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A Nation of Cane, A Nation of Imports: An Analysis of the Determinants of Sugar Import Dependency in Indonesia

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Abstract. *Indonesia, once a major global sugar producer, has become increasingly dependent on imports to meet domestic demand. This study analyzes the determinants of sugar import dependency in Indonesia using an econometric approach. The research utilizes time-series data from 2000 to 2024 and applies model economic Indonesian sugar to examine the effects of key variables, including domestic sugar production, consumption, international sugar prices, exchange rates, and government policies. The findings show that domestic production has a significant negative effect on sugar imports, while consumption and international prices have a positive and significant impact. Exchange rate depreciation is also associated with higher import values. In addition, inconsistent government policies contribute to structural inefficiencies in the sugar sector, further reinforcing import dependency. These results indicate that Indonesia's reliance on sugar imports is driven not only by the imbalance between domestic supply and demand but also by broader economic and institutional factors. Therefore, policy efforts should focus on increasing agricultural productivity, modernizing sugar processing industries, and ensuring consistent trade regulations. Strengthening these aspects is essential to reduce import dependency and enhance the competitiveness and sustainability of Indonesia's sugar industry.*

Keywords*: Domestic production; Econometric analysis; Sugar import dependency; Trade policy*

INTORDUCTION

The pressures of population growth and the food industry in Indonesia have prompted serious attention to food supply. The plantation sector serves as a key source of food, in addition to its other economic roles (Cahyaningsih et al., 2025 and Fadillah et al., 2024). One of the most important plantation commodities is sugar. Historically, Indonesia was once one of the world's largest sugar producers during the colonial era, however, in recent decades, its competitiveness has declined due to various factors, such as low land productivity, outdated processing technology, and the conversion of sugarcane plantation land (Knight, 2018). Indonesia's plantation sector particularly for sugarcane, which serves as raw material for sugar and is used in the food, chemical, phamaceutical, and energy industries holds immense potential that should be harnessed. Specifically regarding raw materials for sugar production, its development has not kept pace with the steadily rising annual consumption, which is not accompanied by sufficient production capacity. In 2017, Indonesia's sugar production reached 5.4 million tons with consumption at 5.56 million tons; production figures for 2018 stood at 5.53 million tons, while consumption reached 5.59 million tons. Indonesia's sugar production growth in 2019 was recorded by the USDA at 5.68 million tons, with consumption at 5.71 million tons (USDA/GAIN, 2019). Based on production figures over the past three years, it is evident that the domestic sugar industry has not yet been able to meet national consumption needs. Although the government, through relevant agencies, has implemented a series of policy programs aimed at increasing production, it has not yet been able to meet the target of making Indonesian sugar a key component of sugar self-sufficiency (FAO, 2023).

Indonesia's sugar supply shortfall is the main factor driving the country to continue importing, and these imports are increasing year on year. Data from the observation period shows that Indonesia's sugar imports have grown by an average of 8.27% annually, which, from an economic resilience perspective, is not a positive development. In 2017, Indonesia imported 4.1 million tonnes of sugar with an import value of US$2.2 billion, and sugar imports in 2018 increased by 6% with the import value reaching US$2.3 billion (BPS, 2018). Indonesia's sugar imports are sourced from Thailand, Brazil and Australia, with Thailand accounting for the largest share. Thailand was the largest supplier, with sugar imports to Indonesia totalling 2.05 million tonnes and an import value of US$ 1.1 million in 2017. Indonesia's sugar imports from Australia in 2017 reached 878,000 tonnes with an import value of US$468 million, whilst imports from Brazil amounted to 1.07 million tonnes with an import value of US$575 million (Rachman, 2019). Based on data for the period 2010 to 2025, it is recorded that sugar consumption shows a relatively stable upward trend, from around 5.42 million tonnes in 2010 to 7.70 million tonnes in 2025. If converted into economic value, assuming an average domestic sugar price of around Rp12,000/kg based on the national retail price range, the value of consumption increases from around Rp65.0 trillion to Rp92.4 trillion (Indonesian Ministry of Trade, 2025). On average, consumption grew by around 2.4 to 2.6% per year, indicating a consistent increase in domestic demand. Meanwhile, sugar imports show high growth but are highly volatile, rising from 1.19 million tonnes or worth Rp14.3 trillion in 2010 to 3.93 million tonnes worth Rp47.2 trillion in 2025, with an average growth rate of around 13.6%

per year, though accompanied by sharp volatility due to the impact of import policies, global sugar prices, and domestic supply imbalances (Ministry of Agriculture of the Republic of Indonesia, 2025).

On the other hand, domestic sugar production has remained relatively stagnant, rising only from 2.36 million tons (worth Rp28.3 trillion) to 2.67 million tons, with an average annual growth rate of about 0.8 to 1.2%. This situation indicates that, from the perspective of the rupiah's value, the gap between consumption and production is widening, and must therefore be bridged by imports, the value of which is also rising and remains volatile. In terms of trends, the area under cultivation increased from around 436,570 ha to 518,662 ha during the observation period, representing an average annual growth of approximately 1.1 to 1.3 per year. This growth was relatively slow and experienced a contraction midway through the period before rising again. However, this increase in cultivated area has not been accompanied by a significant rise in production. This indicates issues with land productivity (yield), such as low sugarcane yield, inefficient sugar mills, and sub optimal technology adoption, as highlighted in the Sugar Commodity Outlook report by the Ministry of Agriculture of the Republic of Indonesia, 2022. If, based on the data in Figure 1, consumption levels appear to be insufficient to be met by the combined total of production and imports, this shortfall can in fact be covered by Indonesia's sugar stockpile of 1.5 million tonnes, alternatively, the government often draws on the opening stock from the previous year (carry over) and any remaining imports to meet demand, particularly in the run-up to the crushing season. Overall data on sugar consumption, imports and production in Indonesia for the period 2019 to 2025 can be seen in Figure 1. This study aims to analyse the determinants of sugar import dependency in Indonesia as a paradoxical phenomenon 'a sugarcane producing country that remains dependent on sugar imports' by examining the relationship between consumption growth, domestic production, the expansion of sugarcane acreage, and the dynamics of domestic sugar prices. In explaining the gap between national sugar supply and demand, the aim is to formulate effective policy implications to reduce import dependency and support the achievement of sugar self sufficiency in Indonesia.

