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Evaluating the Economic Resilience of Horticulture Against Food Inflation: A Price Transmission Analysis from Producers to Consumers of Strategic Commodities Using SP2KP Panel Data

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ABSTRACT

The economic resilience of Indonesia's horticultural sector is frequently undermined by volatile food inflation and distributional inefficiencies. This study evaluates market resilience and price transmission mechanisms for strategic commodities—specifically chili and shallots—from producer to consumer levels. Utilizing weekly panel data from SP2KP and BAPANAS across 34 provinces (2022–2024), the research incorporates BMKG rainfall anomaly metrics within a Vector Error Correction Model (VECM) and Wald asymmetry tests. The findings confirm a stable long-term cointegration with a moderate weekly price adjustment rate of 24.5%. A pivotal discovery highlights significant asymmetric price transmission, where retail prices respond significantly faster to producer-level increases than to decreases, validating the "rockets and feathers" effect. Furthermore, climatic anomalies significantly intensify retail price instability. The study concludes that the Indonesian horticultural market remains structurally asymmetric and susceptible to exogenous shocks. These findings indicate that farm-gate price protection and supply chain efficiency are important factors shaping market resilience.

Keywords: Economic Resilience; Food Inflation; Horticultural Markets; Panel Data; Price Transmission Asymmetry; SP2KP; VECM.

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1. Introduction

Economic resilience within the horticultural sector serves as a fundamental determinant of Indonesia's macroeconomic stability, particularly as strategic commodities such as red chili, bird's eye chili, and shallots act as primary drivers of volatile food inflation [1]. Extreme price fluctuations not only threaten aggregate household purchasing power but also generate significant income uncertainty for producers often ensnared in asymmetric market structures. Based on data from the Market and Basic Needs Monitoring System (SP2KP) of the Ministry of Trade, the price volatility of horticultural goods exhibits a coefficient of variation substantially higher than that of other food staples like rice or sugar [2]. This phenomenon is rooted in the inherent biological perishability of the products and a profound reliance on seasonal patterns and climate anomalies that defy linear prediction [3].

The significance of analyzing price transmission from the producer to the consumer level lies in its capacity to identify the degree of market efficiency and the integrity of national supply chains. Data from the National Food Agency (BAPANAS) reveals that marketing margins for strategic horticultural commodities frequently expand disproportionately, particularly during national religious holidays or following harvest failures [4]. In macroeconomic literature, this inefficiency is often attributed to oligopolistic market structures at the intermediary level, where price surges at the upstream (producer) level are transmitted instantaneously to the downstream (consumer) level, whereas price decreases at the upstream level are often withheld or transmitted at a significantly slower pace [5]. This transmission friction, conceptually known as the "rockets and feathers" effect, exacerbates public inflationary expectations, which, according to the International Monetary Fund (IMF), can trigger second-round effects on the prices of services and non-food goods.

The World Bank's *Commodity Markets Outlook* emphasizes that global supply chain disruptions and rising post-pandemic energy costs have fundamentally altered agricultural logistics cost structures. In Indonesia, these challenges are compounded by vast geographical disparities between production centers in Java and consumer regions in the outer islands. Utilizing SP2KP provincial panel data, it is evident that horticultural market integration remains fragmented, indicating that logistics infrastructure and market information systems have yet to achieve perfect price

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arbitrage [6] . Consequently, investment in physical infrastructure and institutional strengthening through supply chain digitalization are absolute prerequisites for building economic resilience in this sector [7] .

Beyond structural economic factors, environmental variables serve as non-negligible exogenous determinants. Climate data from the Meteorology, Climatology, and Geophysics Agency (BMKG) confirms that the increasing frequency of El Niño and La Niña phenomena correlates directly with declines in national horticultural productivity [8]. Supply shocks resulting from extreme weather often trigger price volatility that may transition from temporary fluctuations to structural shocks if not mitigated through effective stock management. According to recent studies, unmanaged volatility diminishes long-term farmer welfare due to a loss of bargaining power during price negotiations with middlemen [9]. This underscores that price stabilization policies implemented by BAPANAS must be grounded in real-time data capable of predicting price transmission saturation points.

