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Effect of Import Policy on Beef Supply and Demand in Indonesia before and after the COVID-19 Pandemic

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ABSTRACT

Beef production in Indonesia has experienced a decline after the COVID-19 pandemic, leading to an expanding gap between the supply and demand of beef. This widening gap has resulted in an increased reliance on beef imports, which in turn impacts domestic food stability. This study examines the impact of import policies on the supply and demand of beef both before and after the COVID-19 pandemic. Utilizing secondary data related to beef production, consumption, and prices, officially released by relevant ministries or institutions, the analysis was conducted using an econometric model with a simultaneous system equation. The results show that implementing a policy to decrease beef imports while concurrently increasing imports of feeder after the pandemic can enhance beef production by 25%, surpassing levels observed before the COVID-19 pandemic. Such a policy will lead to a decrease in the national beef supply, although demand will remain unchanged during both periods. By using a simultaneous equation system approach that links the dimensions of beef production and consumption, this study offers comprehensive insights for policymakers in designing policies and programs to increase Indonesia's beef production.

Keywords: beef import; cattle; feeder import; simultaneous equation models; sustainable production

INTRODUCTION

Beef is a national strategic commodity, known as one of the nine basic necessities (sembako), because it is a protein source in high demand by the public (Agus & Widi, 2018). The demand for beef is rising, driven by increasing incomes and population growth (Bunmee *et al.*, 2018; Komalawati *et al.*, 2019; Myae & Goddard, 2020; BPS, 2022). It is projected that beef consumption will escalate from 2.18 kg/capita to 2.30 kg/capita within the next five years, necessitating an additional 2.2 million cattle by 2026 (FAO, 2022).

However, the bulk of Indonesia's beef production originates from small-scale farming or as a secondary business, challenging the country's ability to meet its growing demand for beef. This situation is anticipated to increase beef import (Anaking & Suryani, 2020), potentially leading to a long-term dependency on imported beef and exacerbating domestic cattle scarcity (Kusriatmi *et al.*, 2014; Mumba *et al.*, 2017). However, if imports dominate the fulfilment of national beef demand, it will disrupt the sustainability of the domestic cattle farming business. Although beef production in Indonesia saw an upward trend from 2010 to 2021, its growth was slower than its consumption (BPS, 2020; BPS, 2022). The gap between Indonesia's beef production and consumption has been widening annually, worsening during the COVID-19 pandemic when beef production in Indonesia declined, specifically in 2020 (BPS, 2022).

Since the onset of the COVID-19 pandemic in March 2020, Indonesian government has imposed a Large-Scale Social Restrictions (PSBB) policy. At the beginning of the implementation of this policy, there was a decrease in the development of product distribution, consumption, and production, which was marked by a 5.32% decrease in Gross Domestic Product (GDP) growth in the second quarter of 2020 compared to the second quarter of 2019. This is evidenced by a decrease in the distribution of imported beef, where the amount of imported beef from India decreased to 17.6 thousand tones (a decrease of 81.26%) in 2020 from 93.9 thousand tonnes in 2019. The global beef cattle industry, including major beef-producing countries, such as America, faced significant problems during the COVID-19 pandemic, both in terms of supply and demand for cattle and beef (Martinez *et al.*, 2021). Furthermore, the COVID-19 pandemic led to a decrease in purchasing power and

demand for beef, reduced profitability, increased production costs, disruption in distribution and marketing, and a downturn in business (Mayu *et al.,* 2023), resulting in the decreased meat production (Ijaz *et al.*, 2021; Islam *et al.,* 2022; Rahman *et al.*, 2022; Whitehead & Brad Kim, 2022). This affected production sustainability and economic losses (Rahman *et al.,* 2022). The COVID-19 pandemic also led to a decline in Indonesia's livestock GDP, which is thought to have had an impact on the decline in domestic beef cattle production in the long term (Ilham & Haryanto, 2020).

Given this context, the reliance on beef imports to bridge the gap between domestic beef production and consumption threatens food stability. In general, the fulfilment of the national beef demand comes mainly from local cattle, whereas the rest comes from imported feeders and beef. The Indonesian Central Statistics Agency (BPS) data show that domestic beef production in 2021 was only 486,552 tones against a total demand of 685,850 tones (BPS, 2022). Therefore, 29.06% of beef imports are required to fulfill this demand.

Over time, Indonesia's beef imports have shown an increasing trend, though the number of breeders and feeder imports have fluctuated over the years. Between 2010 and 2021, beef and feeder imports averaged growth rates of 3.49% and 18.11% per year, respectively (BPS, 2020; BPS, 2022). The Indonesian government has implemented an import tariff policy for restrictions, as stipulated in Minister of Finance Regulation No. 26/2022, on establishing a goods classification system and import duty tariffs on imported goods. However, the import tariff policy only applies to beef, namely five percent, whereas feeder and breed cattle are not subject to import tariffs.

One of the nation's developmental efforts, especially in agriculture, is to increase beef production to fulfill the increasing demand for beef in Indonesia. The government conducts several national programs to support domestic beef production, including the *Sikomandan* program (*Sapi Kerbau Komoditas Andalan Negeri*) and the feed bank program (Ministry of Agriculture, 2020). Both programs are expected to accelerate the increase in cattle production in Indonesia and gradually reduce the dependence on imports. With these two programs, it is hoped that an increase in the number of Indonesian beef cattle breeders will accelerate the production of domestic beef cattle. This is important because domestic beef production plays an important role in the national economy and food security.

Several studies on beef supply-demand models have been conducted in Indonesia and other countries. For instance, empirical studies in Indonesia (Kusriatmi *et al.,* 2014; Ekowati *et al.,* 2016; Maruli *et al.,* 2017; Komalawati *et al.,* 2019; Maruli *et al.,* 2020; Kusumaningrum *et al.,* 2021; Danasari *et al.,* 2023), Malaysia (Buda & Mohamed, 2021), and Tanzania (Kibona *et al.,* 2022). While numerous studies have explored the impact of import policies on beef supply and demand, there has been a notable lack of focus on the effects of these policies in the aftermath of the COVID-19 pandemic in Indonesia. Therefore, this study aimed to analyze the impact of import policies on beef supply and demand in Indonesia after the COVID-19 pandemic. This study used simultaneous equation modeling to holistically determine the effects of import policies on beef supply and demand. Other parameters describe the behavior of the factors that determine the supply and demand of beef products in the model.