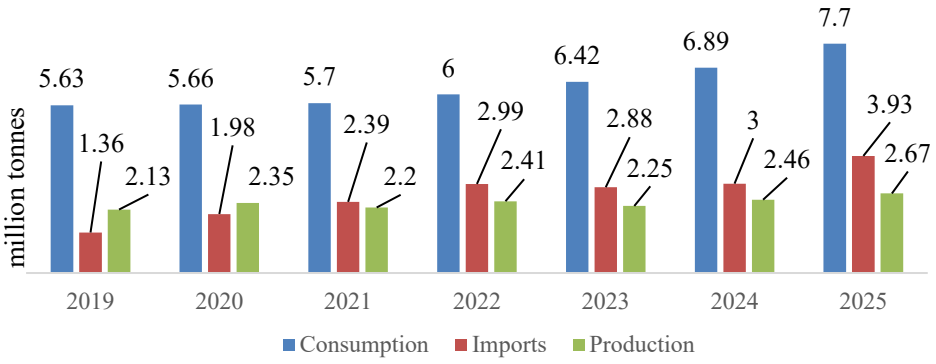

Figure 1 Indonesian Sugar Consumption, Imports and Production periode 2019 - 2025

RESEARCH METHODOLOGY

The type and source of data used in this study consist of time series data covering a 25 year period from 2010 to 2025. Time series data are particularly suitable for model development, as they facilitate forecasting, interpretation, and economic hypothesis testing (Enders, 2004). The data were obtained from various official institutions, agencies, and international organizations to support the analysis and interpretation of the development of the sugarcane-based sugar industry. These sources include Central Bureau of Statistics (BPS), Ministry of Agriculture of the Republic of Indonesia, Directorate General of Estate Crops, Centre for Socio-Economics and Agricultural Policy (PSEKP), International Sugar Organization (ISO), United States Department of Agriculture (USDA), World Bank, Food and Agriculture Organization (FAO), World Trade Organization (WTO), Federal Reserve Bank of St. Louis (FRED), and Organisation for Economic Co-operation and Development (OECD). Data processing in this study was conducted using SAS/ETS (Statistical Analysis System/Econometric Time Series). The econometric model specification of the Indonesian sugar industry was developed based on empirical evidence and previous studies. This research aims to explain the paradox of Indonesia as a sugarcane-producing country that still depends on sugar imports. The model is constructed as a system of simultaneous equations representing the interrelationships among variables, as illustrated in Figure 2. It consists of equations for sugarcane plantation area by ownership type, productivity, production, and sugar imports. The model structure follows the expected theoretical signs, where oval shapes represent endogenous variables and rectangular shapes represent exogenous variables. The policy simulations in this study include the expansion of sugarcane plantation areas in Indonesia, referring to Presidential Regulation No. 40 of 2023, which serves

as the main legal framework for accelerating national sugar self-sufficiency through increased land area and productivity.