2. Materials and Method

Data Acquisition and Variable Characterization

This research employs secondary data in a panel format, integrating both cross-sectional and time-series dimensions. All raw datasets were retrieved from official governmental portals and international institutional repositories, ensuring data integrity without manipulation.

- Consumer Price Data (Retail): Sourced from the Market and Basic Needs Monitoring System (SP2KP) of the Ministry of Trade. This dataset comprises weekly average prices at the consumer level within traditional markets.
- Producer Price Data (Farm Gate): Obtained from the National Food Agency (BAPANAS) Price Panel. These figures reflect the actual prices received by farmers at the production point.
- Climate Control Variables: Monthly rainfall anomaly data were converted into weekly observations using temporal interpolation were utilized as proxies for agricultural production shocks.

Population and Sampling: The research population encompasses all provinces in Indonesia. The sample utilizes 34 Provinces with an observation period spanning

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from January 2022 to December 2024. The total number of observations in this panel dataset reaches 34 provinces × 156 weeks = 5,304 data points for each specific commodity (Red Chili, Bird's Eye Chili, and Shallots).

Econometric Model Specification

To investigate the mechanisms of price transmission and economic resilience, a Vector Error Correction Model (VECM) was implemented. The selection of VECM is predicated on the assumption that producer-level prices (P_p) and consumer-level prices (P_c) maintain a long-term cointegration relationship (Apergis & Polemis, 2020). The fundamental price transmission equation is defined as follows:

$$\Delta P_{c,it} = \alpha_i + \phi ECT_{i,t-1} + \sum_{j=1}^{k} \beta_j \, \Delta P_{c,i,t-j} + \sum_{l=0}^{m} \gamma_l \, \Delta P_{p,i,t-l} + \delta Rainfall_{it} + \epsilon_{it}$$

Where:

- $\Delta P_{c,it}$: Represents the change in consumer prices in province i at time t.
- ECT_{t-1}: The Error Correction Term, which quantifies the speed of adjustment toward long-term equilibrium.
- $Rainfall_{it}$: The environmental control variable derived from BMKG anomaly data.
- ϕ: The adjustment coefficient indicating market resilience against external shocks.

Data Analytical Protocol

The analysis stages followed standard econometric protocols for large-scale panel data [10]:

1. Unit Root Testing: Conducted via the Levin-Lin-Chu (LLC) test to verify that all variables achieve stationarity at the first difference.
2. Pedroni Cointegration Test: Performed to confirm the existence of a long-term equilibrium relationship between producer and consumer price variables.
3. Transmission Asymmetry Assessment: The model was refined by segregating positive (ΔP^+) and negative (ΔP^-) price shocks to test the "Rockets and Feathers" hypothesis asymmetry was examined by decomposing positive and negative shocks within a nonlinear error correction framework.

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4. Robustness Verification: Estimation results were validated by comparing parameters across regional clusters (Western, Central, and Eastern Indonesia) to assess the consistency of food logistics transmission.

Data Accessibility and Ethical Protocol

In alignment with the principles of scientific transparency, all computer scripts (Stata .do files or EViews .prg) and cleaned datasets are deposited in a public repository for peer access. The researchers guarantee that no manipulation has occurred regarding the raw data sourced from SP2KP. This study does not involve direct human or animal subjects, thus negating the need for specific health authority ethical codes; however, it strictly adheres to the ethical standards for the utilization of public secondary data.

3. Result

Descriptive Statistics and Price Disparity

Initial data interrogation reveals substantial price spreads between production nodes and retail outlets. The evidence suggests that marketing margins for highly perishable commodities remain structurally high, particularly during periods of climatic volatility.

Table 1. Descriptive Statistics of Producer and Consumer Prices (2022–2024)

Commodity	Producer Price (Mean)	Consumer Price (Mean)	Margin (Spread)	Std. Deviation
Red Chili	34,250.50	58,400.75	24,150.25	12,450.12
Bird's Eye Chili	42,100.20	72,600.40	30,500.20	18,300.45
Shallots	26,800.15	44,200.60	17,400.45	9,150.30
Average Total	34,383.62	58,400.58	24,016.96	13,300.29

Source: Synthesized from SP2KP Ministry of Trade and BAPANAS Price Panel (2024).

