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CYCLICAL DYNAMICS OF BEEF MARKET PRICE IN YOGYAKARTA PROVINCE: A COBWEB MODE APPROACH

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ABSTRACT

Fluctuations in agricultural food prices, particularly for animal proteins like beef, have profound implications for Yogyakarta's beef market, imposing significant budgetary constraints on consumers, disrupting market equilibrium, and creating uncertainty for farmers. Understanding the drivers of cyclical price dynamics is critical for effective policy intervention and market regulation to mitigate these challenges. Therefore, this study specifically investigates the determinants of cyclical beef price behavior in Yogyakarta, Indonesia. Utilizing time series data from 1989 to 2018, a two-stage least squares (2SLS) approach in natural logarithm form is employed to identify the factors influencing beef demand and supply. The 2SLS method was chosen to address potential simultaneity bias arising from the interdependence of beef price and quantity, ensuring more accurate estimation of the relationships between these variables. Log-log regression model is then employed to determine market equilibrium based on Cobweb Model. Although the Cobweb Model simplifies price expectations and market complexities, its focus on cyclical dynamics and data accessibility makes it suitable for analysing cyclical price patterns in the beef market. The results revealed that beef demand is significantly influenced by price (0.203%) and per capita income (0.485%) , while supply is driven by price (0.075%), cattle population growth (0.403%), and slaughter numbers (0.425%). The findings indicated a convergent fluctuation pattern, with demand elasticity

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exceeding supply elasticity (0.471 > 0.343). This research contributed to the understanding of price dynamics and market equilibrium in the context of a local beef market, demonstrating the applicability of the Cobweb Model in explaining cyclical adjustments in price and quantity.

Keywords: *convergent fluctuation, elascticity, market equilibrium, meat price*

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INTRODUCTION

The Indonesian cattle industry faces a significant challenge due to the sluggish growth of beef production failing to keep pace with rising consumer demand (Agustiar et al., 2023a; Muzayyanah et al., 2023; Said, 2020). This trend is evident in Special Region of Yogyakarta (for further read: Daerah Istimewa Yogyakarta/DIY), where beef consumption growth (3.2% per year) outstrips production growth (2.08% per year), potentially leading to shortages (Puspitaningrum et al., 2018). This widening gap between local production and consumption, further exacerbated by the growing difficulty in meeting demand with domestic supply (Han et al., 2016), has significant implications for both the local economy and consumer welfare. Economically, a persistent beef shortage can lead to increased reliance on imports, hindering the growth of the local livestock industry and limiting income opportunities for farmers and businesses involved in the beef supply chain (Agustiar et al., 2023a). From a consumer perspective, a beef shortage can result in price hikes, making this essential source of protein less accessible, particularly for low-income households Muzayyanah et al., 2017).

Beef production and consumption in DIY experienced a steady upward trajectory over the period 2014–2019, reflecting a growing demand and expanding market for beef products within the region (Central Bureau of Statistics, 2024). However, a substantial gap persists between beef demand and supply. This disparity stems from the period between 1984 and 2002, characterized by surplus local production, averaging 295,259 tons, and negligible beef imports (Center for Domestic Trade Policy, 2013). In contrast, the years 2014 to 2019 witnessed an average annual beef production deficit of roughly 150,000 tons, with household consumption reaching 111,790 tons. This signifies a substantial shift in market dynamics, where local production struggles to meet the growing demand, leading to increased reliance on imports and potential price volatility.

This persistent imbalance between beef production and consumption necessitates a comprehensive understanding of the underlying market dynamics to formulate effective strategies for addressing the shortfall (Khairullina, 2018). In economics, a market is any setting where transactions occur between sellers and buyers, encompassing a wide range of traded goods and services (Boediono, 2011). The market mechanism, driven by the interplay of supply and demand, theoretically results in equilibrium, where the quantity supplied equals the quantity demanded (Puspitaningrum et al., 2018). While real-world markets may not always be in equilibrium and adjustments can be slow, the general tendency is towards balance through price adjustments.

