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Econometric analysis of factors affecting sugar supply in Indonesia a simultaneous equations approach

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ABSTRACT

As the primary sweetener, sugar has yet to be fully substituted by alternative sweeteners. Its significance is further reflected in its extensive linkages with various downstream industries, including the food and beverage sector. This study aims to analyze the factors influencing sugar supply in Indonesia and to examine the elasticity of sugar supply. The research utilizes secondary time series data covering the period from 1992 to 2024. A quantitative analysis using a simultaneous equation model estimated through the Two-Stage Least Squares (2SLS) approach. This study employs a quantitative approach within a simultaneous equation modeling framework. The research findings indicate that key factors influencing the supply of sugar in Indonesia include domestic production, imports, exports, and national sugar stock levels. Sugar production plays a central role in determining overall supply. Additionally, domestic sugar consumption has a positive elasticity with respect to sugar imports, meaning that higher consumption leads to increased import volumes. In contrast, the exchange rate and domestic sugar production exhibit negative elasticity, suggesting that an appreciation of the currency or an increase in domestic production tends to reduce the volume of sugar imports. Domestic sugar prices have a negative elasticity in relation to Indonesia's sugar exports.

Contribution/Originality: This study is original as it specifically conducts an analysis of the factors influencing sugar supply in Indonesia and examines the elasticity of sugar supply. The paper contributes by using a simultaneous equation model estimated through the Two-Stage Least Squares (2SLS) approach.

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1. INTRODUCTION

Sugar production in Indonesia primarily comes from sugarcane, which is cultivated in several provinces such as East Java, Central Java, and Lampung. Despite Indonesia's significant potential in sugarcane production, domestic sugar production is still unable to fully meet domestic demand. Factors such as weather conditions, pest attacks, and suboptimal agricultural technology have contributed to low sugarcane and sugar productivity in Indonesia (Ministry of Agriculture, 2024).

Sugar is a strategic commodity that holds a vital role in both the economy and daily consumption. As the primary sweetener, sugar is widely utilized and cannot be easily substituted by alternative sweeteners. Its significance is further underscored by its extensive linkage with various downstream industrial sectors, including the food and beverage industry, refined sugar processing, and the pharmaceutical sector (Togi et al., 2011). Additionally, sugarcane the primary raw material for sugar production also serves as a renewable resource for bioethanol, contributing to the development of sustainable energy sources (Syachbudy, Firdaus, & Daryanto, 2017). Sugar, as a strategically important commodity, presents a number of persistent challenges within Indonesia's agricultural sector. Issues within the sugar industry are evident across both the on-farm and off-farm subsystems. In the on-farm subsystem, low productivity and limited land availability remain the primary constraints. Meanwhile, in the off-farm subsystem, inefficiencies in the operation of domestic sugar mills are the main concerns (Yunitasari, Hakim, Juanda, & Nurmalina, 2021).

Disruptions often ripple through the national sugar network whenever something goes wrong at the farm level or further along the supply chain. Sugar lovers outpace domestic growers, and the gap between appetite and harvest only widens (Sutanto & Muljaningsih, 2022; Zainuddin, Asmarantaka, & Harianto, 2017). A long, steady drop in output stems partly from landlords swapping cane fields for rice paddies or quick-turn horticulture that promise bigger paychecks at the end of the season (Wibowo, 2012). Additionally, suboptimal sugar production is attributed to inefficiencies in factory management, poor quality of raw materials, limited availability of skilled human resources, and inadequate technological management. As a result, sugar yields in Indonesia remain low, compounded by labor inefficiencies and suboptimal machine performance (Shinta & Pratiwi, 2011). These persistent issues limit the capacity of domestic sugar production to meet national demand. Consequently, the shortfall in domestic output has led to a reliance on imported sugar to fill the supply gap. In 2024, imports accounted for approximately 60 percent of the total national sugar supply (Figure 1).

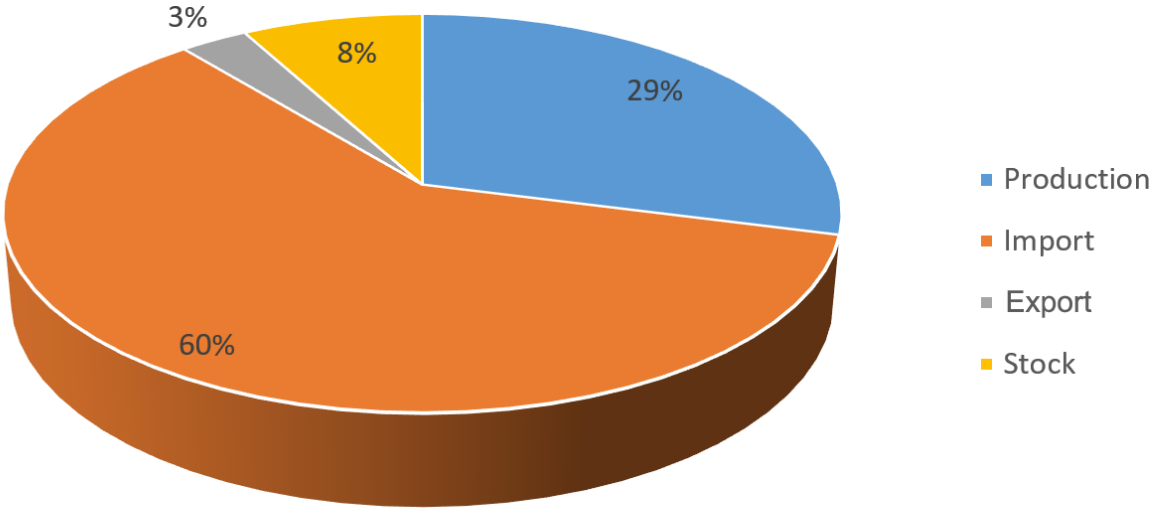

Figure 1. Percentage of Total Indonesian Sugar Supply in 2024.
Source: (FAO, 2024) and Central Bureau of Statistics (2024).