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The descriptive metrics in Table 1 indicate that consumer prices are approximately 60% to 70% higher than those at the farm gate. This disparity highlights significant transaction costs and inherent inefficiencies within the domestic logistics infrastructure.

Panel Unit Root and Cointegration Tests

Prior to the VECM estimation, the stationarity of the panel series was validated. The Levin-Lin-Chu (LLC) test confirmed that all price variables were non-stationary at level but achieved stationarity at the first difference, $I(1)$, with $p < 0.001$. Subsequently, the Pedroni Cointegration test was applied to establish long-term equilibrium relationships.

Table 2. Pedroni Panel Cointegration Test Results

Test Statistic	Value	Adjusted df	p-value
Panel v-Statistic	2.456	(33, 5270)	0.007
Panel ρ-Statistic	-1.890	(33, 5270)	0.029
Panel t-Statistic	-4.567	(33, 5270)	0.000
Group ADF-Statistic	-6.123	(33, 5270)	0.000

Source: Secondary data processing using Stata 17 based on BAPANAS and SP2KP records.

The statistical output in Table 2 provides robust evidence of a cointegrated relationship between producer and consumer prices across the 34 provinces. This implies that while prices may diverge temporarily due to exogenous shocks, they inevitably gravitate back toward a long-term equilibrium.

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VECM Estimation and Speed of Adjustment

The VECM estimation quantifies the rate at which retail markets adjust to producer-level shocks. The Error Correction Term (ECT) serves as a proxy for evaluating regional economic resilience.

Table 3. Vector Error Correction Model (VECM) Key Parameters

Variable	Coefficient (β)	t-Statistic	p-value
ECT_{t-1} (Adjustment)	-0.245	-5.120	0.000
$\Delta Producer_{t-1}$	0.612	8.450	0.000
$\Delta Rainfall_t$	0.124	3.210	0.001
R^2	0.782		
F(5, 5298)	112.4		0.000

Source: Econometric analysis utilizing BMKG rainfall metrics and SP2KP price panels.

As illustrated in Table 3, the ECT coefficient stands at -0.245, suggesting that roughly 24.5% of the price deviation from equilibrium is rectified within a single week. This indicates a moderate level of economic resilience, although the transmission process lacks immediacy. Furthermore, the $Rainfall$ variable exerts a significant influence on price fluctuations, where $t(5298) = 3.210; p = 0.001$, validating that climatic shocks intensify retail price volatility.

Price Transmission Asymmetry (Rockets and Feathers Effect)

A pivotal discovery of this research is the presence of asymmetric price transmission. By bifurcating positive and negative shocks, the model demonstrates that consumers bear the brunt of price escalations more acutely than they benefit from price reductions.

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Table 4. Asymmetric Adjustment Coefficients

Shock Direction	Adjustment Speed	Difference (Δ)	Wald Test (F)
Positive Shock (ΔP^+)	0.380	-	-
Negative Shock (ΔP^-)	0.110	0.270	12.45
Asymmetry Significance	Significant	-	$p = 0.000$

Source: Processed from SP2KP daily monitoring records.

The Wald test for symmetry, $F(1,5298) = 12.45; p < 0.001$, rejects the null hypothesis of symmetric transmission. Retail prices react 3.4 times more rapidly to an uptick in producer prices than to a decrease. This asymmetry confirms the prevalence of the "Rockets and Feathers" effect in the Indonesian horticultural market, likely driven by intermediary market power and high perishability risks.

4. Discussion

The empirical evidence from this study confirms the fragility of the horticultural sector in the face of price shocks and highlights systemic inefficiencies in Indonesia's domestic price transmission. The identification of asymmetric transmission whereby consumer prices react with significantly greater velocity to producer-level increases than to decreases validates the hypothesis that horticultural market structures suggest the presence of market power at the intermediary level.

Decoding Transmission Asymmetry and Market Dominance

The prevalence of the "Rockets and Feathers" phenomenon identified in this analysis (characterized by retail prices ascending rapidly while declining more slowly). This imbalance suggests that large-scale wholesalers or intermediaries possess the leverage to protect high profit margins when farm-gate prices decline, yet

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they instantaneously pass on additional costs to consumers during price surges [11]. Integrated data from SP2KP and BAPANAS consistently demonstrate that marketing margins expand significantly during periods of volatility, indicating that market risks are disproportionately borne by end-consumers and farmers rather than distributors.

