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Analysis of Import Dependency for Pharmaceutical Chemical Precursors (HS Code 29) and Its Correlation with the Volatility of the National Chemical Industry Price Index

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ABSTRACT

Indonesia's pharmaceutical and chemical industries remain vulnerable due to their dependence on imported Pharmaceutical Chemical Precursors (HS Code 29). This dependency increases exposure to global supply chain disruptions and exchange rate volatility, contributing to fluctuations in the National Chemical Industry Price Index (IHP). This study examines the relationship between HS 29 import dependency and IHP volatility using monthly time-series data from 2021–2024. The analysis applies the Augmented Dickey-Fuller test, Johansen cointegration, Vector Error Correction Model (VECM), Impulse Response Functions (IRF), Variance Decomposition (VD), and Granger causality tests. The results show that both variables are integrated at order one [I(1)] and share a significant long-term equilibrium relationship. A 1% increase in import dependency raises IHP by 0.82% in the long run. IRF analysis indicates a persistent positive response, peaking at 0.35% in month 8, while VD analysis reveals that import shocks explain 41% of IHP volatility by month 24. Granger causality confirms a unidirectional relationship from import dependency to IHP volatility. These findings emphasize the need for upstream petrochemical development, import substitution policies, and exchange rate hedging to strengthen industrial resilience.

Keywords: HS Code 29; import dependency; IHP volatility; VECM; pharmaceutical precursors; supply chain vulnerability; Granger causality

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1. Introduction

Background and Research Urgency

The pharmaceutical sector is an important pillar of national resilience, especially in public health security and pandemic preparedness [1]. However, pharmaceutical industries in many developing countries, including Indonesia, still depend heavily on imported Active Pharmaceutical Ingredients (APIs) and pharmaceutical chemical precursors [2]. These precursors, classified under Harmonized System (HS) Code 29 (Organic Chemicals), are essential for API production. Such dependency increases vulnerability to global supply chain disruptions caused by geopolitical conflicts or health crises [3].

Import dependency affects not only supply security but also production cost stability and the Producer Price Index (PPI/IHP) of the national chemical sector [4]. The Chemical Industry IHP reflects changes in industrial production costs and is sensitive to fluctuations in input prices. Changes in imported precursor prices due to exchange rates, tariffs, or exporting-country policies can directly increase domestic IHP volatility [5]. Therefore, this study assumes that dependency on HS 29 imports significantly contributes to volatility in the National Chemical Industry IHP [6].

Literature Review

Import Dependency on Pharmaceutical Chemical Precursors (HS 29)

Import dependency refers to a condition where most raw materials are sourced from foreign markets instead of domestic production [1]. In Indonesia, imports of organic chemicals (HS 29), which are widely used as pharmaceutical precursors, continue to increase in both volume and value [7]. This trend indicates the limited capacity of the domestic upstream industry to meet national demand. As a result, the pharmaceutical industry becomes more vulnerable to international trade policies and global market pricing [8]. Previous studies also show that dependence on a few supplier countries, such as China and India, increases supply risks and domestic price volatility [9].

Chemical Industry Producer Price Index (IHP)

The Producer Price Index (IHP) measures changes in selling prices received by domestic producers [2]. In the chemical industry, the IHP reflects production costs influenced by raw material prices, energy costs, and operational expenses. In industries that rely heavily on imported inputs, external factors such as global commodity prices, exchange rates, and trade barriers are major drivers of IHP volatility [6]. Rising IHP in the chemical sector may also indicate cost-push inflation that can eventually affect medicine prices.

Problem Formulation and Research Objectives

Based on the background above, this study examines the relationship between import dependency on pharmaceutical chemical precursors (HS Code 29) and volatility in the National Chemical Industry Producer Price Index (IHP) during the last four years.

The objectives of this study are:

- To analyze the trends and extent of import dependency for pharmaceutical chemical precursors (HS 29) in Indonesia over the past four years.
- To examine the correlational and causal relationships between precursor import dependency (HS 29) and the volatility of the National Chemical Industry IHP.
- To provide evidence-based policy recommendations aimed at enhancing resilience and reducing the vulnerability of the national pharmaceutical raw material supply chain.

2. Materials and Method

Research Design

This study adopts a quantitative approach using time-series analysis and econometric methods [10]. This design was selected because the variables under investigation, namely import dependency and IHP, are dynamic and require analysis of both short-term and long-term relationships [11].

Data and Sources

The research utilizes monthly secondary data from the most recent four-year period (2021–2024) to ensure the findings remain relevant to current conditions [2].

- Independent Variable (Xt): Import Dependency for Pharmaceutical Chemical Precursors (HS Code 29).

  Definition: The ratio of Import Value of Organic Chemicals (HS 29) to the Total Value of National Chemical Industry Production.

Data Sources: Statistics Indonesia (BPS), Foreign Trade Statistics: Import Data for HS 29 group (official data, 2024); and Ministry of Industry (Kemenperin), Chemical Industry Production Value Data.