If sugar imports cannot be effectively controlled and export performance fails to improve, the result may be an increasingly severe trade deficit (Pudjiastuti, 2014). Moreover, the influx of imported sugar into the domestic market presents an additional challenge, particularly due to the significant price disparity between domestically produced and imported sugar. Price remains a critical variable in ensuring the adequacy and stability of the national sugar supply. Based on data from the Directorate General of Plantations and the World Bank Pink Sheet, domestic sugar prices in Indonesia are nearly 200 percent higher than international prices (Figure 2). While international sugar prices have remained relatively stable, ranging between IDR 6,000 and IDR 6,500 per kilogram, domestic sugar prices have consistently ranged from IDR 15,000 to IDR 16,000 per kilogram. A significant increase in sugar prices can influence the national inflation rate, given that sugar contributes approximately 0.40 percent to overall inflation (Central Statistics Agency (BPS), 2024). Moreover, rising sugar prices can affect household spending on food, as sugar accounts for 1.21 percent of total food expenditure. In addition, sugar plays a notable role in determining the poverty line, contributing 1.96 percent in urban areas and 2.76 percent in rural areas (Central Statistics Agency (BPS), 2024).

Studies on sugar supply are essential for identifying the dominant factors that influence the availability of sugar in the domestic market. Numerous investigations have been carried out to analyze the determinants of sugar supply in Indonesia. For instance, research by Sadiyah, Muhaimin, and Suhartini (2014) found that several key variables affecting sugar supply include fertilizer prices, labor wages, interest rates, domestic sugar prices, sugarcane production, and sugar imports from the previous year. Apriyanto (2009) uncovered that Indonesia's granulated-sugar availability hinges almost exclusively on the acreage devoted to sugar-cane cultivation. In a separate investigation, Abdul, Sa'Diyah, and Eka (2017) presented the supply equation as little more than a bookkeeping identity, with domestic output balanced neatly by the tonnage imported. Those findings, however, belong to a literature body that seldom moves beyond the narrow prism of white crystal sugar. Almost every prior model calculates supply by totaling production and import figures, yet overlooks stockpiles and export flows that could tilt the balance. These key gaps, the current inquiry will probe what really drives sugar supply in Indonesia and estimate how responsive that supply is to price signals.

The sugar supply in Indonesia is a crucial aspect of the country's economy, particularly in the agricultural and industrial sectors. Sugar is not only used as a household consumption item but also as a raw material for the food and beverage industry. In recent years, Indonesia has faced challenges in meeting domestic sugar demand, influenced by various factors such as domestic production, imports, and global market dynamics (Central Statistics Agency (BPS), 2024).

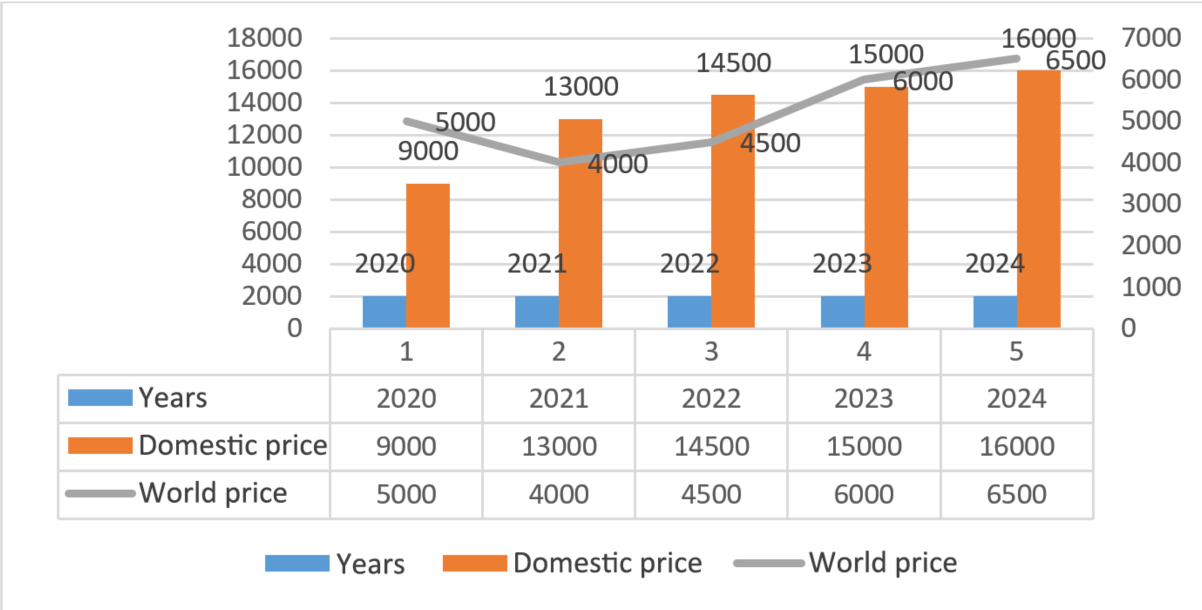

Figure 2. Comparison of domestic prices and world sugar prices (Rp).
Source: Directorate General of Plantations (2024) and World Bank (2024).