METHODS

This research employs quantitative methodologies, utilizing an econometric model with simultaneous equations for analysis. The study utilizes annual secondary time-series data for the period 1990–2021. These data were obtained from various sources, such as the Directorate General of Animal Husbandry and Animal Health of the Ministry of Agriculture, the Indonesian Central Statistics Agency (BPS), the Indonesian Central Bank, FAO, the Directorate General of Customs and Excise, and the Ministry of Finance, as well as various studies related to this research. These data were used to develop a simultaneous equation model. Quantitative variables in Indonesia rupiah (IDR) were modeled using the national Consumer Price Index (CPI) with 2010 as the base year, and United State Dollar (USD) variables were modeled using the CPI of the country of origin of imports with a base year of 2010.

The model specifications formulated in this study were closely related to the research objective of developing a model of Indonesian beef supply and demand before and after the COVID-19 period to accelerate the increase in domestic beef production, cattle production, and beef supply. The analysis was divided into two periods: before and after the COVID-19. The data used for the periods before and after COVID-19 are the years 1990–2019 and 2020–2021, respectively. The beef supply and demand equation models after the COVID-19 pandemic were analyzed using the two-stage least square (2SLS) method and SAS/ETS 9.4 software. The detailed beef supply and-demand model is as follows:

$$PTSD_t = a_0 + a_1POPS_t + a_2IMBT_{t-2} + a_3RIB_{t-1} + a_4CH_{t-1} + a_5SB_t + a_6D1_t + u_1 \quad (1)$$

$$POPS_t = b_0 + b_1PTSD_t + b_2TISI_t + b_3TPDS_t + b_4JPS_t + b_5POPS_{t-1} + u_2 \quad (2)$$

$$TISI_t = IMSB_t + IMBT_t \quad (3)$$

$$IMSB_t = c_0 + c_1HSBIR_t + c_2PTSD_t + c_3JWM_t + c_4HTSDR_t + c_5QDSI_t + c_6NTR_t + c_7IMSB_{t-1} + u_3 \quad (4)$$

$$QSDS_t = TPDS_t + IMDS_t - EXDS_t \quad (5)$$

$$TPDS_t = PDSD_t + PDTI_t \quad (6)$$

$$PDTI_t = K_2 * IMDB_t \quad (7)$$

$$PDSD_t = d_0 + d_1HDSDR_{t-1} + d_2TIDS_t + d_3PTSD_{t-2} + d_4D1_t + d_5PDSD_{t-1} + u_4 \quad (8)$$

$$IMDS_t = e_0 + e_1HDSIR_t + e_2NTR_t + e_3PDSD_t + e_4QDSI_t + e_5IMDS_{t-1} + u+ \quad (9)$$

$$IMDB_t = K_1 * IMSB_t \quad (10)$$

$$TIDS_t = IMDS_t + IMDB_t \quad (11)$$

$$QDSI_t = f_0 + f_1HDSDR1_t + f_2HDAR1_t + f_3HTAR_t + f_4PMP_t + f_5QDSI_{t-1} + u_6 \quad (12)$$

$$HDSDR_t = g_0 + g_1HDSJR_t + g_2HDSIR_t + g_3TW_t + g_4HDSDR_{t-1} + u_7 \quad (13)$$

$$HDSIR_t = h_0 + h_1HRSAR_t + h_2HDDR1_t + h_3TIM1_t + h_4HDSIR_{t-1} + u_8 \quad (14)$$

$$HTSDR_t = i_0 + i_1 HSBIR_t + i_2 PTSD1_t + i_3 LPOPS1_t + i_4 HTSDR_{t-1} + u_9 \quad (15)$$

Where, a_1, a_2, a_3, $a_4 > 0$; a_5, $a_6 < 0$; b_1, $b_2 > 0$; b_3, $b_4 < 0$; $0 < b_5 < 1$; c_1, c_2, $c_6 < 0$; c_3, c_4, $c_5 > 0$; $0 < c_7 < 1$; d_1, $d_3 > 0$; d_2, $d_4 < 0$; $0 < d_5 < 1$; e_4, > 0; e_1, e_2, $e_3 < 0$; $0 < e_5 < 1$; $f_1 < 0$; f_2, f_3, f_4, > 0; $0 < f_5 < 1$; g_1, g_2, $g_3 > 0$; $0 < g_4 < 1$; h_1, h_2, $h_3 > 0$; $0 < h_4 < 1$; $i_1 > 0$; i_2, $i_3 < 0$; and $0 < i_4 < 1$ is the estimated coefficient, and u_1-u_9 is the error. Descriptions of the endogenous and exogenous variables from the supply and demand of beef models in Indonesia are presented in Table 1.

Next, the model validation test aimed to measure the performance of the model in predicting data that had never been observed before as a basis for simulations. Model validation was performed using the Root Means Squares Percent Error (RMSPE), and Theil's Inequality Coefficient (U) (Sitepu & Sinaga, 2018). The RMSPE statistic is used to measure how far the estimated value of endogenous variables deviates from the flow of their actual values in relative size (percentage) or how closely the estimated values follow the development of their actual values. The U-statistic value is useful for determining the ability of the model to forecast simulation analysis. The criteria were formulated as follows:

$$RMSPE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}\left(\frac{Y_t^s - Y_t^a}{T_t^a}\right)^2}$$

$$U = \frac{\sqrt{\frac{1}{n}\sum_{t=1}^{n}(Y_t^s - Y_t^a)^2}}{\sqrt{\sqrt{\frac{1}{n}\sum_{t=1}^{n}(Y_t^s)^2} + \sqrt{\frac{1}{n}\sum_{t=1}^{n}(Y_t^a)^2}}}$$

Where Y_t^s is the base simulation result of the observation variable, Y_t^a is the actual value of the observation variable, and n is the number of observation periods. The import policies in this study included beef import policy, feeder cattle import policy, and import tariffs. The impact of import policies on beef supply and demand in Indonesia is tested using a valid model.