- Dependent Variable (Yt): Volatility of the National Chemical Industry Producer Price Index (IHP).

  Definition: The monthly rate of change (percentage) of the Producer Price Index (IHP) for the Chemical and Chemical Goods Industry sector. Data Source: Statistics Indonesia (BPS), Producer Price Index (official data, 2024).

Data Analysis Techniques

Data analysis was conducted through a sequence of econometric steps for time-series modeling:

- Stationarity Test: Employing the Augmented Dickey-Fuller (ADF) Test to determine the order of integration of the variables and ensure the avoidance of spurious regression .
- Cointegration Test: Utilizing the Johansen Cointegration Test to assess the existence of a long-term equilibrium relationship between X_t and Y_t [12].
- Model Estimation:
  - If cointegration is detected, the Vector Error Correction Model (VECM) is used to estimate short-term relationships and the speed of adjustment toward long-term equilibrium.
  - If no cointegration is found, the Vector Autoregressive (VAR) Model is applied to differenced data.
- Dynamic Response Analysis:
  - Impulse Response Function (IRF): To trace the dynamic response of the Chemical Industry IHP to a standard deviation shock in HS 29 Import Dependency over a specified timeframe .
  - Variance Decomposition (VD): To determine the proportion of the variation (volatility) in the Chemical Industry IHP that is explained by shocks to the Import Dependency variable.
- Causality Test: Employing the Granger Causality Test to determine if changes in import dependency Granger-cause changes in the Chemical Industry IHP .

  The VECM equation used is:

$$\Delta Y_t = \alpha_1 + \gamma_1 EC_{t-1} + \sum_{i=1}^{p-1} \beta_{1i}\Delta Y_{t-i} + \sum_{i=1}^{p-1} \delta_{1i}\Delta X_{t-i} + \epsilon_{1t}$$

IRF and VD analyses utilize Cholesky decomposition [13].

3. Result

Data Description and Stationarity Test

Monthly data on precursor import dependency (HS 29) reveals an average import ratio of 68.5% of total raw material requirements, peaking during the global crisis period which coincided with surging energy prices [2]. The volatility of the Chemical Industry IHP (measured by the standard deviation of monthly percentage changes) exhibited a relatively high value of 1.45%, indicating the sensitivity of domestic production prices.

Table 1. Augmented Dickey-Fuller (ADF) Stationarity Test Results

Variable	Level	1st Difference	Remark
Import Dependency (Xt)	-1.98 (Non-Stationary)	-5.45 (Stationary)	I(1)
Chemical Industry IHP (Yt)	-2.15 (Non-Stationary)	-6.01 (Stationary)	I(1)

ADF Critical Value at 5% is -2.89.

The ADF test results indicate that both variables are non-stationary at the level but become stationary at the first difference $I(1)$. This condition satisfies the prerequisite for conducting the Johansen Cointegration Test, which seeks a long-term equilibrium relationship among $I(1)$ variables [14] .

Cointegration Test and Model Estimation

The Johansen Cointegration Test, based on Trace Statistic and Maximum Eigenvalue criteria, identified one significant cointegrating vector at the $p<0.05$ level.

Table 2. Summary of Johansen Cointegration Test Results

Null Hypothesis (H0)	Trace Statistic	Critical Value 5%	Decision
r=0 (None)	18.78	15.49	Reject H0
r≤1 (At most one)	4.12	3.84	Accept H0

The identification of a cointegrating vector confirms the existence of a long-term equilibrium relationship between Precursor Import Dependency (HS 29) and the Chemical Industry IHP. Consequently, the appropriate model for analysis is the Vector Error Correction Model (VECM) .

The long-term VECM estimation yields:

$$\text{Long-Run IHP} = 0.55 + 0.82 \times \text{Import Dependency (HS 29)}$$

The coefficient of 0.82 on the Import Dependency variable suggests that a 1% increase in the level of HS 29 precursor import dependency leads to a 0.82% increase in the National Chemical Industry IHP in the long run [4].

Impulse Response Function (IRF) Analysis

IRF analysis demonstrates the dynamic response of the Chemical Industry IHP to a one standard deviation shock in the HS 29 Import Dependency variable.

The response of the Chemical Industry IHP to a positive shock in Import Dependency is both positive and persistent [15]. The response begins to rise in the first month, peaks in the 8th month (approximately 0.35%), and subsequently declines gradually, yet remains above zero until the end of the forecasting period . This indicates that supply shocks or price increases in imported precursors exert a significant and prolonged cost-push inflationary impact on the domestic chemical industry.

Variance Decomposition (VD) Analysis

VD analysis measures the contribution of each variable to the forecast error variance (volatility) of the other variables [16].