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2. METHODOLOGY

The type of data in this study is secondary data in the form of time series for the period 1992-2021. Data were collected from various sources, including the Food and Agriculture Organization (FAO), World Bank, Bank Indonesia, Central Bureau of Statistics, Indonesian Sugar Association, and the Ministry of Agriculture.

2.1. Data Processing and Analysis Method

Data processing in this study was carried out using Microsoft Excel 2020 and Econometric Views 12 (EViews 12) software. The analysis method applied is a quantitative method using a simultaneous equation form. Each model is estimated using the Two-Stage Least Squares (2SLS) approach. Furthermore, to obtain the short-term elasticity (SR) and long-term elasticity (LR) values, the following formula is used (Pindyck & Rubinfeld, 1991).

$$Esr\ (Yt, Xt)\ =\ \beta t\ (Xt)\ /\ (Yt)$$

Where:
Esr (Yt, Xt) = Short-term elasticity of explanatory variable Xt to endogenous variable.
Yt βt = Estimated parameter of explanatory variable.
Xt (Xt) = Average of explanatory variable.
Xt (Yt) = Average of endogenous variable Yt.
The long-term elasticity value can be obtained from the following calculation:

$$Elr\ (Yt, Xt)\ =\ (Yt, Xt)\ /\ 1 - \beta\ lag$$

Where:
Elr (Yt, Xt) = Long-term elasticity of endogenous variable Yt to explanatory variable.
Esr (Yt, Xt) = Short-term elasticity of explanatory variable Xt to endogenous variable.
Yt βt lag = Estimated parameter of endogenous variable lag.

2.2. Specification of Simultaneous Model

A model is considered good if it meets several criteria as follows:

1. Economic criteria refer to the suitability of the model to economic theory regarding the direction of the relationship between economic variables. Model evaluation is carried out based on the principles of economic theory.

2. Statistical Criteria: This criterion involves statistical testing to determine the significance of exogenous variables to endogenous variables in each equation. Evaluation of statistical criteria can help ensure that the simultaneous model built is reliable and in accordance with the observed data and the underlying theory.
3. Econometric Criteria Econometric criteria are based on the assumptions of multiple regression models, namely: a. Errors have a normal distribution. b. The variance is constant (homoscedasticity). c. No autocorrelation is found. d. There is no multicollinearity.

2.3. Construction of the Economic Model of Sugar Supply in Indonesia

The economic model in this study employs simultaneous equations. The model is formulated into five equations, consisting of two identity equations and three structural equations. The identity equations include the Indonesian sugar stock model and the Indonesian sugar supply model. The structural equations encompass the equations for the amount of sugar production, sugar imports, and sugar exports in Indonesia.

1. Equation for the Amount of Indonesian Sugar Production

$$KGIt = a0 + a1KTIRt + a2LTIRt + a3YGIRt + a4KRGt + \mu 1$$

Where :
KGIt = Indonesian sugar production in year t (Ton).
KTIRt = Sugar cane production in year t (Ton).
LTIRt = Sugar cane area in previous year t-1 (ha).
YGIRt = Yield (%).
KRGt = Sugar productivity in year t (ton/ha).
a0 - a4 = Regression coefficient of variables affecting Indonesian sugar production.
μ 1 = Error term Hypothesis: a1, a2, a3, a4 > 0.

2. Equation of Indonesian Sugar Import Amount

$$IGIt = b0 + b1KURSt + b2INIRt + b3CGIRt + b4PGIt + b5PGIRt + \mu 2$$

Where:
IGIt = Indonesian sugar import (Ton).
KURSt = Exchange rate (IDR/US$).
INIRt = Inflation (%).
CGIRt = Domestic sugar consumption (Ton).
PGIt = Indonesian sugar production (Ton).
PrGIRt = Domestic sugar price (IDR/ton).
b1 – b5 = Regression coefficients of variables affecting Indonesian sugar imports.
μ 2 = Error term Hypothesis: b3 > 0; b1, b2, b4, b5 < 0.

3. Equation of the amount of Indonesian sugar exports

$$EGIt = c0 + c1KURSt + c2PGIt + c3GDPIRt + c4PrGIRt + \mu 3$$

Where:
EGIt = Indonesian sugar exports in year t (Tons).
KURSt = Exchange rate in year t (IDR/US$).
PGIt = Indonesian sugar production in year t (Tons).
GDPIRt = Gross Domestic Product in year t (IDR).
PrGIRt = Domestic sugar price (IDR/ton).
c1 – c4 = Regression coefficients of variables affecting Indonesian sugar exports
μ3 : Error term
Hypothesis: c1, c2, c3, > 0; c4 < 0

4. Equation of the Total Sugar Stock at the End of the Previous Year

$$SGATt - 1 = SpGIt - 1 - CGIRt - 1$$

where:
SGATt = Indonesia's final sugar stock in the previous year t-1 (Tons).
SpGIt-1 = Domestic sugar supply in the previous year t-1 (Tons).
CGIRt-1 = Domestic sugar consumption in the previous year t-1 (Tons).