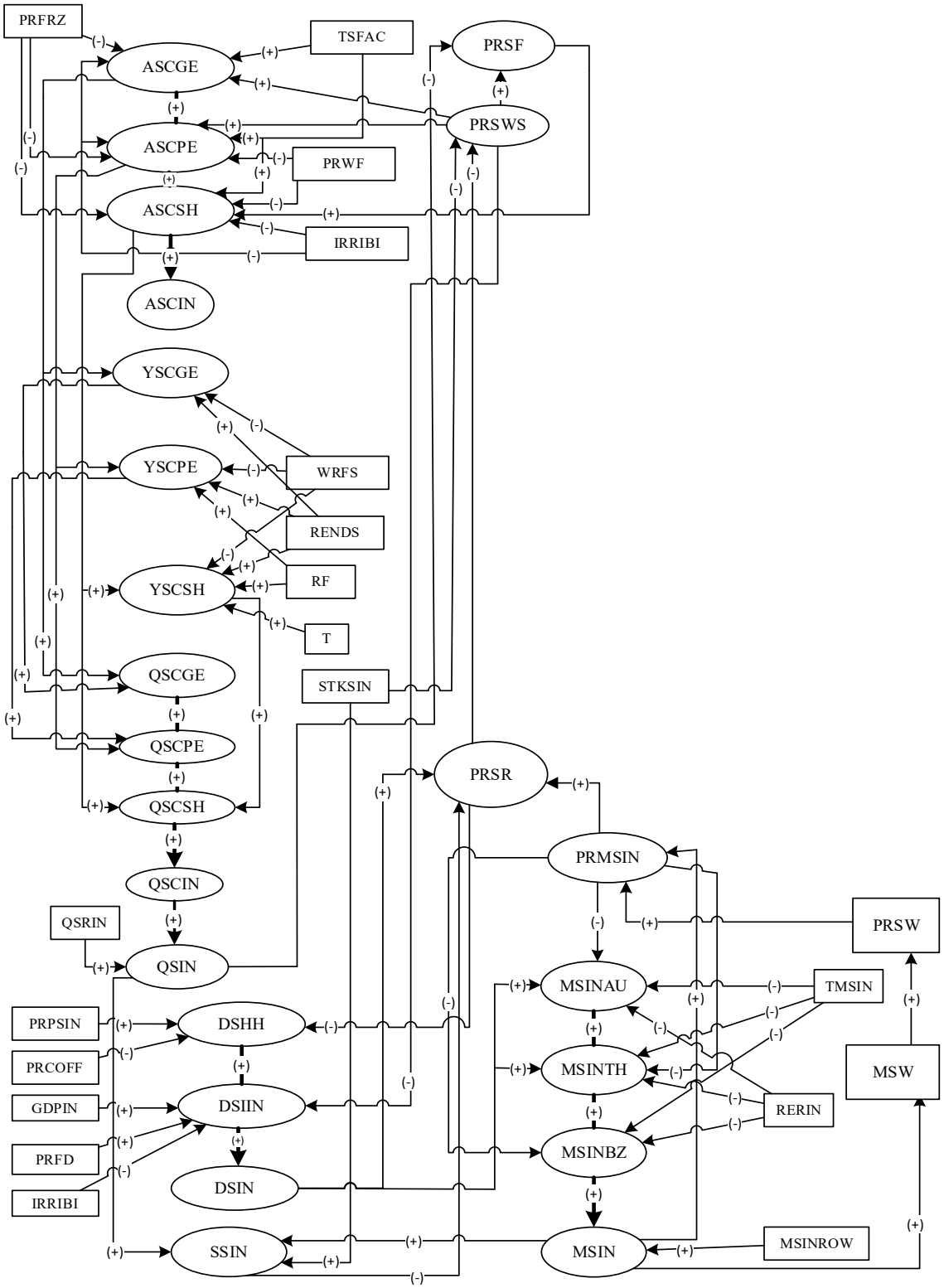

Figure 2 Relationships among variables in the Indonesian sugar industry model

The model consists of 24 equations and is identified within a structural equation system based on the order condition (Koutsoyiannis, 1977). The simulation scenarios applied in this study are as follows: S1 simulates the impact of a 20 percent increase in fertilizer subsidies based on Presidential Regulation No. 6 of 2025; S2 simulates a 15 percent increase in farm-gate sugar prices based on Minister of Trade Regulation No. 7 of 2020 and its updates, which regulate price floors to protect farmers; and S3 simulates the implementation of a revitalization program involving the addition of 10 sugar mills and an 18 percent expansion in plantation area, based on Presidential Regulation No. 40 of 2023 on the acceleration of national sugar self-sufficiency and bioethanol development.

The area of sugarcane plantations based on ownership status can be expressed in the equation for the total area of state and privately owned sugarcane plantations (ASC_t), which is influenced by sugar prices (Rahman, 2013), fertilizer use, interest rates, and the number of sugar mills. The area of sugarcane plantations owned by smallholders ($ASCSH_t$) is influenced by the farmer-received sugar price ($PRSF_t$), where the price received affects the harvest yield on smallholder plantations (Rachman, 2019). In the production system, sugarcane productivity is incorporated, reflecting the sugarcane yield rate; thus, the level of sugarcane yield is projected through the results of the sugarcane milling process at sugar mills, which produce crystal sugar determined by high quality sugarcane seeds and timely harvesting. Indonesia's sugar productivity is included in the equation based on the respective ownership status of the sugarcane cultivation areas. Sugar production is the product of the area of sugarcane cultivation and Indonesia's sugar productivity in the year of observation. Price levels are not included in the endogenous equation category because the study will only examine the area of cultivation, which influences sugar import levels from the largest source countries: Brazil ($MSINBZ_t$), Australia ($MSINAU_t$), and Thailand ($MSINTH_t$). In the equation for Indonesia's sugar imports from these major countries, the price of Indonesian sugar is determined by global sugar prices, import volumes, and the rupiah exchange rate. Formula for the area of sugarcane plantations in Indonesia:

$$ASCGE_t = a_0 + a_1\, PRSWS_t + a_2\, PRFRZ_t + a_3\, TSFAC_t + a_4\, (IRRBI_t - IRRBI_{t-1}) + a_5\, ASCGE_{t-1} + U_1 \quad (1)$$
$$ASCPE_t = b_0 + b_1\, (PRSWS_t - PRSWS_{t-1}) + b_2\, PRWF_t + b_3\, PRFRZ_t + b_4\, TSFAC_t + b_5\, IRRIBI_{t-1} + b_6\, ASCPE_{t-1} + U_2 \quad (2)$$
$$ASCSH_t = c_0 + c_1\, (PRSF_t - PRSF_{t-1}) + c_2\, PRWF_t + c_3\, PRFRZ_t + c_4\, TSFAC_t + c_5\, IRRIBI_t + c_6\, ASCSH_{t-1} + U_3 \quad (3)$$
$$ASCIN_t = ASCGE_t + ASCPE_t + ASCSH_t \quad (4)$$

hypothesis :

$a_1, a_3 > 0,\ a_2, a_4 < 0,\ 0 < a_5 < 1,\ b_1, b_4 > 0,\ b_2, b_3, b_5 < 0,\ 0 < b_6 < 1,\ c_1, c_4 > 0,\ c_2, c_3, c_5 < 0,\ 0 < c_6 < 1$