RESULTS

Determining the Beef Supply and Demand in Indonesia

The parameters for estimating the determinants of beef supply and demand are listed in Table 2. Beef supply is calculated as the sum of domestic beef production and beef imports, minus beef exports. The results showed that beef production is significantly influenced by domestic beef prices and cattle production from two years earlier, with a coefficient of determination (R^2) of 0.9024, indicating that the variation in explanatory variables can predict the variation in beef production by 90.24%. Meanwhile, domestic cattle production is influenced by factors such as the national cattle population, breed imports, realization of Artificial Insemination (AI) technology, rainfall, and interest rates, with a coefficient of determination (R^2) of 0.8010. The parameter signs of the explanatory variable parameter estimates correspond to the theoretically expected signs.

The national cattle population emerges as a crucial factor in determining beef production behavior in Indonesia. Table 2 shows that domestic cattle production and total cattle imports influence the national cattle population. In this study, domestic beef production included beef produced from domestic cattle and imported feeder cattle fattened domestically. The coefficient of determination (R^2) of the national cattle population equation was 0.9502, indicating that the endogenous variables could be predicted very well by the explanatory variables. The estimation results underscore that total cattle imports of both breeding and feeder cattle markedly influence the national cattle population.

The factors affecting the national beef demand are shown in Table 3. People's income and the previous year's beef demand significantly influenced the national beef demand. The parameter estimation results obtained using the two-stage least squares method, exhibit a coefficient of determination (R^2) of 0.9708.

Table 4 presents parameter estimates of the factors that determine price behavior. The prices examined in this study include domestic beef, imported, and domestic cattle prices. The analysis shows that domestic beef prices are significantly influenced by prices in Jakarta and imported beef prices. Conversely, cattle prices are significantly influenced by the previous year's domestic prices. Imported beef prices are significantly affected by global beef price changes, alterations in import tariffs, and the previous year's imported beef prices. These three equations also display a high coefficient of determination (R^2). Based on the results, it can be concluded that import policy affects beef production and price behavior. Therefore, the impact of imports on the supply and demand of beef products is analyzed in a policy simulation scenario.

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The results of the validation tests, analyzed using the RMSPE and the U-Theil coefficient, are shown in Table 5. The analysis reveals that endogenous variables with RMSPE values less than 50% range 55% (1990–2021), 55% (1990–2019), and 95% (2020–2021), respectively. Equations yielding RMSPE values greater than 50% primarily originate from the identity equation, owing to errors of endogenous variables that affect each other. Most variables exhibit Theil's (U-Theil) inequality coefficients close to zero, except for domestic cattle production. Based on the validation test results, it can be concluded that the beef supply and demand model fulfil the necessary assumptions for conducting policy simulations.

Government policies can have varying impacts on each endogenous variable, either positive, negative, or neutral. The model simulation in this study was conducted using five historical policy scenarios adapted to domestic and international policies on cattle and beef

Table 1. Description of endogenous and exogenous variables from the supply and demand of beef models in Indonesia

Variables	Description	Unit
QSDS	National beef supply	Tones
PTSD	Domestic beef cattle production	000 Heads
POPS	National beef cattle population	000 Heads
TISI	Total cattle imports	Tones
IMSB	Feeder cattle imports	Tones
TPDS	Total beef production	Tones
PDTI	Additional meat production from ex-imported feeder cattle	Tones
PDSD	Domestic beef production	Tones
IMDS	Beef imports	Tones
IMDB	Meat imports in the form of feeder	Tones
TIDS	Total beef imports	Tones
QDSI	National beef demand	Tones
IHKI	Indonesia Consumer Price Index (CPI) with 2010 as the base year	Unitless
IHKA	Australia CPI with 2010 as the base year	Unitless
IHKW	America CPI with 2010 as the base year	Unitless
HDSD	Price of domestic beef	IDR/tones
HDSDR	Real price of domestic beef (HDSD/IHKI)	IDR/Tones
HDSI	Price of imported beef	IDR/tones
HDSIR	Real price of imported beef (HDSI/IHKW)	USD/tones
HTSD	Price of domestic cattle	IDR/tones
HTSDR	Real price of domestic cattle (HTSD/IHKI)	IDR/tones
HSBI	Price of imported feeder cattle	IDR/tones
HSBIR	Real price of imported feeder cattle (HSBI/IHKW)	IDR/tones
RIB	Realization of Artificial Insemination (IB)	000 Doses
CH	Rainfall	Mm
SB	Interest rate	%
D1	Dummy COVID-19	0= before COVID-19, 1= after COVID-19
NTR	Exchange rate	IDR/USD
JPS	Number of cattle slaughtered	000 Heads
JWM	Number of foreign tourists	000 People
IMBT	Imports of breeding cattle	Tones
EXDS	Beef exports	Tones
K1	Conversion of meat from imported feeder cattle (in 2020, the average weight of slaughter cattle was 487.02 kg/head, the average weight of carcass was 245.95 kg/head, and conversion of meat from the carcass was 80%)	0.4043
K2	Convert additional weight of imported feeder cattle into slaughter cattle (in 2020, the average weight of feeder was 346.34 kg/head, and the average weight of slaughter cattle was 487.02 kg/head).	0.4062
HAD	Price of chicken meat	IDR/tones
HDAR	Real price of chicken meat (HDA/IHKI)	IDR/tones
HTA	Price of chicken egg	IDR/tones
HTAR	Real price of chicken egg (HTA/IHKI)	IDR/tones
PMP	Community income	IDR/capita
HDSJ	Price of Jakarta beef	IDR/tones
HDSJR	Real price of Jakarta beef (HDSJ/IHKI)	IDR/tones
TW	Time trend	Unitless
HRSA	Price of Australian beef	USD/tones
HRSAR	Real price of Australian beef (HRSA/IHKA)	USD/tones
HDD	Price of world beef	USD/tones
HDDR	Real price of world beef (HDD/IHKW)	USD/tones
TIM	Beef import tariffs	%
HDSDR1	Changes in real price of domestic beef ($HDSDR_t$ - $HDSDR_{t-1}$)	IDR/tonnes
HDAR1	Changes in real price of chicken meat ($HDAR_t$ - $HDAR_{t-1}$)	IDR/tonnes
HDDR1	Changes in world beef prices ($HDDR_t$ - $HDDR_{t-1}$)	USD/tonnes
TIM1	Changes in beef import tariffs (TIM_t - TIM_{t-1})	%
PTSD1	Changes in domestic cattle production ($PTSD_t$ - $PTSD_{t-1}$)	000 Heads
LPOPS1	Changes in the previous year's cattle population ($POPS_{t-1}$ - $POPS_{t-2}$)	000 Heads