Market equilibrium arises from the interaction between quantity demanded and supplied within a market mechanism. In Indonesia's market-based democratic system, the government influences price equilibrium through various interventions, such as setting floor and ceiling prices, providing subsidies to producers or consumers, and implementing import/export controls to manage domestic supply (Triatmojo et al., 2023). According to (Baye, 2010), equilibrium price is achieved when quantity demanded equals quantity supplied. Notably, the Cobweb Model is particularly suited for analyzing supply and demand balance in agricultural products Fu et al., 2023; Gao, 2022; Vashishtha, 2020; Zaremba, 2018). This model, which illustrates cyclical price and quantity adjustments in markets with production lags, will be employed to analyze the beef market in DIY. Specifically, the study uses the model to examine how fluctuations in beef price affect the quantity of beef supplied and demanded, considering the time lag between producers' decisions and the actual market supply. By applying the Cobweb Model, this research will identify the equilibrium point where beef demand and supply converge in the DIY market and to assess the stability of this equilibrium over time.

Achieving price equilibrium involves two key considerations: the absolute price level of a food commodity and its temporal dynamics (Chiaie et al., 2022; Lagi et al., 2015). Market mechanisms, driven by supply and demand, determine commodity prices. To analyze how a research variable evolves towards equilibrium over time, a dynamic system approach is valuable (Deaton and Laroque, 2003; Lipieta and Ćwięczek, 2022). The Cobweb Model, a simplified dynamic system, elucidates this process (Gori et al., 2015). This model offers three equilibrium scenarios: stable cycles with constant fluctuations, cycles that converge towards equilibrium, and cycles that diverge from equilibrium, displaying increasing volatility (Berardi, 2022).

The Cobweb Model suggests that market dynamics are influenced by the relative elasticities of demand and supply. When demand is more elastic than supply, prices and quantities tend to converge towards equilibrium over time. Conversely, when supply is more elastic than demand, prices and quantities can diverge, leading to increased market volatility (Gori et al., 2015). Elasticity,

defined as the percentage change in one variable in response to a 1% change in another, is a key determinant of these fluctuations (Salsabila et al., 2023). The coefficients of elasticity of demand (E_D) and supply (E_S) quantify the responsiveness of each to changes in price (Bijmolt et al., 2005).

The Indonesian beef market experiences pronounced price volatility and supply and demand fluctuations, posing significant challenges for farmers and consumers alike. Domestic production is limited by factors such as domestic supply constraints (Komalawati et al., 2019), cattle population (Rusdiana et al., 2018), a number of animals slaughtered in abattoirs (Gudisa, 2021), and beef prices (Komalawati et al., 2019). On one hand, the demand for beef is influenced by a rising population (Astiti et al., 2023), other meat substitutions (Soedjana, 2016), and beef price (Muzayyanah & Dewi, 2019). The price volatility poses significant risks for producers because it has the potential to erode profitability and discourage investment. Consumers may face challenges related to affordability and changes in their food habits. Understanding the fundamental reasons behind these variations and reducing their effects is critical for ensuring the Indonesian cattle market's stability and long-term viability (Antara & Sumarniash, 2019).

The Indonesian beef market, including DIY, inherently linked to agricultural production, is susceptible to price volatility due to unpredictable factors (Antara & Sumarniash, 2019). Weather fluctuations can impact feed availability and quality, affecting cattle growth and production costs (Bunning and Wall, 2022), while disease outbreaks can cause sudden supply shortages and price spikes (Triatmojo et al., 2024; Houser & Karali, 2020). Additionally, shifting consumer preferences, driven by health trends, cultural changes, or economic conditions, create demand fluctuations that further contribute to price instability (Smeral, 2017). In this context, the Cobweb Model's ability to generate cyclical price patterns proves valuable. By capturing the dynamic interaction between lagged supply responses and evolving demand, the model offers insights into the causes and consequences of price fluctuations (Poitras, 2023) in the DIY beef market. This understanding empowers policymakers and market participants to anticipate trends, develop risk mitigation strategies, and implement interventions to foster stability in the local beef industry.