In the sugar production system, there is a metabolic process in sugarcane plants that leads to the formation of sugar. The granulated sugar used in productivity measurement refers to crystallized sucrose. The process of producing granulated sugar takes place in sugar mills, where harvested sugarcane is processed through extraction equipment to obtain juice from the cane stalk, which is then refined into sugar crystals. The resulting sugar crystals reflect the sugar recovery rate (rendement) of the cane. The level of recovery depends on both the condition of the sugarcane and the milling process in the factory. To achieve a high recovery rate, sugarcane must come from high-quality seed varieties, be harvested at the appropriate time, and be supported by efficient milling facilities. The productivity of granulated sugar in Indonesia is categorized based on ownership status, namely state-owned plantations, private plantations, and smallholder plantations. The following presents the productivity equations of Indonesian sugarcane plantations in terms of granulated sugar production:

$$YSCGE_t = d_0 + d_1\, ASCGE_{t-1} + d_2\, (WRFS_t - WRFS_{t-1}) + d_3\, RENDS_t + d_4\, YSCGE_{t-1} + U_4 \quad (5)$$
$$YSCPE_t = e_0 + e_1\, ASCPE_{t-1} + e_2\, WRFS_t + e_3\, RENDS_t + e_4\, RF_t + U_5 \quad (6)$$
$$YSCSH_t = f_0 + f_1\, ASCSH_{t-1} + f_2\, WRFS_t + f_3\, RENDS_t + f_4\, T_t + f_5\, RF_t + f_6\, YSCSH_{t-1} + U_6 \quad (7)$$

hypothesis :

$d_1, d_3 > 0,\ d_2 < 0,\ 0 < d_4 < 1,\ e_1, e_3, e_4 > 0,\ e_2 < 0,\ f_1, f_3, f_4, f_5 > 0,\ f_2 < 0,\ 0 < f_6 < 1$

Sugar production in state-owned, private, and smallholder plantations is calculated as the product of sugarcane cultivated area, granulated sugar productivity, and the sugar recovery rate (rendement), resulting in what is referred to as white crystal sugar production. Sugar mills in Indonesia that use raw sugar as an input to produce refined sugar are not included in this analysis due to data limitations over the study period. Therefore, granulated sugar (white crystal sugar) and refined sugar are treated as equivalent or homogeneous in this study. Total sugar production in Indonesia is defined as the sum of production from state-owned, private, and smallholder plantations. The production equations for granulated sugar based on each ownership status, as well as total granulated sugar production, are formulated as follows:

$$QSCGE_t = ASCGE_t * YSCGE_t \quad (8)$$
$$QSCPE_t = ASCPE_t * YSCPE_t \quad (9)$$
$$QSCSH_t = ASCSH_t * YSCSH_t \quad (10)$$
$$QSCIN_t = QSCGE_t + QSCPE_t + QSCSH_t \quad (11)$$

$QSIN_t = QSCIN_t + QSRIN_t$ …….. (12)

Indonesia's sugar demand is categorized into two types: household sugar demand and demand from the food and beverage industry. Household demand mainly refers to white crystal sugar, which is widely available in the domestic sugar market, while demand from the food and beverage industry primarily involves refined sugar. Household sugar demand in Indonesia is influenced by retail sugar prices, palm sugar prices, coffee prices, GDP, and population size. Meanwhile, sugar demand from the food and beverage industry is influenced by real wholesale prices, as well as the prices of sweetened food and beverage products, commonly categorized as snack foods. These include sugar-based products such as chocolate, chewing gum, and other confectionery items, which are widely produced for direct consumption or as industrial inputs (sugar confectionery). In this study, sugar supply is determined by total domestic sugar production, total sugar imports, and Indonesia's sugar stocks. The equations for total sugar demand comprising household and food and beverage industry demand and total sugar supply in Indonesia are formulated as follows:

$DSHH_t = g_0 + g_1\ PRSR_t + g_2\ PRPSIN_t + g_3\ PRCOFF_{t-1} + g_4\ RGDPIN_{t-1} + g_5\ DSHH_{t-1} + U_7$ ……... (13)
$DSIIN_t = h_0 + h_1\ PRSWS_{t-1} + h_2\ PRFD_{t-1} + h_3\ RGDPIN_t + h_4\ IRRIBI_t + h_5\ DSIIN_{t-1} + U_8$ ……. (14)
hypothesis :
$g_2, g_4 > 0$; $g_1, g_3 < 0$; $0 < g_5 < 1$, $h_1, h_4 < 0$; $h_2, h_3 > 0$; $0 < h_5 < 1$
$DSIN_t = DSHH_t + DSIIN_t$ ……... (15)
$SSIN_t = QSIN_t + MSIN_t + STKSIN_{t-1}$ ……...(16)

Domestic sugar prices in Indonesia are categorized into three interrelated equations: farm-gate sugar prices, wholesale sugar prices, and retail sugar prices. Retail sugar prices, which are paid by consumers, are influenced by the transmission of import sugar prices that affect wholesale prices. Wholesale prices, which incorporate production costs, in turn influence farm-gate prices. These farm-gate prices may be supported by government subsidies when there is a decline in the selling price of sugarcane to wholesalers or domestic sugar producers. All nominal domestic sugar price data are converted into real terms by deflating them using the consumer price index (CPI) in period t (Rachman, 2019). The equations for domestic sugar prices consisting of real farm-gate prices, wholesale prices, and retail prices are formulated as follows:

$PRSF_t = i_0 + i_1\ PRSWS_t + i_2\ QSIN_t + i_2\ PRSF_{t-1} + U_9$ …... (17)
$PRSWS_t = j_0 + j_1\ PRSR_t + j_2\ STKSIN_{t-1} + j_3\ PRSWS_{t-1} + U_{10}$ …... (18)
$PRSR_t = k_0 + k_1(PRMSIN_t - PRMSIN_{t-1}) + k_2\ SSIN_t + k_3\ DSIN_{t-1} + k_4\ PRSR_{t-1} + U_{11}$ ……..... (19)
hypothesis :
$i_1 > 0$, $i_2 < 0$, $0 < i_3 < 1$, $j_1 > 0$, $j_2 < 0$, $0 < j_3 < 1$, $k_1, k_3 > 0$, $k_2 < 0$, $0 < k_4 < 1$

