine whether these adjustments are unidirectional or bidirectional. By analyzing price transmission dynamics, the study will assess how efficiently price changes move across different market levels. Furthermore, the potential influence of market power and product differentiation along the cassava value chain will also be explored.

Scope of Research

The scope of this study is centered on the examination of price transmission within Thailand's cassava value chain, specifically focusing on the interactions between farmgate, wholesale, and export prices. The study limits its investigation to the cassava market in Thailand, utilizing monthly price data over a twenty-year period to observe the price transmission and suggest potential explanations for market inefficiencies and imbalances between different market actors, rather than definitively identifying their causes. The research provides insights into both short-term and long-term adjustments in response to price changes across different stages of the value chain.

Research Methodology

Data Collection

The study utilizes monthly price data from January 2003 to January 2023, covering farmgate, wholesale, and export prices for cassava. The farmgate price of cassava roots is sourced from the Office of Agricultural Economics (OAE), while the wholesale and export prices of cassava chips and starch are obtained from the Department of Internal Trade (DIT) under the Ministry of Commerce. The data is logarithmically transformed for further analysis to ensure consistency in the model.

Analytical Methods

To test the presence of unit roots in the price variables, the Augmented Dickey-Fuller (ADF) test was applied, as proposed by Dickey and Fuller (1979). The ADF test was used to determine whether the variables follow a unit root process or are stationary. The following regression model was used in testing for unit roots:

$$y_t = \alpha + \rho y_{t-1} + \delta t + u_t \tag{1}$$

In the ADF test, lags of the dependent variable are incorporated to account for serial correlation, as described in the extended model:

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \sum_{j=1}^{k} \varsigma_j \Delta y_{t-j} + u_t \tag{2}$$

In the model with j lags specified, testing for the presence of a unit root involves evaluating the null hypothesis that the variable has a unit root, represented by $\beta = 0$, which is equivalent to testing whether $\rho = 1$. If both $\alpha = 0$ and $\delta = 0$, the variable y_t follows a random walk without drift or time trend. If only $\delta = 0$, y_t follows a random walk without drift. If the variables are found to be stationary after first differencing (i.e., integrated of order 1 or I(1)), a cointegration test is performed to assess the presence of long-run relationships among the variables.

Model Specification

If the series are found to be cointegrated, the Vector Error Correction Model (VECM) is used to explore both long-term and short-term price dynamics. The VECM allows for the estimation of the speed at which prices adjust to deviations from long-run equilibrium in response to short-term shocks. The general form of the VECM can be expressed as follows (Johansen, 1991; Lütkepohl, 2005):

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \quad (3)$$

where y_t is a $Kx1$ vector of variables, Γ_i are matrices of parameters, and ε_t is a vector of error term. α represents the adjustment coefficients of the cointegrating equations, indicating the speed at which the variables adjust toward the long-run equilibrium after a shock. β represents the cointegrating relationships among the variables, specifically indicating the long-term equilibrium relationship between the variables in the system. Γ_i captures the short-term dynamics, explaining how the variables interact in the short run. In cases where the price variables are not cointegrated, a Vector Autoregressive (VAR) model is employed to analyze the differenced series. The VAR model is suitable for capturing short-run dynamics when no long-run equilibrium relationship exists among the variables.

Results

Thailand's Cassava Supply Chain

Figure 1 provides a detailed view of the Thai cassava supply chain in 2021, emphasizing the industry's heavy dependence on exports. A significant 72.7% of the cassava supply was used for export products, with the remaining 27.3% for domestic use. Cassava starch was the primary export, constituting 60.5% of the 33.2 million tons of cassava root exported, followed by cassava chips and pellets at 38.9%. The domestic market contrasts sharply with about 738,153 farm households supplying cassava to just 1,092 processing facilities. The downstream market is even more concentrated, with only 8 food and sugar processing firms and 9 ethanol producers, some of which also produce biogas and electricity. Despite the limited product diversity within Thai processing firms, export markets use Thai cassava for a variety of high-value products. However, there's a disparity in the number of processors and exporters, with cassava starch supported by 181 exporters from 127 processors, while cassava chips and pellets, managed by 965 processors, have only 88 exporters. This indicates a higher dependency of the chip and pellet industries on the Chinese market, compared to the more globally diversified starch industries (Department of Industrial Work, 2023; Office of Commodity Standard, 2023; Sowcharoensuk, 2023).