5. Total Sugar Supply in Indonesia

$$SpGIt = PGIt + IGIt - EGIt + SGATt$$

Where:
SpGIt = Indonesia's sugar supply in the year t (tons).
PGIt = Indonesia's sugar production in the year t (tons).
IGIt = Indonesia's sugar import in the year t (tons).
EGIt = Indonesia's sugar export in the year t (tons).
SGATt-1 = Sugar stock at the end of the previous year t-1 (tons).

2.4. Identification of the Economic Model of Indonesian Sugar Supply

Identification can be performed on a model if the total number of variables in the equation is equal to or greater than the total number of dependent variables minus one. The identification of the structural model can be achieved by

(K-M) > (G-1)
Where:
K = Number of variables in the model (Endogenous and predetermined variables).
M = Total dependent and independent variables in one equation and

G = Number of equations in the model (Number of dependent variables).

If an equation in the model shows the following conditions:

(K - M) > (G - 1) = over identified.

(K - M) = (G - 1) = exactly identified.

(K - M) < (G - 1) = under identified.

Structural equations can be estimated if each equation is stated to be exactly identified or overidentified in order to be able to predict each parameter correctly.

2.5. Estimation Method of the Indonesian Sugar Supply Economic Model

If all structural equations are overidentified, then these equations can be estimated using several methods, including 2SLS (Two-Stage Least Squares). The 2SLS method relies on several assumptions, namely that the disturbances satisfy the stochastic assumptions: equal to zero, constant variance, and zero covariance. The structural model specification must be precise in terms of predetermined variables. The number of observations in the sample must exceed the number of predetermined variables in the model, and the explanatory variables must not experience perfect collinearity (Hermawan & Adam, 2010). Table 1 shows the results of the model determination of each variable equation.

Table 1. Results of model determination of each variable equation.

Variabel	K	M	G	K-M	G-1	Description
KGIt	13	4	5	9	4	Over identified
IGIt	13	5	5	8	4	Over identified
EGIt	13	4	5	9	4	Over identified
SGATt	13	2	5	11	4	Over identified
SGIt	13	4	5	8	4	Over identified

2.6. Stationery Test

Researchers conducting time-series analyses regularly invoke the stationarity test to purge data of problematic autocorrelations arising from non-stationarity. A sequence of observations is classified as stationary when its mean and variance do not drift over time, while the covariance between any two points depends only on the gap separating them, not on the calendar dates themselves. Under the narrower heading of constant mean, a series qualifies as stationary in that regard when its values consistently oscillate around a fixed average rather than trending upwards or downwards. A time series is conventionally deemed stationary in variance when its dispersion around the central value remains constant over the entire interval of observation. Analysts frequently confront non-stationarity in the mean; the standard remedy is to difference the raw observations until a stable average profile emerges. In contrast, situations where the degree of variability itself changes are often corrected by applying the natural logarithm to the original dataset. When data exhibit non-stationarity in their mean or variance, appropriate techniques such as differencing, square root transformation, or logarithmic transformation can be employed to stabilize the data (Juanda & Junaidi, 2021). There are three common approaches to evaluate data stationarity: observing trends through graphical analysis, examining autocorrelation and correlograms, and conducting unit root tests. In this study, the unit root test was selected as the primary method for assessing stationarity.

2.7. Classical Assumption Testing

1. The classical assumption tests in regression analysis are conducted to ensure that the resulting model satisfies the BLUE (Best Linear Unbiased Estimator) criteria, thereby validating its use as a reliable estimation tool. To meet these properties, several key classical assumptions must be evaluated: 1. Multicollinearity Test, Multicollinearity refers to a situation where there is a linear correlation between independent variables. When the explanatory variables in a regression model become tightly interwoven, the coefficient of determination R-squared can swell to an unnaturally high number, yet many of those same predictors may appear statistically insignificant. This behavior exposes one of the subtle distortions produced by multicollinearity. A widely adopted yardstick for spotting the trouble is the Variance Inflation Factor, or VIF. Gujarati (2007) cautions that, as a rough rule of thumb, any predictor that lands with a VIF value below 10 sits comfortably outside the reach of serious collinearity complications.
2. The heteroscedasticity test is conducted to evaluate whether the error variance in a regression model is constant across all levels of the independent variables (Gujarati, 2007). A condition in which the error variance is not constant is referred to as heteroscedasticity, which violates one of the key classical assumptions of regression analysis. Heteroscedasticity occurs when the variance of the error terms changes with different values of the explanatory variables, whereas the classical assumption of multiple linear regression requires that the error variance remain constant (homoscedasticity). In this study, the Breusch–Pagan–Godfrey test is employed to detect heteroscedasticity. If the test results yield a Chi-square probability value greater than the predetermined significance level, it can be concluded that there is no evidence of heteroscedasticity in the model.
3. Researchers routinely employ the autocorrelation test to determine whether the residuals of a regression model act independently over time or retain some temporal linkage, a concern first underscored by Gujarati (2007). Because time-ordered datasets naturally pair present observations with their historical counterparts, the phenomenon appears with particular frequency in that context. Positive autocorrelation inflates the apparent reliability of estimates, while negative autocorrelation does the opposite; either condition threatens the statistical efficiency and inferences drawn from the analysis.