Table 2. Determinants of beef supply in Indonesia

Variables	Variable labels	Parameter estimate	Probability (α)	Sig.
Domestic Cattle Production in year t ($PTSD_t$): tones/year				
R^2 = 0.8010; Fcount = 15.42; Pr>F <0.0001				
Intercept		-1,414	0.159	
$POPS_t$	National cattle population in year t	0.24	0.000	***
$IMBT_{t-2}$	Import of cattle breeds in year t-2	0.08	0.318	ns
RIB_{t-1}	AI realization in year t-1	0.05	0.608	ns
CH_{t-1}	Rainfall in year t-1	0.40	0.077	*
SB_t	Interest rate in year t	-0.36	0.984	ns
D1	Dummy COVID-19	-677.41	0.044	**
National Cattle Population in year t ($POPS_t$): heads/year				
R^2 = 0.9502; Fcount = 91.49; Pr>F <0.0001				
Intercept		2,042	0.169	
$PTSD_t$	Domestic cattle production in year t	1.30	<0.0001	***
$TISI_t$	Total cattle imports in year t	0.01	0.037	**
$TPDS_t$	Total beef production in year t	-0.01	0.088	*
JPS_t	Number of cattle slaughtered in year t	-0.49	0.534	ns
$POPS_{t-1}$	National cattle population in year t-1	0.76	<0.0001	***
Imported Feeder Cattle in year t ($IMSB_t$): tones/year				
R^2 = 0.7978; Fcount = 12.40; Pr>F <0.0001				
Intercept		122,815	0.126	
$HSBIR_t$	Real price of imported feeder cattle in year t-1	-18,380	0.400	ns
$PTSD_t$	Real price of domestic cattle production in year t	-29.35	0.123	ns
JWM_t	Number of foreign tourists	5.08	0.073	*
$HTSDR_t$	Real price of domestic cattle in year t	2.16	0.142	ns
$QDSI_t$	Beef demand in year t	0.07	0.570	ns
NTR_t	Exchange rate in year t	-5.95	0.129	ns
$IMSB_{t-1}$	Imports of feeder cattle in year t-1	0.52	0.007	***
Domestic Beef Production in year t ($PDSD_t$): tones/year				
R^2 = 0.9024; Fcount = 44.38; Pr>F <0.0001				
Intercept		712.51	0.985	
$HDSDR_{t-1}$	Real price of domestic beef in year t-1	2.89	0.002	***
$TIDS_t$	Total beef imports in year t	-0.06	0.585	ns
$PTSD_{t-2}$	Domestic cattle production in year t-2	32.36	0.004	***
D1	Dummy COVID-19	-56,91	0.017	**
$PDSD_{t-1}$	Domestic beef production in year t-1	0.39	0.003	***
Beef Imports in year t ($IMDS_t$): tones/year				
R^2 = 0.9426; Fcount = 78.87; Pr>F <0.0001				
Intercept		121,077	0.002	
$HDSIR_t$	Real price of imported beef in year t	-34,195	0.001	***
NTR_t	Exchange rate in year t	-4.62	0.007	***
$PDSD_t$	Domestic beef production in year t	-0.33	0.008	***
$QDSI_t$	National beef demand in year t	0.51	<0.0001	***
$IMDS_{t-1}$	Beef import in year t-1	0.21	0.208	ns

Note: ***= highly significant (p<0.01), **= significant (0.01<0<0.05), *= significant (0.05<p<0.10), ns= non-significant (p>0.10).

imports in Indonesia. These scenarios include a 20% decrease in beef imports (Simulation 1) and a 10% decrease in feeder cattle imports (Simulation 2). The beef and feeder cattle import policy aims to meet the national beef demand according to the Indonesian Ministry of Agriculture's strategic plan for 2020-2024. Simulation 3 envisaged a 20% increase in productive female (breeder) imports following the 2016 UPSUS SIWAB (special efforts for cows to be pregnant) implementation roadmap, aiming to boost the productive female population in Indonesia. Simulation 4 involved a 5% increase in beef import tariffs to protect local farmers' price. The final scenario (Simulation 5) combined a 20% decrease in beef imports and a 20% increase in breeder imports. These policy simulation changes were made during two periods: before and after COVID-19. Table 6 presents the impact of these import policies on Indonesia's beef supply and demand across the five simulations.

The results show that the policy of reducing beef imports by 20% did not affect beef production in Indonesia before the pandemic, whereas after the pandemic, the policy increased domestic beef production by

Table 3. Determinants of beef demand in Indonesia

Variables	Variable labels	Parameter estimate	Probability (α)	Sig.
National Beef Demand in year t ($QDSI_t$): tones/year				
R^2 = 0.9708; Fcount = 159.73; Pr>F <0.0001				
Intercept		145,670	0.001	
HDSDR1	Changes in real price of domestic beef ($HDSDR_t$ - $HDSDR_{t-1}$)	-0.81	0.365	ns
HDAR1	Changes in real price of chicken meat ($HDAR_t$ - $HDAR_{t-1}$)	0.32	0.893	ns
$HTAR_t$	Real price of chicken eggs in year t	-0.32	0.643	ns
PMP_t	Community income in year t	4.40	0.001	***
$QDSI_{t-1}$	National beef demand in year t-1	0.43	0.012	**

Note: ***= highly significant (p<0.01), **= significant (0.01<0<0.05), *= significant (0.05<p<0.10), ns= non-significant (p>0.10).