Figure 2 presents the monthly prices of cassava root and its intermediate value-added products along the cassava value chain, namely cassava chip and cassava starch, at the wholesale and export markets. The prices of these products exhibited a close correlation and moved in a similar fashion. However, the prices of starch at the wholesale and export markets were slightly more volatile, as indicated by occasional sharp increases and declines observed throughout the period.

Additionally, the correlation tests indicate a strong correlation between the farm-gate price of cassava root and its value-added products, especially between cassava root and starch, suggesting a more robust linkage along the value chain (Table 1). However, as the distance between nodes on the value chain increases, such as from farm-gate to export markets, this correlation diminishes. This pattern implies that external factors increasingly influence prices at further stages of production and processing, thereby reducing price correlation.

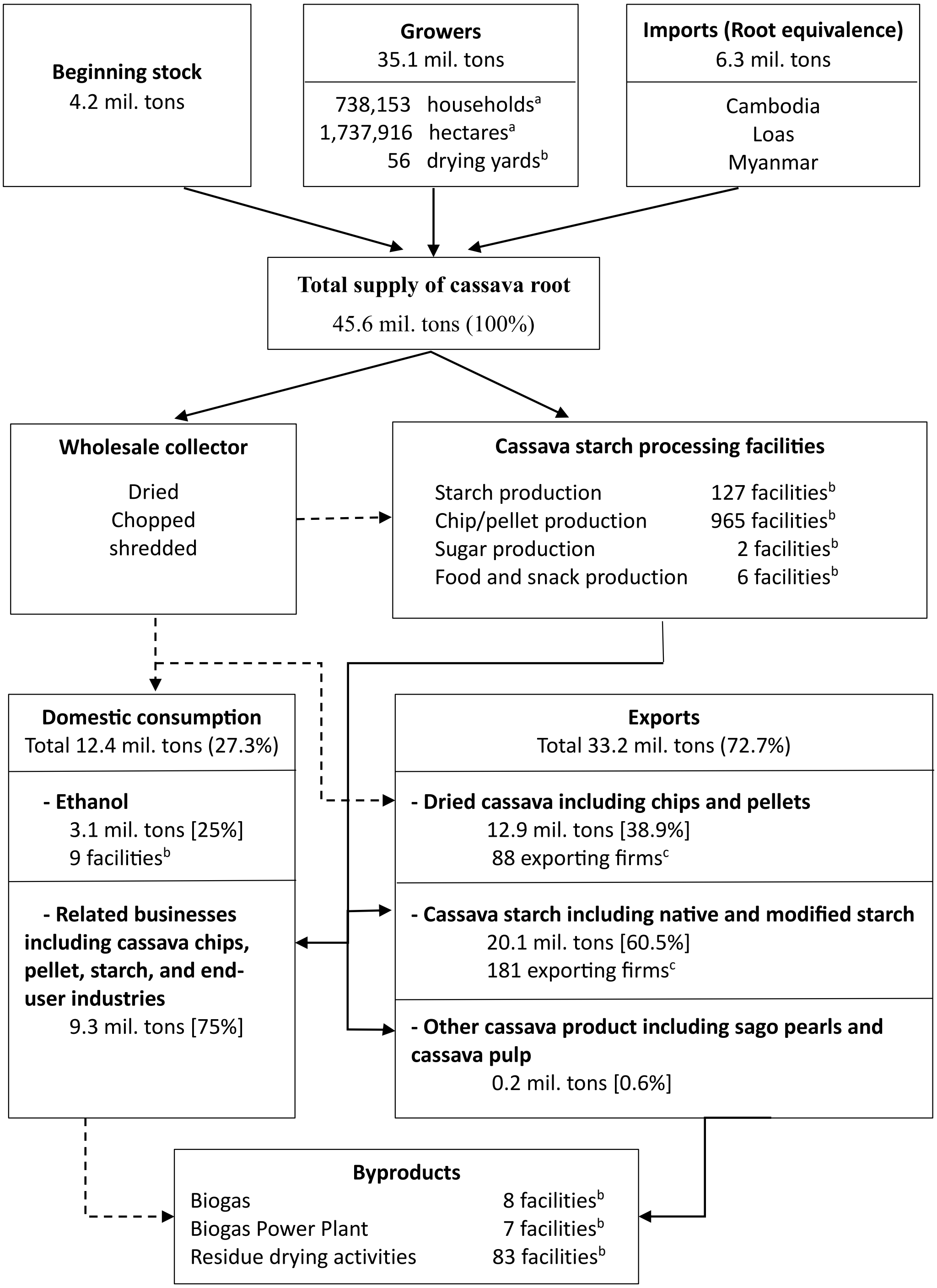

Figure 1 Thai cassava supply chain in 2021 (adapted from Sowcharoensuk (2023))

Source: [a] Office of Agricultural Economics, Ministry of Agriculture and Cooperatives; [b] Department of Industrial Work, Ministry of Industry; [c] Office of Commodity Standard, Ministry of Commerce

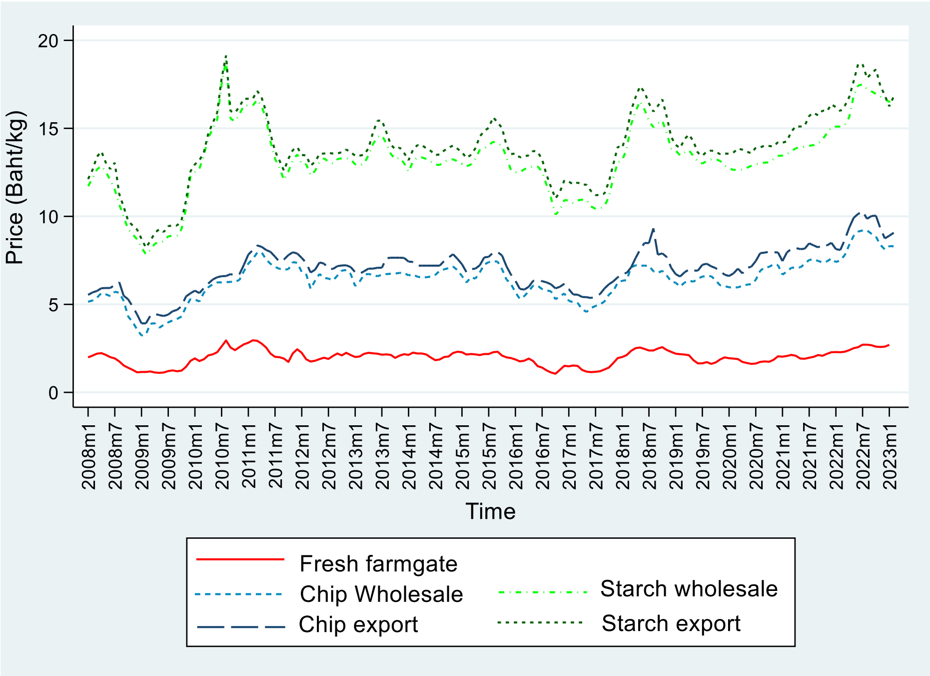

Figure 2 Monthly prices of cassava products along the cassava value chain

Table 1 Correlations among monthly prices within the cassava value chain in Thailand

Variables	(1)	(2)	(3)	(4)	(5)
(1) Root farmgate	1.000				
(2) Chip wholesale	0.786***	1.000			
(3) Chip export	0.740***	0.977***	1.000		
(4) Starch wholesale	0.909***	0.864***	0.830***	1.000	
(5) Starch export	0.885***	0.879***	0.856***	0.989***	1.000

Note: 1) *** denotes significance at 1% level.

2) The variables within this dataset were logarithmically transformed for analysis.