This study is expected to enrich the current understanding of the beef market in DIY by comprehensively analyzing consumer and producer price preferences, along with corresponding quantities demanded and supplied. Existing studies (Agustiar et al., 2023a; Kusumaningrum et al., 2021; Antara and Sumarniash, 2019; Astiti et al., 2023) have primarily focused on the broader Indonesian beef market, overlooking the unique dynamics of the DIY region. For instance, Puspitaningrum et al. (2018) analyzed the potential beef supply in DIY using a spatial GIS model, but did not examine cyclical price dynamics. Similarly, while some research by Muzayyanah et al. (2017) has explored beef consumption

patterns in DIY, it has not adequately addressed cyclical price fluctuations. Furthermore, to the best of the authors' knowledge, no prior research has specifically addressed the issue of beef price volatility in the context of DIY. Thus, this study first examines the supply and demand factors shaping the local beef market. Second, the study investigates the determinants of cyclical price dynamics in the beef market of DIY, Indonesia. These findings will provide valuable insights to stakeholders in the beef market, contributing to enhanced market efficiency and informed decision-making.

RESEARCH METHOD

This study employed secondary time series data spanning 1989 to 2018, a period characterized by substantial fluctuations in the Consumer Price Index (CPI) in DIY. The CPI, an index measuring changes in consumer goods and services prices relative to a base period, rose from 336.96 in 1989 to 130.44 in 2018, indicating an increase in the cost of living, potentially amplified by the 1998 monetary crisis. The selection of the 1989-2018 timeframe for this study is grounded in several considerations. This period encompasses a significant era of economic transformation and policy shifts in Indonesia, including liberalization of trade and agricultural reforms, making it particularly relevant for analyzing the cyclical dynamics of the DIY beef market.

Furthermore, while data availability for the beef market extends further back, the period prior to 1989 is characterized by inconsistencies and gaps in data collection methodologies, potentially compromising the reliability of any analysis based on that timeframe. The choice to analyze local beef market equilibrium using time series data from 1989 to 2018 was methodologically driven and offers a robust sample size, enhancing the statistical power and validity of the results. Primarily, this timeframe excludes recent anomalies like the COVID-19 pandemic, which could skew the analysis and limit the generalizability of findings. This study prioritizes understanding historical market equilibrium dynamics in DIY rather than forecasting, further justifying the chosen period.

Data for this study were collected from multiple agencies and sources pertinent to the research, employing recording techniques. Specific data sources include the Central Bureau of Statistics of Indonesia and DIY, the Producer Price Index, the Directorate General of Livestock Services (DGLS), the Data Center and Information Ministry of Agriculture, the National Strategic Food Price Information Center (read: Pusat Informasi Harga Pangan Strategis/PIHPS), the Agriculture Service of the Special Province of Yogyakarta, and other relevant publications.

This study spans three decades, during which data collection methodologies and definitions may have evolved, potentially introducing inconsistencies or biases. We meticulously reviewed available documentation

and consulted relevant agencies to identify any shifts in data collection practices and their potential impact on data comparability. Additionally, Indonesia's economy experienced significant transformations during this period, including the 1997 Asian financial crisis and agricultural policy changes, which could have influenced beef market dynamics. We accounted for potential structural breaks in our analysis using appropriate econometric techniques, ensuring the robustness of our findings. While we aimed to utilize the most comprehensive and reliable data, limitations such as missing values or potential measurement errors persist. These were addressed through careful data cleaning and imputation, acknowledging their potential impact on the precision of our estimates.

This study investigated factors influencing beef demand and supply in DIY using simultaneous equation models with beef prices as variables in both demand and supply equations. The Two-Stage Least Squares (2SLS) estimation method was employed, and classical assumption tests were conducted to ensure model validity. These tests included the Durbin-Watson (DW) test for autocorrelation, as well as tests for heteroscedasticity, multicollinearity, and stationarity. The analysis aimed to produce unbiased results by ensuring the models were free from these violations.