Table 4. Determinants of beef price in Indonesia

Variables	Variable labels	Parameter estimate	Probability (α)	Sig.
Real Price of Domestic Beef in year t ($HDSDR_t$): IDR/tones				
R^2 = 0.8655, Fcount = 40.22; Pr>F <0.0001				
Intercept		14,984	0.135	
$HDSJR_t$	Real price of Jakarta beef in year t	0.34	0.045	**
$HDSIR_t$	Real price of imported beef in year t	4,082	0.004	***
TW	Time trend	582.26	0.029	**
$HDSDR_{t-1}$	Real price of domestic beef prices in year t	0.02	0.929	ns
Real Price of Imported Beef in year t ($HDSIR_t$)				
R^2 = 0.8416; Fcount = 33.20; Pr>F <0.0001				
Intercept		-0.05	0.905	
$HDSAR_t$	Australian beef prices	0.23	0.084	*
HDDR1	Changes in world beef prices ($HDDR_t$ - $HDDR_{t-1}$)	0.21	0.216	ns
TIM1	Changes in beef import tariffs (TIM_t - TIM_{t-1})	0.02	0.564	ns
$HDSIR_{t-1}$	Real price of imported beef in year t-1	0.70	<0.0001	***
Real Price of Domestic Cattle in year t ($HTSDR_t$)				
R^2 = 0.7129, Fcount = 15.52; Pr>F <0.0001				
Intercept		3,327	0.419	
$HSBIR_t$	Real price of imported feeder cattle in year t	1,824	0.429	ns
PTSD1	Changes in domestic cattle production ($PTSD_t$ - $PTSD_{t-1}$)	-1.55	0.388	ns
LPOPS1	Changes in the previous year's cattle population ($POPS_{t-1}$ - $POPS_{t-2}$)	-0.001	0.999	ns
$HTSDR_{t-1}$	Real price of domestic cattle prices in year t-1	0.78	<0.0001	***

Note: ***= highly significant (p<0.01), **= significant (0.01<0<0.05), *= significant (0.05<p<0.10), ns= non-significant (p>0.10).

0.14%. Import policies in Simulations 1, 2, 3, and 4 had no significant effect on domestic beef prices before and after COVID-19, and in Simulation 5 in the period after COVID-19. Meanwhile, the import policy in Simulation 5 (20% decrease in beef imports and 20% increase in breeder imports) before COVID-19 reduced domestic beef prices by 0.01%.

Furthermore, we found that a 5% increase in import tariffs increased domestic beef production by 0.01% prior to COVID-19, with no discernible impact afterward. The highest increase in domestic beef production occurred under Simulation 5, which combined a 20% reduction in beef imports with a 20% increase in breeder imports, resulting in increases of 0.12% and 0.15%, respectively. Based on the simulation results, we conclude that the policy of reducing beef imports and increasing breeder imports positively affects domestic beef production. The results also show that most parameters have theoretically expected signs.

National beef supply will decrease with the implementation of import policy Simulations 2, 3, 4, and 5 in the period before COVID-19, while in the period after COVID-19, national beef supply will decrease when import policy Simulations 1, 2, 3, and 5 are implemented. This is because Indonesia's beef imports are still relatively high at 29.06% (BPS, 2022b). However, the simulated import policy did not affect national beef demand.

DISCUSSION

The import restriction policy aims to protect domestic beef production mainly from smallholder farms. In contrast, industrial feedlot farms produce more meat from ex-imported feeder cattle, either ready for slaughter or fattened. A reduction in beef imports is expected to increase domestic beef production. By contrast, import tariff policies enacted by developing

Table 5. Validation results of the beef supply and demand model in Indonesia

Variables	1990-2021		Before COVID-19 (1990-2019)		After COVID-19 (Year 2020-2021)	
	RMSPE (%)	U-Theil	RMSPE (%)	U-Theil	RMSPE (%)	U-Theil
PTSD	92.92	0.66	95.19	0.69	51.55	0.35
POPS	15.49	0.08	15.76	0.08	11.01	0.06
IMSB	345.5	0.23	357.5	0.23	39.06	0.17
PDSD	42.83	0.25	43.83	0.26	25.03	0.14
IMDS	480.3	0.29	497.1	0.33	30.34	0.12
QDSI	7.87	0.03	7.94	0.03	6.77	0.03
HDSDR	7.86	0.03	7.98	0.03	5.91	0.03
HDSIR	11.43	0.05	11.52	0.05	10.12	0.05
HTSDR	37.71	0.09	38.99	0.09	6.92	0.04
IMDB	345.5	0.23	357.5	0.23	39.06	0.17
PDTI	345.5	0.23	357.5	0.23	39.06	0.17
TPDS	38.28	0.22	39.18	0.23	22.05	0.12
TIDS	324.8	0.27	336.1	0.29	32.61	0.13
QSDS	15.96	0.08	16.37	0.08	8.32	0.04
TISI	268.2	0.23	277.4	0.23	38.94	0.17

Note: PTSD= Domestic cattle production, HTSDR= Real price of domestic cattle, POPS= National cattle population, IMDB= Meat imports in the form of feeder, IMSB= Feeder cattle imports, PDSD= Domestic beef production, PDTI= Additional meat production from ex-imported feeder cattle, IMDS= Beef imports, TPDS= Total beef production, QDSI= National beef demand, TIDS= Total beef imports, HDSDR= Real price of domestic beef, QSDS= National beef demand, HDSIR= Real price of imported beef, TISI= Total cattle imports, RMSPE= Root means squares percent error, and U-Theil= Theil's inequality coefficient.