Source: Author's Calculation

Unit-root and Co-integration Tests of Monthly Prices

The ADF test, following the specifications of including an intercept, both an intercept and trend, or none, was utilized to examine the presence of unit roots (Table 2). Most of the monthly prices, expressed in logarithmic form, are found to be stationary after first differencing, indicating that they are integrated of order one or I(1). However, there is an exception in the case of the cassava farm-gate price, where the price is stationary at the level under the model with only an intercept.

Table 2 ADF unit-root test for monthly prices of cassava products

Variable	Specification	ADF at level		ADF at difference	
		Test	Critical value	Test	Critical value
Root farmgate	None	0.108	-2.588	-6.628***	-2.588
	Intercept	-2.642	-2.347***	-6.642***	-2.347
	Trend and	-2.727	-4.010	-6.624***	-4.010
Chip wholesale	None	0.345	-2.588	-6.270***	-2.588
	Intercept	-2.110	-2.347	-6.282***	-2.347
	Trend and	-2.624	-4.010	-6.268***	-4.010
Chip export	None	0.326	-2.588	-6.704***	-2.588
	Intercept	-2.231	-2.347	-6.726***	-2.347
	Trend and	-2.946	-4.010	-6.711***	-4.010
Starch wholesale	None	0.215	-2.588	-6.349***	-2.588
	Intercept	-2.129	-2.347	-6.353***	-2.347
	Trend and	-2.504	-4.010	-6.342***	-4.010
Starch export	None	0.229	-2.588	-6.784***	-2.588
	Intercept	-2.352	-2.347	-6.784***	-2.347
	Trend and	-2.789	-4.010	-6.769***	-4.010

Note: *** denotes significance at 1% level

Source: Author's Calculation

The co-integration tests yield substantial evidence supporting the existence of a long-term relationship among the analyzed prices in the vertical chains. Various test statistics, including the trace statistic, maximum-eigenvalue statistic, Schwarz Bayesian information criterion (SBIC), Hannan and Quinn information criterion (HQIC), and Akaike information criterion (AIC), were employed in the co-integration analysis. Table 3 outlines the results of the co-integration tests. Remarkably, the null hypothesis of a maximum rank of zero was clearly rejected, while the null hypothesis of a maximum rank of one remained robust. This reaffirms the solid presence of a persistent long-term relationship along the vertical chain of cassava products.

Table 3 Cointegration rank test of cassava product prices

Group	Variables	Maximum rank	Trace statistic	Maximum-eigenvalue statistic	SBIC	HQIC	AIC
Root and chip	Root and chip (wholesale)	0	33.326	25.419	-1.333	-1.395	-1.438
		1	7.906*	7.906*	-1.357*	-1.462*	-1.533
		2			-1.344	-1.469	-1.554
	Root and chip (export)	0	34.934	28.064	-0.948	-1.011	-1.054
		1	6.8697*	6.870	-.987*	-1.092*	-1.163
		2			-0.969	-1.094	-1.179
	chip (wholesale) and chip (export)	0	39.983	31.695	-0.249	-0.311	-0.353
		1	8.288*	8.288*	-.307*	-.411*	-0.482
		2			-0.296	-0.420	-0.505
Root and starch	Root and starch (wholesale)	0	41.389	32.242	-0.266	-0.329	-0.371
		1	9.147*	9.147	-.328*	-.432*	-0.504
		2			-0.322	-0.447	-0.532
	Root and starch (export)	0	33.981	26.056	-0.029	-0.134	-0.205
		1	7.925*	7.925*	-.057*	-.204*	-0.304
		2			-0.044	-0.212	-0.326
	Starch (wholesale) and starch (export)	0	24.138	17.974	1.201*	1.160	1.132
		1	6.164*	6.164*	1.217	1.134*	1.077
		2			1.240	1.136	1.066
Chip and starch	Chip (wholesale) and starch	0	28.850	19.858	1.362*	1.300	1.258
		1	8.991*	8.991*	1.368	1.263*	1.193
		2			1.376	1.251	1.166
	Chip (export) and starch (export)	0	28.393	19.493	1.867*	1.805	1.763
		1	8.900*	8.900*	1.875	1.770*	1.700
		2			1.883	1.758	1.673
	Chip (wholesale) and starch (export)	0	29.386	20.175	1.533*	1.471	1.429
		1	9.210*	9.210*	1.537	1.433*	1.363
		2			1.544	1.419	1.334
	Chip (export) and starch (wholesale)	0	28.168	19.254	1.720*	1.658	1.615
		1	8.913*	8.913*	1.729	1.624*	1.554
		2			1.737	1.612	1.527