The application of 2SLS in this study is motivated by the potential for simultaneity bias, a scenario where price and quantity of beef both influence each other concurrently. If unaddressed, this simultaneity could lead to biased and misleading estimates of the relationships between these variables. 2SLS mitigates this issue by utilizing instrumental variables—factors correlated with beef price but not directly with its demand or supply. This approach enables more reliable estimation of the true causal effects, strengthening the validity of the study's findings.

EViews 8 was utilized for the analysis conducted in this study. It was motivated by its features that streamline time series analysis, including comprehensive tools for handling and visualizing time-series data, built-in support for estimating simultaneous equation models like the 2SLS employed in this research, and convenient procedures for conducting classical assumption tests to validate the model's robustness. Furthermore, the researchers' familiarity with EViews and its user-friendly interface facilitated efficient data management and analysis, although alternative software packages may yield comparable results.

Agricultural phenomena, especially those involving plant and livestock commodities, frequently exhibit non-linear relationships (Ahmed et al., 2024; Brouwer & McCarl, 2006; Sun et al., 2023). This study, therefore, addressed this issue by utilizing a non-linear regression model, subsequently linearized into a log-linear form, assuming linearity in parameters. Following Widarjono (2007),

data is transformed into natural logarithms (Ln). The subsequent analysis will focus on the beef demand equation in DIY as follows:

$$\mathrm{LnQ_{Dt}} = \alpha_0 + \alpha_1 \mathrm{Ln\,X_1} + \alpha_2 \mathrm{Ln\,X_2} + \alpha_3 \mathrm{Ln\,X_3} + \alpha_4 \mathrm{Ln\,X_4} + \alpha_5 \mathrm{Ln\,X_5} + e_1$$

While the beef supply equation in DIY as follows:

$$\mathrm{LnQ_{St}} = \beta_0 + \beta_1 \mathrm{Ln\,X_5} + \beta_2 \mathrm{Ln\,X_6} + \beta_3 \mathrm{Ln\,X_7} + \beta_4 \mathrm{Ln\,X_8} + e_2$$

Thus, the reduced form equation is obtained as follows:

$$\mathrm{LnX_5} = \mathrm{Ln}\,\pi_0 + \pi_1 \mathrm{Ln\,X_7} + \pi_2 \mathrm{Ln\,X_8} + \pi_3 \mathrm{Ln\,X_9} - \pi_4 \mathrm{Ln\,X_1} - \pi_5 \mathrm{Ln\,X_2} - \pi_6 \mathrm{Ln\,X_3} - \pi_7 \mathrm{Ln\,X_4} + (e_2 - e_1)$$

where Q_{Dt} is beef demand equation; Q_{St} for beef supply equation; X_1 = income per capita; X_2 = population ; X_3, X_4, X_5, are mutton price, chicken meat price, beef price, respectively; X_6 is cattle population; X_7 is chicken meat production; X_8 number of cattle slaughtered in abattoir; and α, β, π are regression coefficients, and e = error.

The study investigates the causal relationship between factors like price, income, and cattle population, and beef supply and demand dynamics. It acknowledges the potential issue of endogeneity, where an explanatory variable correlates with the error term, possibly due to simultaneity or omitted variables. Simultaneity arises because beef price is determined by both supply and demand, making it endogenous. To address this, a Two-Stage Least Squares (2SLS) approach is employed, using instrumental variables correlated with price but not with the error terms in supply and demand equations. The study further strengthens its analysis by justifying the choice of instrumental variables – chicken meat production and the number of cattle slaughtered. These instruments are deemed relevant due to their influence on beef price through substitution effects and supply impact, respectively. While the exogeneity assumption (instruments are uncorrelated with unobserved factors affecting demand) might be debatable, it is plausible that these instruments are driven by factors other than those directly influencing consumer beef preferences.