Table 6. Impact of import policy on Indonesian beef supply and demand

Variables	Before COVID-19						After COVID-19					
	Initial average	Simulation change (%)					Initial average	Simulation change (%)				
		S1	S2	S3	S4	S5		S1	S2	S3	S4	S5
PTSD	298	0.00	-0.07	14.76	9.96	11.27	1,684	-0.05	-0.92	1.08	0.00	1.03
POPS	10,921	0.00	-0.01	1.67	0.31	0.10	15,814	-0.02	-0.41	0.14	0.00	0.11
IMSB	189,680	0.00	0.003	-0.68	-0.46	-3.58	198,311	0.01	-4.69	-0.27	0.00	-0.26
PDSD	234,185	0.00	0.04	0.02	0.01	0.12	334,071	0.14	0.07	0.004	0.00	0.15
IMDS	102,392	0.00	-1.61	-0.01	-0.01	-1.64	231,004	-3.31	-0.03	-0.002	0.00	-3.31
QDSI	394,641	0.00	0.00	0.00	0.00	0.00	680,376	0.00	0.00	0.00	0.00	0.00
HDSDR	59,430	0.00	0.00	0.00	0.00	-0.01	76,160	0.00	0.00	0.00	0.00	0.00
HDSIR	2.88	0.00	0.00	0.00	0.00	-0.02	3.25	0.00	0.00	0.00	0.00	0.00
HTSDR	26,801	0.00	0.00	0.00	0.00	0.00	38,333	0.00	0.00	0.00	0.00	0.00
IMDB	75,872	0.00	0.003	-0.68	-0.46	-3.58	79,325	0.01	-4.69	-0.27	0.00	-0.26
PDTI	30,819	0.00	0.003	-0.68	-0.46	-3.58	32,222	0.01	-4.69	-0.27	0.00	-0.26
TPDS	265,005	0.00	0.04	-0.07	-0.05	-0.31	366,292	0.13	-0.35	-0.02	0.00	0.11
TIDS	178,264	0.00	-0.93	-0.30	-0.12	-2.47	310,328	-2.46	-1.23	-0.07	0.00	-2.53
QSDS	443,240	0.00	-0.35	-0.16	-0.11	-1.18	676,621	-1.06	-0.75	-0.04	0.00	-1.10
TISI	190,843	0.00	0.003	-0.68	-0.46	-3.50	198,552	0.01	-4.69	-0.26	0.00	-0.24

Note: PTSD= Domestic cattle production, HTSDR= Real price of domestic cattle, POPS= National cattle population, IMDB= Meat imports in the form of feeder, IMSB= Feeder cattle imports, PDTI= Additional meat production from ex-imported feeder cattle, PDSD= Domestic beef production, TPDS= Total beef production, IMDS= Beef imports, TIDS= Total beef imports, QDSI= National beef demand, QSDS= National beef demand, HDSDR= Real price of domestic beef, TISI= Total cattle imports, HDSIR= Real price of imported beef. S1= Simulation 1, a 20% decrease in beef imports; S2= Simulation 2, a 10% decrease in feeder cattle imports; S3= Simulation 3, a 20% increase in productive female (breeder) imports; S4= Simulation 4, a 5% increase in beef import tariffs; and S5= Simulation 5, combined a 20% decrease in beef imports and a 20% increase in breeder imports.

countries as trade barriers aim to protect farmers by likely increasing import prices.

From this study, five important findings can enhance domestic beef production and elucidate the role of import policy. First, based on the empirical data, the results show that domestic beef prices in the previous year, domestic cattle production over the last two years, and domestic beef production in the previous year significantly influence domestic beef production. These results follow previous research which states that domestic beef prices and domestic cattle production are determinants of beef production (Ashfield *et al.*, 2013; Kusriatmi *et al.*, 2014; Bunmee *et al.*, 2018; Diakité *et al.*, 2019; Addis *et al.*, 2021; Kusumaningrum *et al.*, 2021; Lindawati *et al.*, 2021; Addis *et al.*, 2023).

Second, domestic beef prices determine the beef supply and demand. The empirical results showed that domestic beef prices significantly affect domestic

beef production. However, an increase in the current year's price over the last year can dampen national beef demand. In other words, changes in domestic beef prices have a positive effect on producers but a negative effect on consumers. Changes in import tariff policies increase the price of imported beef through the payment of import taxes (Salvatore, 2013). This increases the price of beef in the domestic market in response to an increase in the price of imported beef under an import tariff policy. This is consistent with the results of research conducted by Kusriatmi *et al.* (2014), Komalawati *et al.* (2019), and Kusumaningrum *et al.* (2021).

Third, the real price of domestic beef is influenced by several factors: the Jakarta beef price, imported beef price, and the previous year's beef price. Jakarta and imported beef prices positively and significantly influenced domestic beef prices at the 5% level ($p<0.05$). Moreover, Indonesia is a net importer and price taker in the beef trade, meaning that Indonesia's domestic beef prices will only follow the movement of imported beef prices, which are influenced by global beef prices. This is in line with a study conducted by Zainuddin *et al*. (2015), who demonstrated that the integration of beef prices in domestic and global markets in the long- and short-term has implications for the stability of Indonesian beef prices.

Fourth, based on the empirical findings (Table 3), the national beef demand significantly affected people's income and national beef demand in the previous year. Increasing income will increase the national beef demand (Komalawati *et al.,* 2019). As the national beef demand rises, beef imports increase. Domestic beef production cannot fulfill national beef consumption (Anaking & Suryani, 2020). In addition, beef imports are significantly affected by imported beef prices, exchange rates, domestic beef production, and beef imports in the previous year. All parameter coefficients have theoretically expected signs: negative signs for imported beef prices, exchange rates, and domestic beef production, and positive signs for national beef demand and the previous year's beef imports. According to Kusriatmi *et al.* (2014), a decrease in imported beef prices significantly increased beef consumption. Furthermore, Komalawati *et al.* (2019), Buda & Mohamed (2021), and Danasari *et al.* (2023) state that beef consumption increases along with the decreased imported beef prices.