Indonesia is one of the largest sugar importers in the global market, with the majority of its imports originating from Thailand, Brazil, and Australia. Brazil accounts for approximately 47 percent of Indonesia's total sugar imports, followed by Thailand at 6.5 percent, Australia at 6 percent, and the remaining 40.5 percent coming from other countries. The value of Indonesia's sugar imports was US$ 1.11 million in 2010 and reached its peak in 2016 at US$ 2.09 million. In the import model, the real import price of sugar in Indonesia is specified as a single equation that influences sugar imports from each exporting country. Indonesia's sugar import tariff, represented by value added tax, and total domestic sugar demand affect the volume of imports from Brazil, Thailand, and Australia. The import price of sugar is assumed to be uniform across source countries and is influenced by world sugar price transmission, the exchange rate, and total sugar imports in Indonesia. The equations for sugar imports from each exporting country, along with the real import price of sugar in Indonesia, are formulated as follows:

$MSINBZ_t = l_0 + l_1\ PRMSIN_t + l_2\ TMSIN_t + l_3\ RERIN_t + l_4\ DSIN_t + l_5\ MSINBZ_{t-1} + U_{12}$ …… (20)
$MSINTH_t = m_0 + m_1\ PRMSIN_t + m_2\ TMSIN_t + m_3\ RERIN_{t-1} + m_4\ DSIN_t + m_5\ MSINTH_{t-1} + U_{13}$ …….. (21)
$MSINAU_t = n_0 + n_1\ PRMSIN_t + n_2\ TMSIN_t + n_3\ RERIN_{t-1} + n_4\ DSIN_t + n_5\ MSINAU_{t-1} + U_{14}$ ……(22)
$PRMSIN_t = o_0 + o_1(PRSW_t - PRSW_{t-1}) + o_2\ (MSIN_t - MSIN_{t-1}) + o_3\ PRMSIN_{t-1} + U_{15}$ ……..…..(23)
$MSIN_t = MSINTH_t + MSINBZ_t + MSINAU_t + MSINROW_t$ ……...(24)
hypothesis :
$l_4 > 0$, $l_1, l_2, l_3 < 0$, $0 < l_5 < 1$, $m_4 > 0$, $m_1, m_2, m_3 < 0$, $0 < m_5 < 1$, $n_4 > 0$, $n_1, n_2, n_3 < 0$, $0 < n_5 < 1$,o_1, $o_2 > 0$, $0 < o_3 < 1$

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RESULTS AND DISCUSSION

The real price of paddy is not included in the equation for state-owned sugarcane plantation area ($ASCGE_t$), as planting decisions in state plantations are largely determined by government policies that require farmers to continue cultivating sugarcane, even when alternative crops such as rice may offer more favorable prices or lower production costs. As shown in Table 1 the estimation results indicate that all variables in the ASCGEt equation namely the real wholesale sugar price ($PRSWS_t$), real fertilizer price ($PRFRZ_t$), number of sugar mills ($TSFAC_t$), and real investment interest rate ($IRRIBI_t$) are not statistically significant. The elasticity values are also relatively small (inelastic), such as the real sugar price elasticity of 0.0059 in the short run and 0.0282 in the long run, while fertilizer prices show a negative but inelastic response. This suggests that the plantation area of state owned sugarcane is relatively unresponsive to changes in economic variables. In contrast, private sugarcane plantations ($ASCPE_t$) show more responsive behavior. The real sugar price has a positive and statistically significant effect, with elasticities of 0.42 in the short run and 0.85 in the long run. The number of sugar mills also has a positive and significant effect, with elastic responses of 1.7 in the short run and 3.6 in the long run. Meanwhile, the real price of paddy, fertilizer price, and investment interest rate have negative effects on plantation area, although not all are statistically significant. These findings indicate that the expansion of private sugarcane plantation area is strongly driven by the growth in the number of sugar mills. For smallholder sugarcane plantations ($ASCSH_t$), the plantation area is influenced by changes in the real farm-gate sugar price, real paddy price, fertilizer price, number of sugar mills, and real investment interest rate. Although most variables are not statistically significant, the direction of influence shows that sugar prices and the number of sugar mills have positive effects, while paddy prices, fertilizer prices, and interest rates have negative effects. The elasticity of the number of sugar mills is relatively elastic, reaching 1.3 in the short run and 1.8 in the long run. Overall, the number of sugar mills emerges as the most consistent factor influencing the expansion of sugarcane plantation area across all ownership types, particularly in private and smallholder plantations where the response is elastic. This reflects real- world conditions in which an increase in the number of sugar mills raises demand for sugarcane as a raw material, thereby encouraging expansion of plantation area and potentially increasing sugar production in Indonesia.