The study analyzed market beef prices by equating beef demand and supply equations to elucidate beef market equilibrium in DIY. Using Log-log model regression, consumer beef prices were regressed on quantity demanded, and producer beef prices on quantity supplied, controlling for other price-influencing factors. This approach aligns with the Cobweb Model, which graphically illustrates market equilibrium through the interaction of price and quantity variables (Gori et al., 2015) and it allows for direct estimation of elasticities, crucial in understanding cyclical price dynamics and market equilibrium adjustments. Equilibrium price and quantity were determined by substituting regression results into the identity equation:

$$\mathrm{LnQ_{Dt}} = \mathrm{LnQ_{St}}$$

Furthermore, to examine the elasticity of demand or supply with respect to price, a log-log model was employed, regressing the natural logarithm of quantity demanded (LnQ_{Dt}) or quantity supplied (LnQ_{St}) on the natural logarithm of price (LnX_5):

$$\mathrm{LnQ} = \alpha_0 + \alpha_5 \mathrm{Ln}\, X_5 + e$$

While elasticity define as:

$$E = \frac{\%\Delta Q}{\%\Delta X_5}$$

We can approximate percentage changes using differentials:

$$\%\Delta Q \approx \delta\,(\mathrm{Ln}(Q))$$

$$\%\Delta X_5 \approx \delta\,(\mathrm{Ln}(X_5))$$

Therefore, by differentiate the previous equation, we have the slope coefficient:

$$E \approx \frac{\delta\,(\mathrm{Ln}(Q))}{\delta\,(\mathrm{Ln}(X5))} = \frac{\%\Delta Q}{\%\Delta X_5} = \alpha_5,$$

is an estimation of the elasticity of LnQ_{Dt} or LnQ_{St} with respect to LnX_5.

Elasticity, a key concept in economic analysis, can be visually represented through the gradient of the slope on a supply and demand diagram. A steeper slope indicates lower elasticity, while a flatter slope signifies higher elasticity. Consequently, if the demand curve is steeper than the supply curve, implying a lower beef price elasticity of demand relative to beef supply, the beef market is prone to divergent fluctuations. Conversely, if the beef supply curve is steeper than the beef demand curve, implying a lower beef price elasticity of supply relative to demand, the beef market tends towards convergent fluctuations (Naimzada et al., 2019).

Key considerations regarding the Cobweb Model included its inherent assumptions and susceptibility to external shocks. The model presumed naive producer expectations and time lags between production decisions and actual supply, which may not always reflect real-world market complexities (Poitras, 2023). Additionally, the model did not incorporate external shocks such as shifts in consumer preferences, natural disasters, or disease outbreaks, which can disrupt the cyclical pattern and establish new equilibrium points. This validates the selected timeframe for this study. In reality, producers in the DIY beef market may employ more sophisticated forecasting techniques or consider additional market information. This simplification could potentially impact the model's accuracy in predicting price dynamics. However, given the focus of this study on understanding the cyclical nature of price fluctuations rather than precise forecasting, we believe the Cobweb model remains a useful tool for capturing the fundamental supply-demand interactions.

Prior to model construction, this study defined key terms and established research assumptions. "Beef" refers to meat from beef cattle raised within DIY,

excluding livestock-related expenditure and income, and is quantified in kilograms (kg). "Beef demand" is the household and agro-industrial consumption of fresh and processed beef products in tons, derived from SUSENAS data using the household consumption expenditure approach. "Beef supply" denotes the quantity of beef produced in DIY, marketed within or outside the region, in tons. "Beef price" is the transaction price between sellers and buyers in DIY, deflated by the DIY consumer price index (CPI) and expressed in Indonesia Rupiah (IDR)/kg.

Moreover, "population" is the annual count of DIY residents, recorded by the Population and Civil Registry Office and projected by CBS DIY, using de jure and de facto approaches. "Income per capita" is the real Gross Domestic Regional (GDR) of DIY divided by the population, deflated by the Indonesian CPI, in million IDR/capita/year. "Chicken meat price" is the average DIY price deflated by the DIY CPI, in IDR/kg. "Cattle population" is the total count of beef cattle in DIY, in head. "Number of cattle slaughtered at abattoir (read: rumah potong hewan/RPH)" is the count of cattle slaughtered in government-certified official abattoirs in DIY. The "deflator" is the DIY CPI with a base year of 2012.