4. Several statistical tests can be employed to detect the presence of autocorrelation in regression models, including the Breusch–Godfrey test, the Box–Pierce Q test, and the Durbin–Watson test (Firdaus, 2019). The Durbin–Watson test involves examining the Durbin–Watson statistic obtained from the regression output and comparing it with the critical values from the Durbin–Watson table, specifically the lower limit (dL) and the upper limit (dU). This comparison helps determine whether positive or negative autocorrelation is present in the residuals of the model. The comparison results are used to draw the following conclusions: 1.) If d < dL, there is strong evidence of positive autocorrelation; 2.) If d> 4 - dL, there is evidence of negative autocorrelation; 3.) If dL < d < 4 - dU, there is no strong evidence of positive or negative autocorrelation; 4.) If dL ≤ d ≤ dU or 4 - dU ≤ 4 - dL, the test does not provide evidence of the existence of autocorrelation.

2.8. Statistical Testing

Statistical testing is conducted to determine whether the independent variables exert a significant influence on the dependent variables within the model. The tests employed in this study include the coefficient of determination (R^2), the F-test, and the t-test, each of which is described in detail below.

1. Determination Coefficient (R^2): Model fit is assessed by examining the coefficient of determination (R^2), which measures how well the observed data align with the model's estimates. According to Gujarati (2007) the coefficient of determination serves as a descriptive statistic that indicates the proportion of variance in the dependent variable that can be explained by the independent variables in the regression model. The R^2 value ranges from 0 to 1, where a value of $R^2 = 1$ signifies that all variations in the response variable are fully accounted for by the model. A coefficient of determination that approaches 1 is generally interpreted as indicating a strong model fit. F Test The F test is used to assess whether at least one independent variable has a significant effect on the dependent variable (Gujarati, 2007). The F-test is conducted by comparing the calculated F-value with the critical F-value. This test assesses the joint influence of the independent variables on the dependent variable. Specifically, it evaluates the extent to which variations in the dependent variable can be explained by simultaneous changes in all the independent variables included in the model.
2. T-test The T-test is intended to determine whether each estimated coefficient of the independent variable partially has a significant effect on the dependent variable (Gujarati, 2007). Decision making is based on the T-statistic probability value of each independent variable. If the probability (p-value) associated with the t-statistic is less than the critical value at the specified significance level, the variable is considered to have a statistically significant partial effect on the dependent variable. Conversely, if the p-value exceeds the chosen significance threshold, the independent variable is deemed to have no statistically significant effect on the dependent variable.

3. RESULTS AND DISCUSSION OF DESCRIPTIVE STATISTICS OF INDONESIAN SUGAR SUPPLY

Descriptive statistical analysis of Indonesia's sugar supply model is presented in Table 2. According to data from the Food and Agriculture Organization (FAO) covering the period from 1992 to 2024, Indonesia ranks as one of the two largest sugarcane producers in the ASEAN region, with an average annual production of 27,933,395 tons. Thailand holds the leading position, with an average annual production of 71,609,197 tons. During the same period, Indonesia's average annual sugar production was recorded at 2,389,537 tons.

This national sugar output is derived from a cultivated area of approximately 413,210 hectares, yielding an average sugarcane production of 27,933,395 tons per year. The average sugar yield and productivity in Indonesia are recorded at 7.50% and 5.53 tons per hectare, respectively. A significant portion of national sugarcane production, approximately 63.6% is derived from smallholder plantations (Syachbudy et al., 2017).

Domestic sugar output, although bolstered by recent government incentives, still trails consumption by a fair margin. The national average now hovers close to 3.6 million metric tons annually slightly more than producers managed during the last harvest but well below what consumers actually buy. Rising intake is not coincidental; it tracks neatly with population increases, swelling discretionary incomes, and the relentless growth of snack, soft-drink, and confectionery factories dotted across Java and beyond (Peng, Lin, & Guo, 2015; Sulaiman, Sulaeman, Mustikasari, Nursyamsi, & Syakir, 2019).

Shortfalls in local cane processing force importers to fill the breach, and they do so at a torrid pace of roughly 2.26 million tons a year. That relentless foreign demand keeps Indonesia perched among the world's heaviest sugar importers, a title now routinely reaffirmed in trade bulletins (Peng et al., 2015; Toharisman & Triantarti, 2016). Imports of white crystal sugar are primarily utilized to address the imbalance between supply and demand for this type of sugar and to support domestic price stabilization efforts (Hermanto, 2015; Kurniasari, Dwidjono, & Widodo, 2015).

Customs data show that closing sugar inventories at the end of last season varied wildly from a low of 2,792 tonnes to a high of 2,139,771 tonnes. Such a broad range signals deep uncertainty in year-end stock levels and underlines the importance of more systematic planning across agencies and industry players. Better alignment among government regulators, producers, wholesalers, and retailers could help mop up surplus cane price support, keeping the market from sitting on excess sugar that the public never uses. Table 2. Show the descriptive statistics of Indonesian sugar supply variables for the period 1992-2021.