Table 1 Estimation Results of Sugarcane Plantation Area in Indonesia

Variabel	Parameter Estimate	Pr > |t|	Elasticity		Description
			Short Run	Long Run	
State-owned sugarcane plantation area ($ASCGE_t$)					
Intercept	27801.51	0.7885	-	-	
$PRSWS_t$	0.121447	0.8558	0.0059	0.0282	real wholesale sugar price
$PRFRZ_t$	-1.14407	0.5955	-0.0550	-0.0855	real fertilizer price
$TSFAC_t$	812.0085	0.4958	0.6241	0.7227	number of sugar mills
$SIRRIBI_t$	-21.0852	0.9258	-0.0082	-0.0088	real investment interest rate
$ASCGE_{t-1}$	0.125866	0.5985	-	-	
Prob>|F|: 0.5011	R^2 : 0.2955	Dw : 1.9885	Dh : 0.2711		
Private sugarcane plantation area ($ASCPE_t$)					
Intercept	-95000	0.0800	-	-	
$PRSWS_t$	4.250000	0.0150	0.4200	0.8500	real price sugar at farm level
$PRWF_t$	-0.65000	0.5200	-0.0500	-0.1100	real price of paddy
$PRFRZ_t$	-0.75000	0.7800	-0.0200	-0.0400	real price of fertilizer
$TSFAC_t$	3200.000	0.0080	1.7000	3.6000	number of sugar mills
$IRRIBI_{t-1}$	-750.000	0.0900	-0.0350	-0.0800	real investment interest rate
$ASCPE_{t-1}$	0.580000	0.0050	-	-	
Prob>|F| : 0.0001	R^2 : 0.8703	Dw : 2.1028	Dh : -0.5011		
Smallholders sugarcane plantation area ($ASCSH_t$)					
Intercept	-60000	0.7200	-	-	
$PRSF_t$	1.800000	0.3000	0.0700	0.1000	real farmgate sugar price
$PRWF_t$	-2.80000	0.4000	-0.1200	-0.1700	real price of paddy
$PRFRZ_t$	-2.50000	0.5500	-0.0450	-0.0700	real price of fertilizer
$TSFAC_t$	5000.000	0.1500	1.3000	1.8000	number of sugar mills
$IRRIBI_t$	-700.000	0.3500	-0.0500	-0.0800	real investment interest rate

$ASCSH_{t-1}$	0.350000	0.1500	-	-
Prob>|F| : 0.0004	R^2 : 0.7802	Dw : 2.0561	Dh : -0.4001	

Table 2 Estimates of sugar imports and real import prices in Indonesia

Variabel	Parameter Estimate	Pr > |t|	Elasticity		Description
			Short Run	Long Run	
Indonesia's sugar imports from Brazil ($MSINBZ_t$)					
Intercept	320000	0.5000	-	-	
$PRMSIN_t$	-450.000	0.1500	-0.0150	-0.0400	real price sugar imports
$TMSIN_t$	-18000.0	0.0500	-0.7000	-2.0000	Indonesia's sugar imports tariff
$RERIN_t$	-350000	0.3000	-0.1200	-0.3000	Rupiah's interest rate
$DSIN_t$	0.200000	0.0100	1.3000	3.5000	Indonesia's sugar demand
$MSINBZ_{t-1}$	0.450000	0.1000	-	-	
Prob>|F| : 0.0014	R^2 : 0.6027	Dw : 1.4541	Dh : 1.5007		
Indonesia's sugar imports from Thailand ($MSINTH_t$)					
Intercept	1400000	0.1500	-	-	
$PRMSIN_t$	-850.000	0.1200	-0.0200	-0.1800	real price sugar imports
$TMSIN_t$	-25000.0	0.0400	-0.7000	-7.0000	Indonesia's sugar imports tariff
$RERIN_{t-1}$	-50000.0	0.1500	-0.5000	-5.2000	Rupiah's interest rate
$DSIN_t$	0.180000	0.0300	0.8000	7.5000	Indonesia's sugar demand
$MSINTH_{t-1}$	0.800000	0.0010	-	-	
Prob>|F| : 0.0001	R^2 : 0.8007	Dw : 2.5126	Dh : -2.0089		
Indonesia's sugar imports from Australia ($MSINAU_t$)					
Intercept	380000	0.5500	-	-	
$PRMSIN_t$	-300.000	0.4000	-0.0100	-0.0300	real price sugar imports
$TMSIN_t$	-9000.0	0.3000	-0.3500	-1.0000	Indonesia's sugar imports tariff
$RERIN_{t-1}$	-20000.0	0.5000	-0.3000	-0.8000	Rupiah's interest rate
$DSIN_t$	0.100000	0.1200	0.7000	1.9000	Indonesia's sugar demand
$MSINAU_{t-1}$	0.650000	0.0100	-	-	
Prob>|F| : 0.0009	R^2 : 0.6524	Dw :	Dh : 0.3088		
Indonesian real imports price ($PRMSIN_t$)					
Intercept	110.000	0.0500	-	-	
PRSWt	0.750000	0.0500	0.0500	0.2500	world sugar price
MSINt	0.000050	0.4000	0.0200	0.1000	Indonesia's total sugar imports
PRMSINt-1	0.720000	<0.0001	-	-	
Prob>|F| : <.0001	R^2 : 0.9202	Dw : 1.6122	Dh : 1.1002		

Indonesia's sugar imports originate primarily from Brazil, Thailand, and Australia. Table 2 presents the estimation results and the factors influencing sugar imports and the real import price of sugar in Indonesia. Sugar imports from Brazil ($MSINBZ_t$) are influenced by changes in the real import price of sugar ($PRMSIN_t$), import tariffs ($TMSIN_t$), the rupiah exchange rate ($RERIN_t$), domestic sugar demand ($DSIN_t$), and past imports ($MSINBZ_{t-1}$). Similarly, sugar imports from Thailand ($MSINTH_t$) are affected by changes in the real import price, import tariffs, lagged exchange rate, domestic demand, and past imports. Sugar imports from Australia ($MSINAU_t$) are determined by the same set of variables, namely changes in real import prices, tariffs, lagged exchange rate, domestic demand, and previous import levels. Meanwhile, the real import price of sugar ($PRMSIN_t$) is influenced by changes in the real world sugar price, total sugar imports, and its own lagged value. The estimation results show that sugar imports from Brazil are highly responsive to domestic sugar demand, both in the short and long run. A percent increase in sugar demand leads to an increase in imports from Brazil of 1.30 percent in the short run and 3.50 percent in the long run, indicating elastic behavior. In addition, import tariffs have a significant negative effect, with elasticities of -0.70 in the short run and negatif 2.00 in the long run, suggesting that higher tariffs can substantially reduce imports from Brazil. For imports from Thailand, domestic sugar demand also has a positive and significant effect, with elasticities of 0.80 in the short run and 7.50 in the long run, indicating a very elastic long-run response. Import tariffs again show a significant negative effect, particularly in the long run with an elasticity of negatif 7.00. The exchange rate also has a negative influence, implying that depreciation of the rupiah reduces import volumes. In the case of imports from Australia, domestic sugar demand positively affects import volume, with elasticities of 0.70 in the short run and 1.90 in the long run, although the effect is not statistically significant. Other variables such as import prices, tariffs, and exchange rates also show negative relationships but are generally not significant. Overall, domestic sugar demand emerges as the most consistent driver of Indonesia's sugar imports across all source countries, with particularly strong and elastic effects in the long run. At the same time, import tariffs play an important role in controlling import volumes, especially for imports from Brazil and Thailand. The real import price of sugar is mainly influenced by world sugar price transmission and its own past values, indicating a strong persistence in import price dynamics.