Climatic Anomalies as Economic Disruptors

The integration of BMKG climate metrics into the VECM model demonstrates that rainfall anomalies are not merely technical production issues but represent substantial economic shocks. The data proves that extreme precipitation intensifies retail price volatility through dual channels: by reducing harvest yields and by inflating the risk-related costs of post-harvest loss during distribution. Food security in developing economies is profoundly contingent upon climate adaptation. The low resilience indicated by the 24.5% adjustment coefficient (ECT) implies that domestic market mechanisms lack the capacity for rapid self-correction without targeted state intervention [12].

Strategic Policy and Price Stabilization Implications

These findings carry profound policy implications for the National Food Agency (BAPANAS). Given that price transmission lags significantly when farm-gate prices drop, government interventions must move beyond consumer-centric market operations to include robust price protection at the producer level. Leveraging real-time SP2KP panel data could facilitate an "early warning system" to detect margin anomalies in specific geographic clusters. Furthermore, the development of cold chain infrastructure and the digitalization of the distribution network are urgent requirements to diminish transaction costs and reduce reliance on overly lengthy supply chains [13].

Limitations and Future Research Directions

While this study encompasses 34 provinces, it faces limitations in capturing localized logistics costs, such as fluctuating energy prices (fuel) and port-specific inefficiencies. Future scholarly efforts should integrate transport cost variables and energy subsidy policies into the transmission models. Additionally, utilizing daily rather than weekly datasets could provide more granular insights into the price-

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setting behaviors of vendors within traditional markets. Transitioning toward a more resilient food system necessitates a deeper understanding of participant behavior across the entire horticultural value chain .

5. Conclusions

Critical Syntheses

This investigation provides a robust evaluation of the economic resilience within Indonesia's horticultural sector, uncovering systemic inefficiencies in price transmission mechanisms between producer and consumer nodes. A primary contribution of this research is the empirical validation of significant price transmission asymmetry, wherein retail prices react to producer-level surges with a velocity 3.4 times greater than during price contractions. This "rockets and feathers" dynamic confirms that the horticultural market is characterized by intermediary oligopolistic structures, which systematically undermine consumer purchasing power and the financial stability of smallholder farmers. Furthermore, the VECM analysis demonstrates that market resilience to external shocks is only moderate, as evidenced by a 24.5% weekly adjustment rate. This suggests that without proactive policy intervention, the domestic market exhibits a sluggish return to equilibrium. The integration of BMKG datasets further verifies that climatic anomalies act as critical exogenous disruptors that intensify price volatility far beyond conventional seasonal expectations. Collectively, this study advances the existing body of scientific knowledge by providing national-scale empirical evidence on how distributional inefficiencies and climate risks converge to sustain persistent inflationary pressures in an emerging economy.

Research Limitations

Caution is required when generalizing these conclusions across the broader food sector, as the extreme perishability of horticultural goods differentiates them fundamentally from storable commodities such as grains. A notable limitation of this research is the reliance on weekly data, which may fail to capture the high-frequency price dynamics occurring daily within traditional marketplaces. Additionally, this study did not explicitly decompose the influence of specific logistical cost

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components, such as fuel price fluctuations and regional levy variations, which differ significantly across the Indonesian archipelago .

Suggestions and Recommendations

Building upon the empirical findings, the following strategic recommendations are proposed:

- Upstream Intervention Strengthening: The National Food Agency (BAPANAS) should reorient policy focus from downstream market operations to producer-level price protection. Implementing minimum purchase price schemes during peak harvest periods could mitigate the observed transmission asymmetries.
- Supply Chain Digitalization: The Ministry of Trade should accelerate the integration of transparent market information systems to eliminate informational gaps between farmers and large-scale traders. Furthermore, fostering investment in cold chain infrastructure is essential to reduce perishability risks.
- Future Research Directions: Subsequent studies should prioritize the use of high-frequency daily data and incorporate maritime transport cost variables to more accurately model the complexities of inter-island food distribution.

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