Note: * denotes optimal rank or number of cointegrating equation

Table 4 presents estimates of long-run elasticities and adjustment speeds towards equilibrium for various cassava product price pairs. The results are grouped by their relationships in the cassava value chain: root-chip, root-starch, and chip-starch. The analysis confirms long-run relationships among prices across the cassava value chain, with variations in how different price pairs adjust towards equilibrium. Generally, the adjustment speed is slow, suggesting market inefficiencies in responding to supply and demand changes. Limitations due to incomplete data restrict deeper analysis into the causes of these market inefficiencies, such as potential market power or operational inefficiencies.

For root-chip prices, the cassava root price adjusts unidirectionally to changes in chip prices at both wholesale and export levels. The export chip price adjusts faster to wholesale price changes than the farmgate price does, with long-run elasticities of 1.331 for root-chip (wholesale), 0.394 for root-chip (export), and 0.969 for chip (wholesale)-chip (export).

In the root-starch category, only the farm-gate root price adjusts towards the long-run equilibrium with starch prices. The export starch price shows a unidirectional, long-run causality with the wholesale starch price. The adjustment speed across these pairs is slow, with long-run elasticities of 1.446 for root-starch (wholesale), 1.662 for root-starch (export), and 1.068 for starch (wholesale)-starch (export).

For chip-starch prices, both wholesale and export chip prices adjust towards equilibrium with starch prices following shocks. However, the wholesale starch price remains unresponsive to changes in chip prices. The adjustment speed for all these pairs is uniformly slow, with elasticities of 1.091 for chip (wholesale)-starch (wholesale), 1.263 for chip (export)-starch (export), 1.268 for chip (wholesale)-starch (export), and 1.072 for chip (export)-starch (wholesale). These values indicate robust long-run relationships among cassava products at both wholesale and export levels.

Table 4 VECM long-run causality analysis of the cointegrating model of cassava products

Group	Model	Dependent variable (Differenced)	Explanatory variable (Differenced)	CE coefficient	Direction of long-run causality	Long-run elasticities
Root and chip	Root (farmgate) – chip (wholesale)	Root (farmgate)	Chip (wholesale)	-0.136***	Unidirectional	1.331
		Chip (wholesale)	Root (farmgate)	0.152		
	Root (farmgate) – chip (export)	Root (farmgate)	Chip (export)	-0.121***	Unidirectional	0.943
		Chip (export)	Root (farmgate)	0.070		
	Chip (wholesale) – chip (export)	Chip (wholesale)	Chip (export)	-0.078	Unidirectional	1.066
		Chip (export)	Chip (wholesale)	0.324***		
Root and starch	Root (farmgate) – Starch (wholesale)	Root (farmgate)	Starch (wholesale)	-0.249***	Unidirectional	1.447
		Starch (wholesale)	Root (farmgate)	0.147		
	Root (farmgate) – Starch (export)	Root (farmgate)	Starch (export)	-0.200***	Unidirectional	1.663
		Starch (export)	Root (farmgate)	0.375		
	Starch (wholesale) – starch (export)	Starch (wholesale)	Starch (export)	0.074	Unidirectional	1.069
		Starch (export)	Starch (wholesale)	0.282**		

Table 4 (Continue)