The S1 scenario, which simulates a 20 percent increase in fertilizer subsidies, represents a government policy aimed at improving agricultural productivity by ensuring better access to fertilizers at more affordable prices for sugarcane farmers. The simulation results in Table 3 indicate that this policy leads to an expansion of the total sugarcane plantation area in Indonesia by 0.45 percent. The increase occurs across all ownership types, with the largest expansion in private plantations 1.20 percent, followed by smallholder plantations 0.15 percent and state-owned plantations 0.12 percent. The expansion in plantation area is accompanied by improvements in productivity, although the increases are relatively modest. Productivity rises by 0.02 percent in state-owned plantations, 0.03 percent in private plantations, and 0.01 percent in smallholder plantations. As a result, total Indonesian granulated sugar production increases by 0.50 percent, with the largest contribution from private plantations 1.10 percent, followed by smallholders 0.18 percent and state-owned plantations 0.15 percent. Overall, total sugar production increases by 0.30 percent. On the demand side, the increase in production and supply leads to a significant rise in total sugar supply 6.50 percent, which contributes to a decline in domestic sugar prices. The real farm-gate price decreases sharply by 18.00 percent, while wholesale and retail prices decline by 12.00 percent and 14.00 percent, respectively. Lower prices stimulate domestic demand, with household demand increasing by 0.60 percent and demand from the food and beverage industry rising by 1.20 percent, resulting in an overall increase in total sugar demand of 0.90 percent. However, the substantial increase in supply also leads to a strong rise in sugar imports. Imports from Brazil increase by 20.00 percent, from Thailand by 25.00 percent, and from Australia by 18.00 percent, resulting in a total increase in Indonesia's sugar imports of 21.00 percent. In addition, the real price of imported sugar rises by 4.00 percent, and the total value of sugar imports increases significantly by 24.00 percent. Overall, the fertilizer subsidy policy under scenario S1 generates positive impacts on production, plantation area, and productivity, while lowering domestic prices and stimulating demand. However, it also leads to a substantial increase in import dependency, indicating that domestic production growth is still insufficient to fully meet the rising demand.

The S2 scenario, which simulates a 15 percent increase in the real farm-gate price of sugar, reflects a government policy aimed at improving farmers' welfare by adjusting the purchasing price of sugarcane. The simulation results in Table 3 show that this policy has a relatively limited impact on the expansion of sugarcane plantation area. In fact, smallholder plantation area increases only slightly by 0.05 percent, while state-owned plantations increase by 0.08 percent and private plantations decrease by 0.50 percent, resulting in a modest overall increase in total plantation area of 0.18 percent. In terms of productivity, the impact is also relatively small, with increases of 0.02 percent in state-owned plantations, 0.02 percent in private plantations, and only 0.005 percent in smallholder plantations. Consequently, total Indonesian granulated sugar production rises by only 0.20 percent, with smallholder production increasing by 0.06 percent and state-owned production by 0.10 percent, while private production declines by 0.45 percent. The increase in farm-gate prices is transmitted to domestic markets, leading to higher sugar prices at all levels. The real price of sugar for farmers increases by 12.00 percent, followed by increases in wholesale prices 8.00 percent

and retail prices 9.00 percent. As a result of higher domestic prices, sugar demand also rises, with household demand increasing by 0.20 percent and demand from the food and beverage industry increasing more substantially by 1.80 percent, leading to an overall increase in total sugar demand of 1.00 percent. The rise in domestic demand contributes to an increase in sugar imports. Imports from Brazil increase by 3.00 percent, from Thailand by 2.50 percent, and from Australia by 2.00 percent, resulting in a total increase in Indonesia's sugar imports of 2.50 percent. However, the total value of sugar imports slightly declines by 1.50 percent, indicating an adjustment in import prices or composition. Additionally, the real price of imported sugar increases by 3.50 percent. Overall, the policy of increasing the real farm-gate price of sugar provides positive incentives for farmers but generates mixed impacts on the sugar industry. While it raises domestic prices and stimulates demand, it also leads to higher import dependency and only marginal improvements in domestic production performance. The impacts of Scenario S2 show many similarities with previous findings (Rachman et al., 2019a ; Rachman et al, 2019b).

The implementation of the revitalization policy under scenario S3, which involves the addition of 10 sugar mills and an 18% increase in cultivated area, is aimed at strengthening the domestic sugar industry in Indonesia. The simulation results in Table 3 show that this policy increases the total sugarcane plantation area by 0.55 percent. The expansion occurs across all ownership types, with the largest increase in smallholder plantations 0.65 percent, followed by state-owned plantations 0.60 percent and private plantations 0.25 percent. The increase in plantation area is accompanied by improvements in productivity, particularly in state-owned plantations 0.18 percent and smallholder plantations 0.06 percent, while private plantations experience only a marginal increase 0.01 percent. As a result, total Indonesian granulated sugar production rises by 0.60 percent, with the largest contribution coming from state-owned production 0.80 percent and smallholder production 0.70 percent, while private production increases more modestly 0.22 percent. Overall, total sugar production in Indonesia increases by 0.35 percent.