The simulation results show that import policy determines beef production in Indonesia. Based on these findings (Table 6), import policies can increase domestic beef production and decrease domestic beef prices. Therefore, import policies positively affect cattle and beef production. The expected sign of the beef import coefficient was negative. The policy of reducing beef imports by 20% (S1) did not affect domestic cattle production (fixed) before the COVID-19 pandemic. This reduces domestic cattle production after the pandemic. Similarly, domestic beef production, domestic beef prices, and national beef demand and supply in the period before the pandemic did not change, whereas there were changes in domestic cattle production, domestic beef production, and national beef supply in the period after the pandemic.

Beef production in Indonesia includes both domestic and imported beef. Lagged variables influence domestic beef production. This implies that domestic beef production has a relatively slow grace period to readjust to its equilibrium level in response to changes in the economic situation. In line with Marsh (1994), the production response in livestock businesses, such as cattle, requires a relatively longer time owing to biological factors. In the mathematical equation for domestic beef production, the impact of the pandemic is observed through policy dummies that negatively impact domestic beef production. This is also the case in the American beef cattle industry, where the supply of cattle and beef has decreased owing to the COVID-19 pandemic (Martinez *et al.,* 2021). According to Ilham & Haryanto (2020), the COVID-19 pandemic reduced consumer purchasing power due to the PSBB policy's implementation, which ultimately resulted in a decrease in beef production. This is in line with the results of studies conducted by Ijaz *et al.* (2021) and Rahman *et al.* (2022) that COVID 19 caused a decrease in beef production. Similarly, Whitehead & Kim (2022) stated that the COVID 19 pandemic reduced beef supply in the USA and disrupted the supply chain.

Domestic beef production is expected to increase owing to the implementation of import policies, especially the increase in breeder imports. Table 6 illustrates the impact of the import policy, as indicated by the predicted increase in beef production before and after the pandemic. According to these findings, changes in import tariffs indirectly led to a decrease in beef demand as imported beef prices increased. Salvatore (2013) also states that small-country import tariff policies decrease the quantity demanded. A policy to reduce feeder cattle imports by 10% (S2) will reduce domestic cattle production and national beef supply. However, domestic beef production is expected to increase before and after the pandemic.

Import tariffs reduce the quantity of imports and protect domestic production in small countries (Salvatore, 2013; Shagdar & Nyamdaa, 2017). Based on the empirical results, the estimated coefficient of import tariffs on imported beef prices has the theoretically expected sign, and importers pay higher prices because tax payments are imposed on importers by the import tariff policy (Salvatore, 2013). The sign of the predicted imported and domestic beef prices is zero in the periods before and after the pandemic, meaning that the import tariff policy does not affect prices but encourages an increase in domestic cattle production (Table 6).

Based on the empirical and simulation results, import policies are important in determining beef cattle and beef production in Indonesia. Therefore, import policies are important to protect Indonesian farmers. Through an import policy, domestic beef can compete with imported beef. To increase beef supply in the long term, an import policy needs to be supported by an increase in the beef cattle population in the long term. To increase the beef cattle population, productive females (cows) must be maintained and increased in number. It is recommended that the government accelerate the increase in cattle population, maintain stable beef prices,

regulate and supervise distribution, and strengthen good beef cattle farming practices for farmers.

CONCLUSION

Import policy is a determining factor in increasing beef cattle and beef production in Indonesia. As a sustainable production-driving policy, increasing breeder imports positively affected cattle and beef production before and after the pandemic. However, the policy of reducing beef and feeder cattle imports negatively impacted beef cattle production after the pandemic. The import policy did not impact national beef demand but reduced the national beef supply before and after COVID 19. The five simulations of import policy testing show that of all the policies tested, a reduction in beef imports coupled with an increase in feeder imports after the pandemic will increase beef production higher than before the pandemic by 25%. However, this policy will reduce the national beef supply, while demand will remain the same or remain unchanged.

CONFLICT OF INTEREST

S. Mulatsih serves as an editor of the Tropical Animal Science Journal but has no role in the decision to publish this article. The authors also confirm that there is no conflict of interest with any personal, financial, or other organizations related to the materials discussed in the manuscript.

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REFERENCES

Addis, A. H., H. T. Blair, P. R. Kenyon, S. T. Morris, & N. M. Schreurs. 2021. Optimization of profit for pasture-based beef cattle and sheep farming using linear programming: Young beef cattle production in New Zealand. Agriculture 11:849. https://doi.org/10.3390/agriculture11090849

Addis, A. H., H. T. Blair, P. R. Kenyon, S. T. Morris, N. M. Schreurs, & D. J. Garrick. 2023. Agent-based modelling to improve beef production from dairy cattle: young beef production. Agriculture 13:898. https://doi.org/10.3390/agriculture13040898

Agus, A. & T. S. M. Widi. 2018. Current situation and future prospects for beef cattle production in Indonesia - A review. Asian-Australas. J. Anim. Sci. 31:976-983. https://doi.org/10.5713/ajas.18.0233

Anaking, P. & E. Suryani. 2020. Beef supply chain analysis to improve availability and supply chain value using system dynamics methodology. IPTEK Journal Proceedings Series 6:229-234. https://doi.org/10.12962/j23546026.y2020i6.11098

Ashfield, A., P. Crosson, & M. Wallace. 2013. Simulation modelling of temperate grassland based dairy calf to beef production systems. Agric. Syst. 115:41-50. https://doi.org/10.1016/j.agsy.2012.10.001

BPS. 2020. Peternakan dalam Angka 2020. Indonesia Central Statistic Agency, Jakarta, ID.

BPS. 2022. Peternakan Dalam Angka 2022. Indonesia Central Statistic Agency, Jakarta, ID.