Group	Model	Dependent variable (Differenced)	Explanatory variable (Differenced)	CE coefficient	Direction of long-run causality	Long-run elasticities
Chip and starch	Chip (wholesale) – starch (wholesale)	Chip (wholesale)	Starch (wholesale)	-0.098***	Unidirectional	1.091
		Starch (wholesale)	Chip (wholesale	0.117		
	Chip (export) – starch (export)	Chip (export)	Starch (export)	-0.079***	Bidirectional	1.263
		Starch (export)	Chip (export)	0.142**		
	Chip (wholesale) – starch (export)	Chip (wholesale)	Starch (export)	0.068**	Bidirectional	1.269
		Starch (export)	Chip (wholesale)	0.173***		
	Chip (export) – starch (wholesale)	Chip (export)	Starch (wholesale)	-0.107***	Unidirectional	1.072
		Starch (wholesale)	Chip (export)	0.105		

Note: *** denotes significance at 1% level

Table 5 summarizes the direction and speed of these price adjustments. It highlights how prices such as root farmgate, chip wholesale, chip export, starch wholesale, and starch export exhibit adjustment speeds towards long-run equilibrium with each other. The data shows that the root farmgate price adjusts towards chip wholesale, chip export, starch wholesale, and starch export prices with slow adjustment speeds as indicated. Conversely, chip and starch prices at wholesale and export levels show no adjustment towards the root farmgate price, indicating a unidirectional adjustment pattern. These findings suggest a hierarchical influence where primary product prices adjust more to processed product prices rather than vice versa. Interestingly, the wholesale price of starch does not respond to changes in other prices throughout the cassava supply chain.

Table 5 Summary of VECM long-run price adjustment

Price A	Price B				
	Root farmgate	**Chip wholesale**	**Chip export**	**Starch wholesale**	**Starch export**
Root farmgate		← (0.136)	← (0.121)	← (0.249)	← (0.200)
Chip wholesale	⊗		⊗	← (0.098)	← (0.068)
Chip export	⊗	← (0.324)		← (0.107)	← (0.079)
Starch wholesale	⊗	⊗	⊗		⊗
Starch export	⊗	← (0.173)	← (0.142)	← (0.282)	

Note: '⟵' indicates the presence of long-run adjustment of price A with respect to price B

'⊗' indicates no presence of long-run adjustment of price A with respect to price B

Numbers in parentheses indicate the speed of adjustment (co-integrating parameters) of price A towards long-run equilibrium with price B

Source: Author's Calculation

Discussion

The findings from this study both support and challenge existing economic theories. Strong long-run relationships among farmgate, wholesale, and export prices support theories of market integration and cointegration, suggesting that prices in integrated markets tend to move together over time. This is consistent with broader findings that consumer markets in developing countries, including grain products, are often co-integrated with global markets (Baquedano & Liefert, 2014). However, this study highlights anomalies, particularly in the asymmetry of price adjustments: farmgate prices respond to wholesale and export price changes, but not the other way around. This challenges theoretical models that predict symmetric adjustments in well-integrated markets and contradicts earlier findings that suggested bidirectional price adjustments (Conforti, 2004). A meta-analysis of agricultural price transmission supports the notion that asymmetry is more likely in sectors with fragmented farm structures and where government policies and regulations impact price controls (Bakucs et al., 2014).

Notably, the results differ from those of Siriruk and Thongpang (2017), who found that price adjustments flowed from upstream to downstream, with farmgate prices influencing cassava starch export prices but no clear link between farmgate and domestic wholesale prices. This discrepancy may be due to the inclusion of more recent data in the current study, covering a period during which the Thai cassava market underwent significant structural changes, particularly in export destinations. Thailand's dependency on the Chinese market increased substantially, with cassava chip exports to China rising from 67.70% in 2011 to 88.43% in 2021. Likewise, Thailand's starch exports became increasingly concentrated in China, growing from 26.50% to 73.11% over the same period (FAO, 2023). These shifts, along with a concentrated domestic processing sector, suggest that price adjustments are now driven by export market conditions, reversing the previously observed pattern of upstream-to-downstream price transmission.

Future contracts help explain why farmgate prices respond to wholesale and export price changes, but not vice versa. During periods of economic, political, or supply uncertainties, such as droughts, disease outbreaks, or geopolitical tensions, exporters and millers use these contracts to lock in prices and ensure stable supplies. This reduces the need for immediate price adjustments at higher market levels, even when farmgate prices fluctuate. Stockpiling inventories further mitigates risks from volatile supply conditions, stabilizing prices at the wholesale and export levels and insulating them from farm-level volatility. This reliance on future contracts and stockpiling dampens the responsiveness of wholesale and export prices to changes at the farmgate.