Table 2. Descriptive statistics of Indonesian sugar supply variables for the period 1992-2021.

Variabel	Mean	Std.dev.	Min.	Max.
Sugar production (ton)	2.389.537	245.669	1.950.000	2.868.428
Sugarcane production (ton)	27.933.395	2.687.750	23.600.000	33.100.000
Sugar land harvest (ha)	413.210	35.278	335.825	472.776
Rendement (%)	7.50	0.69	5.55	8.38
Sugar productivity (ton/ha)	5.53	0.58	3.98	6.21
Sugar import (ton)	2.360.060	1.693.334	118.941	5.639.677
Kurs exchange (Rp/US$)	9.173	3.985	2.130	14.682
Inflation (%)	8.69	10.06	1.46	58.35
Domestic sugar consumption (ton)	3.715.592	1.980.536	786.243	7.370.000
Sugar export (ton)	14.406	65.940	11	361.536
Product domestic bruto (Triliun Rp)	5.968	5.587,97	256.88	16.980,79
Domestic sugar price (Rp/ton)	6.973.483	4.596.751	1.330.430	14.883.000
Sugar stock previous year (ton)	830.870	641.332	2.792	2.139.771

3.1. Factors Affecting Sugar Supply in Indonesia

The parameter estimation results obtained through the Two-Stage Least Squares (2SLS) method demonstrate strong statistical reliability. The coefficient of determination (R^2) values range from 0.67 to 0.81, indicating that the explanatory variables included in the structural equations generally provide a robust explanation of the variation in the endogenous variables. The statistical analysis reveals that some explanatory variables do not exhibit a statistically significant effect on the endogenous variables at the conventional significance level of $\alpha = 0.05$. In this study, a flexible approach is adopted in interpreting significance levels, with the following notations used: (***) denotes significance at the 1 percent level ($\alpha = 0.01$); (**) denotes significance at the 5 percent level ($\alpha = 0.05$); and (*) indicates significance at the 10 percent level ($\alpha = 0.10$).

The Indonesian sugar-production equation yields a coefficient of determination-R_2-value of 0.7110. Put differently, roughly 71.10 percent of a country's yearly output fluctuations can be traced back to the predictors that researchers decided to include. The remaining 27.90 percent still remains a statistical mystery, pointing to outside forces, unmeasured shocks, or variables the framework simply overlooks.

The sugarcane production variable (PTIR) has a positive and statistically significant effect on Indonesia's sugar production at the 5 percent confidence level. This relationship is reflected in the elasticity values, with a short-term elasticity of 0.5663 and a long-term elasticity of 0.8841. A one-percent increase in sugar-cane acreage, all other qualifiers held constant, tends to boost sugar output by approximately 0.5663 percent almost immediately, and by about 0.8841 percent once the system has stabilized. This observation underscores how raw materials, almost ironically, remain the backbone of any surge in national refinery tonnage. Extensification programs maps, planting schedules, and sometimes even red-tape clearances aim to expand the cultivated area across new ground and thus increase cane production in the mill belt. Achieving this goal requires both identifying idle plots and revitalizing estates already under HGU licenses. Raising sugar-cane farmers' incomes tends to attract producers from competing commodities into the cane sector, and it also helps retain veteran growers, preventing them from shifting to other crops (Yunitasari et al., 2021). That dynamic echoes earlier Indonesian work by Prabowo (2014) and by Sadiyah et al. (2014), both of which traced a clear, across-the-board lift in national sugar output to gains in cane tonnage. Table 3. Show the results of analysis of the Indonesian sugar production equation, including variable coefficients, probability, and elasticity.

Table 3. Results of analysis of Indonesian sugar production equation variable coefficients, probabilities, and elasticities.

Variable	Coefficient	Probability	Elasticity	
			SR	LR
C	-11.583	0.3434	0.5663	0.8841
PTIR	0.4937**	0.0249		
LTIR	0.2538	0.1754		
RGIR	0.4331*	0.0915	0.0662	0.0803
PRG	-0.0970	0.6829		
LagPGI	0.3978**	0.0250		
R-sq	0.7110			
F-count	11.8781			
DW	1.6526			

Note: ** Significant at the level 5 %.
* Significant at the level 10 %.

Field observations repeatedly identify two pivotal moments when sugar-borne losses materialize. The first is the rough, jolting haul from field to yard; the second emerges inside the factory, often masked by blinking conveyor lights (Sunaryo, 2006). Grimy rollers, outdated augers, and cane that slips through chewed edges all conspired to drag national output down (Wibowo, 2012). That profile of loss aligns neatly with Apriawan, Irham, and Mulyo (2015), Their regression plots showed yield responding in line with the grower-shippers' final tonnage..

The estimation results of the sugar import model in Indonesia yielded a coefficient of determination (R^2) of 0.8343. This indicates that approximately 83.43 percent of the variation in Indonesian sugar import volumes can be explained by the explanatory variables included in the model. The remaining 16.57 percent is attributed to factors outside the model, suggesting the presence of external influences or unobserved variables that also affect import behavior.

Table 4. Results of analysis of Indonesian sugar import equation variable coefficient probability elasticity SR – LR.