Buda, M. & Z. Mohamed. 2021. Impact of different importation policies scenarios on beef industry in Peninsular Malaysia. Agraris Journal Agribusiness Rural Development Research 7:24-35. https://doi.org/10.18196/agraris.v7i1.10540

Bunmee, T., N. Chaiwang, C. Kaewkot, & S. Jaturasitha. 2018. Current situation and future prospects for beef production in Thailand - A review. Asian-Australas. J. Anim. Sci. 31:968-975. https://doi.org/10.5713/ajas.18.0201

Danasari, I. F., N. M. W. Sari, D. Septiadi, & N. L. S. Supartiningsih. 2023. Dependency on beef import to support food security in Indonesia. IOP Conf. Ser. Earth Environ. Sci. 1253:012088. https://doi.org/10.1088/1755-1315/1253/1/012088

Diakité, Z. R., M. S. Corson, G. Brunschwig, R. Baumont, & C. Mosnier. 2019. Profit stability of mixed dairy and beef production systems of the mountain area of Southern Auvergne (France) in the face of price variations: Bioeconomic simulation. Agric. Syst. 171:126-134. https://doi.org/10.1016/j.agsy.2019.01.012

Ekowati, T., E. Prasetyo, & M. Handayani. 2016. The factors influencing production and economic efficiency of beef cattle farm in Grobogan Region, Central Java. J. Indones. Trop. Anim. Agric. 43:76-84. https://doi.org/10.14710/jitaa.43.1.76-84

FAO. 2022. Meat Consumption. Agricultural Output - Meat Consumption - OECD Data. https://data.oecd.org/agroutput/meat-consumption.htm. [July 11, 2022].

Ijaz, M., M. K. Yar, I. H. Badar, S. Ali, M. S. Islam, M. H. Jaspal, Z. Hayat, A. Sardar, S. Ullah, & D. Guevara-Ruiz. 2021. Meat production and supply chain under covid-19 scenario: current trends and future prospects. Front. Vet. Sci. 8:1–10. https://doi.org/10.3389/fvets.2021.660736

Ilham, N. & G. Haryanto. 2020. Dampak Pandemi COVID 19 pada Produksi dan Kapasitas Peternak. Dampak Pandemi COVID 19: Perspektif Adaptasi dan Resiliensi Sosial Ekonomi Pertanian. Hal: 193-214. Jakarta: IAARD Press.

Islam, S., M. T. Rahman, S. M. E. Rahman, & M. R. I. Khan. 2022. Impacts of covid 19 pandemic on livestock industry and food security: A review. Asian J. Agric. Biol. 3:1–12. https://doi.org/10.35495/ajab.2021.04.142

Kementan. 2020. Outlook Daging Sapi 2020. Ministry of Agriculture of Republic of Indonesia, Jakarta. http://epublikasi.setjen.pertanian.go.id/epublikasi/outlook/2020/OutlookDagingSapi2020/files/assets/basic-html/toc.html. [May 25, 2022].

Kibona, C. A., Z. Yuejie, & L. Tian. 2022. Factors that influence beef meat production in Tanzania. A Cobb-Douglas production function estimation approach. PLoS ONE 17:1-13. https://doi.org/10.1371/journal.pone.0272812

Komalawati, R. W. Asmarantaka, R. Nurmalina, & D. B. Hakim. 2019. Modeling price volatility and supply response of Beef in Indonesia. Trop. Anim. Sci. J. 42:159-166. https://doi.org/10.5398/tasj.2019.42.2.159

Kusriatmi, R. Oktaviani, Y. Syaukat, & A. Said. 2014. Analysis of the effects of beef import restrictions policy on beef self-sufficiency in Indonesia. J. ISSAAS 20:115-130.

Kusumaningrum, R., A. T. Suryana, & F. C. Hanoum. 2021. The effect of changes in beef prices on beef supply and demand in Indonesia. Enrichment Journal Management 12:374-385.

Lindawati, L., Emalisa, & S. Situmorang. 2021. Analysis of beef price determinants in North Sumatera. IOP Conf. Ser. Earth Environ. Sci. 782:1-6. https://doi.org/10.1088/1755-1315/782/2/022042

Marsh, J. M. 1994. Estimating intertemporal supply response in the fed beef market. America Journal Agricultural Economic 76:444-453. https://doi.org/10.2307/1243656

Martinez, C. C., J. G. Maples, & J. Benavidez. 2021. Beef cattle markets and covid-19. Applied Economic Perspective Policy 43:304-314. https://doi.org/10.1002/aepp.13080

Maruli, P., A. Minha, D. Adriani, & D. Susetyo. 2017. The impact of policy on imported beef from australia and production of domestic beef. Russ. J. Agric. Socioecon. Sci. 65:283-295. https://doi.org/10.18551/rjoas.2017-05.37

Maruli, P., A. Minha, D. Susetyo, & D. Adriani. 2020. Demand model of origin australia beef imports and domestic beef production. Russ. J. Agric. Socioecon. Sci. 102:29-37. https://doi.org/10.18551/rjoas.2020-06.04

Mayulu, H., E. Sawitri, & I. Tricahyadinata. 2023. The impact of covid-19 pandemic on the livestock subsector. Jurnal Sains Kesehatan 5:1-10. https://doi.org/10.25026/jsk.v5i2.1760

Mumba, C., E. Skjerve, M. Rich, & K. M. Rich. 2017. Application of system dynamics and participatory spatial group model building in animal health: A case study of East Coast Fever interventions in Lundazi and Monze districts of Zambia. PLoS ONE 12:1-21. https://doi.org/10.1371/journal.pone.0189878

Myae, A. C. & E. Goddard. 2020. Household behavior with respect to meat consumption in the presence of BSE and CWD. Canadian Journal Agricultural Economics 68:315-341. https://doi.org/10.1111/cjag.12223

Rahman, M. T., M. S. Islam, A. A. Shehata, S. Basiouni, H. M. Hafez, E. I. Azhar, A. F. Khafaga, F. Bovera, & Y. A. Attia. 2022. Influence of covid-19 on the sustainability of livestock performance and welfare on a global scale. Trop. Anim. Health Prod. 54:1-10. https://doi.org/10.1007/s11250-022-03256-x

Salvatore, D. 2013. International Economics. 11th Ed. John Wiley & Sons, Inc., New York.

Whitehead, D. & Y. H. Brad Kim. 2022. The Impact of covid 19 on the meat supply chain in the USA: A review. Food Sci. Anim. Resour. 42:762-774. https://doi.org/10.5851/kosfa.2022.e39