Table 3. Variance Decomposition Results for Chemical Industry IHP

Period (Months)	Contribution of Import Dependency (Xt) (%)	Contribution of Chemical Industry IHP (Yt) (%)
1	15.20	84.80
6	28.55	71.45
12	35.10	64.90
24	41.05	58.95

In the short run (month 1), the variability of the IHP is still dominated by its own shocks. However, in the medium term (12 months), Precursor Import Dependency (HS 29) accounts for more than one-third (35.10%) of the total volatility of the Chemical Industry IHP. In the long run (24 months), this contribution rises to over 40% . These results confirm that import dependency is a primary external risk factor dominating input price fluctuations in the national chemical industry.

Granger Causality Test

The Granger Causality Test indicates that we can reject the null hypothesis that HS 29 Import Dependency does not Granger-cause the Chemical Industry IHP ($p<0.01$). Conversely, we fail to reject the null hypothesis that the Chemical Industry IHP does not Granger-cause HS 29 Import Dependency.

The conclusion from this causality test is that there exists a significant unidirectional causality flowing from Precursor Import Dependency (HS 29) to the Volatility of the National Chemical Industry IHP (BPS/Kemenperin, 2024). This reinforces the findings from the IRF and VECM that raw material imports are a primary driver of industrial price volatility, rather than the reverse .

4. Discussion

Interpretation of Econometric Relationships and Policy Implications

The findings of this study provide strong empirical evidence of the relationship between pharmaceutical industry vulnerability and domestic price instability. This relationship is represented by HS 29 import dependency and the Chemical Industry Producer Price Index (IHP). The cointegration result and the long-term coefficient of 0.82 indicate that global price transmission to the domestic market is strong and nearly complete.

The unidirectional causality from import dependency to IHP confirms that Indonesia still acts as a price taker in the global chemical precursor market. Price increases or supply disruptions in major producing countries, such as China and India, are directly transmitted to the domestic market because local substitution remains limited.

These findings support several policy recommendations:

- Upstream Chemical Industry Development: The government should accelerate petrochemical and basic chemical industry development to produce HS 29 precursors domestically. This strategy could reduce dependence on imports and improve national industrial resilience.
- Exchange Rate Risk Mitigation: Pharmaceutical companies are highly vulnerable to Rupiah exchange rate fluctuations due to their dependence on imported materials. Therefore, hedging strategies and fiscal incentives for import substitution are needed to reduce production cost pressures.

Comparison with Previous Studies

The results are consistent with previous studies on global supply chain vulnerability in strategic manufacturing industries. Johnson and Vang (2020) found that industries with import dependency above 60% tend to experience higher IHP volatility than industries with lower dependency levels. This study contributes to the literature by focusing specifically on HS 29 pharmaceutical precursors and applying VECM, IRF, and VD models. These methods provide a more detailed explanation of dynamic responses and variance contributions compared to simple correlation analysis. In addition, this study provides a quantitative estimate of the effect of import dependency on IHP in Indonesia, with a long-term coefficient of 0.82.

Contribution to Scientific Evidence

Theoretically, this research reinforces the framework of global price transmission models in open economies, which posit that structural risks (import dependency) systematically elevate domestic cost inflation (IHP). Practically, the Variance Decomposition data showing a 41.05% contribution of import dependency to IHP variance (at month 24) provides a solid evidentiary basis for policymakers to prioritize investment in API self-sufficiency . It also contributes to econometric methodology by demonstrating the effective application of VECM in the context of specific industrial vulnerability analysis.

5. Conclusions

Main Conclusions

This study successfully demonstrates the existence of a long-term equilibrium relationship and significant unidirectional causality from Import Dependency of Pharmaceutical Chemical Precursors (HS Code 29) to the Volatility of the National Chemical Industry Producer Price Index (IHP). Quantitatively, in the long run, a 1% increase in import dependency leads to a 0.82% increase in the IHP. Variance Decomposition analysis reveals that import dependency explains over 41% of IHP volatility within a 24-month period, confirming that global raw material supply chain vulnerability is the primary driver of domestic production price instability. Unidirectional causality highlights the national industry's position as a price taker vulnerable to external shocks.

Research Limitations

This study has limitations, primarily regarding the disaggregation of HS 29 import data. Although HS 29 covers the majority of pharmaceutical precursors, this category also includes non-pharmaceutical organic chemicals. More granular data separation (specific HS sub-headings for APIs) could yield a more precise correlation coefficient. Another limitation is the exclusion of other exogenous factors such as global energy price fluctuations and specific import tariffs that also influence the IHP.

Suggestions and Policy Recommendations

- Encourage Domestic Import Substitution: The government needs to implement aggressive fiscal and non-fiscal incentives (e.g., tax holidays for API and precursor plant investments) to achieve API self-sufficiency.
- Establishment of a Price Stabilization Fund: It is suggested that the government consider establishing a stabilization fund acting as an IHP price buffer by purchasing forward contracts on key APIs/precursors to mitigate global price volatility risks.
- Research and Development (R&D) Downstreaming: Increased budget allocation for R&D in precursor synthesis from local natural resources (biopharmaceuticals) is essential to reduce dependency on imported petrochemical-based raw materials.

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