Variable	Coefficient	Probability	Elasticity	
			SR	LR
C	161032	0.0682	-0.8594	-1.1801
KURS	-1.4569**	0.0498		
INIR	-0.0680	0.7453		
KGIR	2.4796**	0.0130		
PGI	-3.2376**	- 0.0354	2.4916	3.4286
HGIR	-0.2252	0.7448	-3.2922	-4.4976
LagIGI	0.2640**	0.0182		
R-sq	0.8343			
F-hitung	18.7728			
DW	1.7714			

Note: ** Significant at the level 5 %.

As indicated in Table 4, movements in the rupiah-dollar price (denoted here as KURS) exert a statistically reliable drag on Indonesia's sugar-buying spree, with significance firmly anchored at the five-percent mark. Short-run sensitivity clocks in at -0.8594; the longer view nudges that figure downward to -1.1801. When the national currency rallies, the local sticker price on foreign sugar climbs, pinching household budgets and trimming purchase orders until shipments shrink. That same currency strength often tilts taste and margin in favor of homegrown sugar, leaving importers with shrinking incentives. Because the long-run elasticity reads so far from zero, it is clear that exchange-rate wobble leaves a deeper dent in import tonnages the further out one looks. The present result diverges sharply from the earlier work of Putri and Sentosa (2021), in which a direct and positive correlation between the exchange rate and import volumes was documented. Domestic sugar use, indexed here as PGIR, exerts a robust and statistically significant influence on the expansion of Indonesian sugar imports; the effect remains stable at the conventional 1 percent cutoff. Elasticity estimates reinforce that view: short-run responsiveness sits at 2.4916 and long-run sensitivity rises to 3.4286, with both figures comfortably beyond the 1 percent threshold for significance. The reported elasticities reveal a fairly pliant market: a single percentage-point rise in national sugar use pushes imports up by about 2.49 percent almost immediately and by roughly 3.42 percent over several months, other conditions constant. Such numbers suggest that domestic producers simply lack the spare capacity to fill a sudden demand gap, forcing buyers to lean more heavily on overseas supplies. That tight relationship mirrors the patterns observed by Rusdi, Primandhana, and Mohammad (2021), whose study of Indonesia's sugar trade revealed the same consumption-import linkage.

Indonesian domestic sugar output, coded PGI in the data set, exerts a statistically robust inverse pull on import volumes, measurable at a 5 percent threshold. Short-run elasticity sits at -3.1922, while the long-term counterpart reads -4.3976, each figure underscoring the productively generous feast that leaves foreign cane rawer than usual. When yardsticks are held constant, a single percentage-point bump in home grinding capacity should shave roughly 3.1922 percent off incoming shipments near-term and close to 4.3976 percent farther down the calendar. A broadening base of domestic refining and milling infrastructure enables the nation to satisfy its own appetite for sugar, thus curtailing dependence on overseas shipments of the commodity. Elasticity estimates, hovering above the one-threshold, reinforce the idea that increments in home output almost immediately shrink the volume of imports. Putri and Sentosa (2021) work corroborates this, reporting a tightly linked, inverse slope between Indonesian production figures and the tonnage brought in from foreign markets.

The estimated parameters derived from the regression on Indonesia's sugar-export volume are displayed in Table 5. The coefficient of determination (R^2) registers at 0.6714, meaning close to 68 percent of the fluctuations in shipment size can be attributed to the predictors in the specification. A residue of roughly 32 percent still eludes explanation, indicating that outside forces or omitted factors continue to influence the outcome.

Table 5. Results of analysis of Indonesian sugar export.

Variable	Coefficient	Probability	Elasticity	
			SR	LR
C	-4998	0.8409		
KURS	-0.0842	0.9680		
PGI	-18.354	0.6589		
GDPIR	2.6542* -3.4146** 0.7588**	0.0574		
HGIR		0.0938 –	138.544	404.218
LagEGI		0.0368	-77.630	-227.990
R-sq	0.6714			
F-hitung	9.7467			
DW	1.8144			

Note: ** Significant at the level 5 %.
* Significant at the level 10 %.

Movements in Indonesia's real-GDP-index-variable (GDPIR) are not merely macroeconomic noise; they exert a significant and statistically reliable influence on sugar shipments, with significance established at the 10 percent level.

The short-run elasticity, measured at 13.8544, indicates that a 1 percent increase in GDP results in approximately a 13.8544 percent rise in export volume. Over a longer horizon, this figure increases to 40.3418, suggesting that, ceteris paribus, an identical GDP increase eventually leads to nearly a 40 percent growth in exports. This positive relationship implies that robust economic growth, as reflected by rising GDP, can stimulate demand across various sectors, including the sugar industry, thereby supporting higher export volumes. An increase in domestic demand has the potential to boost both sugar production and exports. However, these findings differ from those reported by Mwinuka and Mlay (2015), who identified a negative relationship between gross domestic product (GDP) and sugar exports in the context of Tanzania. In Indonesia, the variable representing domestic sugar prices (HGIR) shows a statistically significant negative effect on sugar export growth at the 5 percent significance level. This is reflected in the estimated short-term elasticity of –7.7630 and long-term elasticity of –22.7990, indicating that higher domestic sugar prices are associated with a substantial reduction in export volumes over both time horizons.