Table 3. Summary of the simulation results on the impact of domestic policy on the Indonesian sugar industry for the period 2010 - 2025

Endogenous variables	Base Value	Δ%		
		S1	S2	S3
Area of state-owned (Hectare)	91243	0.12	0.08	0.60
Area of private-owned (Hectare)	142419	1.20	-0.50	0.25
Area of smallholder (Hectare)	269888	0.15	0.05	0.65
Total area of sugarcane plantations in Indonesia (Hectare)	491213	0.45	0.18	0.55
Productivity of state-owned sugarcane (Tonne/Hectare)	4.50	0.02	0.02	0.18
Productivity of private-owned sugarcane (Tonne/Hectare)	6.80	0.03	0.02	0.01
Productivity of smallholder sugarcane (Tonne/Hectare)	6.20	0.01	0.01	0.06
State granulated sugar production (Tonnes)	405000	0.15	0.10	0.80
Private granulated sugar production (Tonnes)	950000	1.10	-0.45	0.22
Smallholder granulated sugar production (Tonnes)	1600000	0.18	0.06	0.70
Total Indonesian granulated sugar production (Tonnes)	2950000	0.50	0.20	0.60
Total Indonesia's sugar production (Tonnes)	5200000	0.30	0.12	0.35
Household demand (Tonnes)	3100000	0.60	0.20	0.03
F&B demand (Tonnes)	3200000	1.20	1.80	0.10
Total sugar demand Indonesia (Tonnes)	6300000	0.90	1.00	0.07
Total sugar supply Indonesia (Tonnes)	9000000	6.50	0.70	0.20
Real price of sugar for farmers (Rp/Kg)	10500	-18.00	12.00	1.20
Real price of retail (Rp/Kg)	13000	-14.00	9.00	0.80
Real price of wholesale (Rp/Kg)	15000	-12.00	8.00	0.60
Sugar imports from Brazil (Tonnes)	1200000	20.00	3.00	-0.10
Sugar imports from Thailand (Tonnes)	1800000	25.00	2.50	-0.05
Sugar imports from Australia (Tonnes)	800000	18.00	2.00	-0.05
Total sugar imports by Indonesia (Tonnes)	3812799	21.00	2.50	-0.05
Value of Indonesia's sugar imports (US$)	1915900455	24.00	-1.50	-0.05

Note:
S1 : Simulation of the impact policy to increase fertiliser subsidies by 20%
S2 : Simulation of the impact policy to increase the farmgate price of sugar by 15%
S3 : Simukation of the impact implementing a revitalisation programme involving the addition of 10 factories and an 18% increase in cultivatived area.

On the demand side, the policy leads to a slight increase in domestic sugar demand. Household demand rises by 0.03 percent, while demand from the food and beverage industry increases by 0.10 percent, resulting in a total demand increase of 0.07 percent. At the same time, total sugar supply increases by 0.20 percent, reflecting improved production capacity. The increase in supply contributes to a decline in domestic sugar prices. The real farm-gate sugar price decreases slightly by 1.20 percent, while wholesale and retail prices decline by 0.60 percent and 0.80 percent, respectively. Lower domestic prices reduce Indonesia's reliance on sugar imports, as imports from Brazil decrease by 0.10 percent, while imports from Thailand and Australia each decline by 0.05 percent. Consequently, total sugar imports decrease by 0.05 percent, along with a slight reduction in the real import price and the total value of sugar imports. Overall, the revitalization policy under scenario S3 generates positive impacts on the Indonesian sugar industry by increasing plantation area, productivity, and domestic production, while simultaneously reducing import dependency and stabilizing domestic prices. The results of scenario S3 are consistent with previous findings (Rachman et al., 2019). Efforts to expand sugarcane acreage and build new sugar mills should focus on improving the efficiency of sugarcane farming and sugar mills (Heryanto & Suryatmana, 2020). Some of the sugar mills in Indonesia are aging and have low productivity.

CONCLUSION

Indonesia's dependence on sugar imports is a structural problem stemming from an imbalance between the growth in production acreage and domestic demand. Although policies such as increased fertilizer subsidies, an expansion of sugar-growing acreage at the farmer level, and industrial revitalization programs have boosted the national sugar production area, productivity, and output, the magnitude of these increases has been relatively limited and has failed to keep pace with the growth rate of demand. On the other hand, sugar demand, particularly from the food and beverage industry, is growing faster than domestic production, creating a gap that continues to drive imports. Furthermore, policies regarding sugar production per hectare reveal a trade off a decrease in domestic sugar production per hectare actually increases imports, while an increase in sugar production per hectare has not been effective in reducing import dependence. Thus, the phenomenon of Indonesia being a sugarcane-producing country yet remaining a sugar importer is caused by the low responsiveness of production to policy, inefficiencies in the sugar industry, and the high domestic market demand that cannot be met by domestic production. To ensure government policies do not focus solely on short term instruments such as subsidies and price setting, but are directed toward a comprehensive structural transformation of the sugar industry. Efforts required include boosting productivity through the adoption of modern agricultural technologies, revitalizing sugar mills to enhance efficiency and yield, and strengthening integration between the upstream and downstream sectors. Additionally, more targeted policies are needed to manage demand, particularly from the food and beverage industry, to avoid complete reliance on imports. Reforming the sugar trade system, strengthening farmer institutions, and creating investment incentives in the private sector are also key to enhancing the competitiveness of the national sugar industry. With a comprehensive and sustainable approach, dependence on sugar imports can be significantly reduced.

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