Research suggests that trade volume plays a significant role in determining the extent of price transmission between regions, with larger traded volumes generally leading to stronger transmission effects (Myers & Jayne, 2012). However, the slow adjustments observed in the Thai cassava market contradict this expectation. Despite Thailand's heavy reliance on exports to China, particularly with cassava chip exports to China, the transmission of price adjustments remains weak and asymmetric. This inconsistency may be explained by the influence of other factors, such as high transaction costs, market fragmentation, and government interventions, which complicate price dynamics. While volatility transmission tends to be more pronounced in markets with high trade dependence, such as cassava in Thailand (Ceballos et al., 2017), the Thai cassava market continues to exhibit persistent asymmetry. Compared to other markets with well-developed infrastructure and short value chains, which show more symmetric price adjustments (Usman & Haile, 2017), the structural factors and fragmentation within Thailand's cassava supply chain likely contribute to these slow and asymmetric price transmissions.

The cassava supply chain in Thailand is marked by an imbalance between numerous small-scale farmers and relatively few intermediate and downstream buyers. This creates concerns about market power among domestic processors, who can influence cassava prices and purchasing decisions. In export markets, processors face challenges due to limited diversification and a small number of exporters for certain products. The concentration of downstream industries, particularly in food, sugar, and ethanol, likely contributes to market inefficiencies and affects price transmission. Farmers have limited bargaining power, while processors struggle internationally despite their domestic advantages. This imbalance, along with external factors such as fluctuating demand from China, the COVID-19 pandemic, and geopolitical tensions, has contributed to slow and unidirectional price adjustments. Data gaps make it unclear whether these inefficiencies are due to market power, increased transaction costs, or inadequate infrastructure.

To enhance market efficiency, diversifying cassava products and expanding export markets is recommended, with a focus on facilitating price transmission from farmers to downstream stakeholders. Empowering farmers through value-added processing is essential, involving the formation of farmer groups and partnerships with government and private processing firms. Providing credit to farming associations engaged in value addition can help absorb excess cassava supplies that periodically impact the market, with these reserves later available for distribution or processing. Efforts to increase farm size, productivity, and cassava root quality can strengthen farmers' bargaining power.

The large-scale farming policy for cassava, introduced in 2018 (Department of Agricultural Extension, 2024), closely aligns with the recommendations aimed at enhancing market efficiency and reducing asymmetric price transmission. By organizing small farmers into collective groups and fostering partnerships with government and private entities, the policy strengthens farmers' market access and bargaining power, reducing their vulnerability to price volatility and inefficiencies. This collective action enables better price negotiations, addressing the slower price adjustments typically seen at the farmgate level. The policy’s emphasis on high-quality cassava varieties and modern farming practices improves productivity and product quality, allowing farmers to better meet market demand and facilitate more efficient price adjustments along the value chain. Additionally, access to credit and financial support for value-added processing helps farmers manage surplus supplies, stabilize income, and reduce price fluctuations, further easing price transmission asymmetries. While the policy tackles structural issues like limited bargaining power and market access, its effect on external market shocks and downstream price inefficiencies may be more limited.

Suggestions

Policymakers and industry stakeholders can use the results from this study to implement strategies aimed at improving market efficiency. However, the study's reliance on existing data may not fully capture rapid market changes or the complete range of influencing factors like logistical challenges or international trade policies. To enhance these results, further research could expand the dataset to include more recent data beyond 2023, incorporate additional variables such as input costs and economic indicators, or apply more complex econometric models to handle asymmetries and non-linear adjustments more effectively. Additionally, these findings could be extended to other fields by comparing cassava market dynamics with those of other agricultural commodities or by applying the methodology to different geographical markets or segments of the cassava value chain, such as the impact of biofuel production on cassava demand. These studies could help in understanding broader economic principles or drawing parallels between different sectors facing similar market dynamics.

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