The findings indicate that domestic sugar prices exert a significant and responsive effect on sugar exports. Specifically, a 1 percent increase in domestic sugar prices is estimated to reduce Indonesia's sugar imports by 7.7630 percent in the short term and by 22.7990 percent in the long term, ceteris paribus. When sugar prices spike within Indonesia, local millers frequently divert their harvests to the domestic market; the immediate profit gains there simply outweigh the longer, riskier wait common in export deals. Such inward focus blunts the country's edge on the world stage, since overseas buyers will naturally lean toward cheaper cargoes from Brazil or Thailand once Jakarta prices push above their comfort zone. This pattern runs counter to the 2015 observations of Mwinuka and Mlay (2015), who argued that rising home-market values had, rather curiously, spurred Indonesian sugar shipments abroad.

3.2. Indonesia's Sugar Stock

Scholars commonly trace a national-ending commodity stock to a straightforward identity equation that offsets yearly supply against consumption. In the case of Indonesia, the year-end figure for sugar simply emerges as the leftover from local use once all sources and losses are tallied. Supply in any calendar term, and the previous one is no exception, collects domestic output, inbound shipments, and opening inventory, then deducts whatever volume leaves the country in exports. Under the ceteris paribus assumption, a larger sugar availability from the prior season mechanically adds to the carry-out inventory, while a reduced output shrinks that same inventory. Domestic demand for sugar during the corresponding period also exerts considerable leverage over year-end holdings. When national consumption rises, the remaining tonnage is correspondingly diminished; conversely, if consumption contracts, the stockpile swells, again holding all else equal.

3.3. Amount of Indonesian Sugar Supply

Planters, traders, and policymakers usually summarize Indonesia's sugar supply with a balance-sheet equation that nets four figures against one another: domestic output, foreign shipments in, overseas sales out, and whatever remains in store from the last harvest. When growers boost production, importers buy additional bulk, or silent warehouses finally see their contents counted, the aggregate supply curve naturally shifts outward. By contrast, any surge in export contracts shrinks the home pool almost dollar-for-dollar, leaving domestic end-users with a tighter market, other conditions unchanged.

1. National sugar output is closely tied to the volumes of sugarcane harvested and the tonnage of raw sugar produced per hectare; when either of those agronomic figures rises, the country's total sugar pool expands without delay. Market clearing, however, is complicated by the exchange rate: a weaker rupiah makes overseas fees steeper, while the same depreciation shutters cheaper imports, magnifying a domestic shortfall. Exchange rate depressions and booming local harvests usually pair with reduced import shipments because both push price-coated customs curves upward. Heavy domestic consumption pushes private firms to scour the offshore market even when currency prices are unfavorable.
2. A stable surge in cane output can raise national sugar stocks quite markedly, all else being equal. Over longer horizons, the currency value repeatedly proves to be a powerful lever, adjusting import invoices and thereby redirecting purchase volumes. Short of extraordinary policy shifts, local demand and mill output keep pacing incoming shipments, a steady interplay that steers Indonesia's overall trucking schedule.
3. Third, Indonesia is a case study in how national production levels shape raw commodity flows. Statistics confirm that rising gross domestic product creates a buoyant export climate for sugar, even as the stronger rupiah trims the volume left for local consumers. Price signals within the archipelago tell a different story. When the cost of refined cane spikes at the mill gate, traders pull back from foreign sales, freeing up more sweetener for neighborhood markets. Economy-wide output and domestic pricing thus emerge as twin levers—capable, almost on cue, of shifting shipment tonnage in either direction.

4. CONCLUSION

The annual loaf of sugar that Indonesia actually receives depends on several dynamic factors. The primary component is the volume of cane harvested each season, as haul size and extraction efficiency jointly determine factory output. Long-standing delays in milling what economists refer to as vintage carry-over can further constrain the domestic supply chain. Import volumes then respond in complex ways to currency fluctuations, rising consumer demand, unexpected yields, and the financial implications of previous shipments. Exports follow a different pattern; increasing GDP typically boosts overseas sales, while rising local prices tend to keep export volumes near home. Additionally, end-of-year stockpiles influence the next crop cycle, since closing stocks are simply the previous supply minus last year's consumption. Findings from elasticity analysis indicate that, in the short run, sugar supply responds significantly to variables such as domestic consumption, domestic production, GDP, and domestic sugar prices. Over the long term, the responsiveness of sugar supply also includes the exchange rate, reflecting a broader set of economic factors that influence supply dynamics over time.

5. SUGGESTIONS

Promoting the expansion of sugarcane cultivation through extensification programs by increasing the plantation area is a strategic step to reduce the country's heavy reliance on sugar imports. This effort requires a thorough assessment of land suitability for new cultivation areas, including the potential utilization of underused or abandoned HGU (Hak Guna Usaha) lands for sugarcane farming. Enhancing the efficiency of machinery and technological applications in the harvesting, transportation, and processing stages of sugarcane production is essential to minimize yield losses and optimize output. Furthermore, fostering research and innovation within the sugar industry is crucial for improving overall production efficiency, thereby reducing operational costs and making domestic sugar prices more accessible to consumers while enhancing competitiveness in international markets. In addition, sustained research efforts are necessary to improve the quality of raw materials, which currently remain suboptimal.

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