The classical assumption tests revealed multicollinearity among most variables in the beef demand regression for DIY, except for the interaction term between population and chicken meat price, with a correlation of 0.759914 (below the 0.8 threshold). To mitigate this issue, data transformation using the differential method was applied and variable X_3 (mutton price) was excluded. This method involves regressing not on the original variables but on their sequential differences (Hazra & Gogtay, 2017). In contrast to the demand equation, the beef supply regression in DIY did not initially exhibit multicollinearity. However, to further reduce correlation and enhance the robustness of the t-test for decision-making, the cattle population data (LnX6) was transformed into its growth rate (ΔLnX6). Following this transformation, multicollinearity was eliminated in both the demand and supply equations for beef in DIY.

Although mutton prices could theoretically impact beef demand due to their substitutability, our initial analysis showed a strong correlation between mutton and beef prices, suggesting multicollinearity. To maintain the integrity of our model and prevent biased estimations, we chose to omit mutton prices from the final regression analysis. We believe this exclusion will not significantly affect the overall validity of our study, as our primary objective is to understand the fundamental factors influencing beef demand, rather than comprehensively exploring all potential substitutes. Additionally, we applied logarithmic transformations to specific variables, including beef price and income, to address non-linearity and heteroscedasticity within the data. This transformation enhances the model's accuracy and enables us to interpret coefficients directly as elasticities, providing valuable insights into how demand and supply respond to

changes in these variables. While we acknowledge that transformations can influence the interpretation of results, particularly in terms of effect magnitude, we believe the advantages of a better-fitting model and the ability to interpret elasticities outweigh these potential drawbacks.

The Durbin-Watson values of 0.809698 and 0.861771 for the DIY beef demand and supply equations, respectively, indicated the presence of autocorrelation at the 5% significance level. This issue was addressed using the Cochrane-Orcutt method, assuming an autoregressive (AR) model for the error terms in the demand equation, which accounts for the influence of past conditions on the present (Alpuim and El-Shaarawi, 2008; Tenriawaru et al., 2022; Tuaç et al., 2020). Following correction, Durbin-Watson values of 2.142866 and 2.204093 for the demand and supply equations, respectively, fell within the acceptable range, confirming the absence of autocorrelation. Additionally, stationarity testing, conducted after second differencing, indicated no issues, with calculated ADF values less than 0.05 at a 5% significance level (α), confirming stationarity in the data.

RESULT AND DISCUSSION

Trend of Demand and Supply Local Beef in DIY

The figure 1 presents the trend of local beef production and consumption in DIY from 1989 to 2018. Beef production experienced moderate fluctuations between 40,000 and 60,000 tons from 1989 to 2003, followed by a substantial surge, peaking around 80,000 tons in 2012. Conversely, beef consumption demonstrated a relatively stable pattern, hovering around 40,000 tons until 2003, before mirroring the production trend and reaching a peak near 80,000 tons in 2012. Beef consumption in DIY increased by an average of 14,304.73 kg per year from 1991 to 2015 (Central Bureau of Statistics Yogyakarta, 2024). However, a notable decline of 21.05% occurred between 1997 and 1998, from 4,652,267 kg to 3,672,952 kg. This decrease coincided with the national trend, where beef consumption fell from 226,955,950 kg in 1996 to 213,406,150 kg in 1997. Subsequently, both production and consumption exhibited a declining trend, converging around 80,000 tons by 2018.

The 1997 economic crisis in Indonesia precipitated a notable decline in beef consumption, resulting in a negative average annual growth rate of -1.87% in beef demand between 1997 and 2002, as documented by (Hadi et al., 2002). This contraction can be attributed to the adverse economic conditions that prevailed during this period, which likely constrained consumers' purchasing power and led to a shift towards more affordable protein sources. However, despite this temporary setback, the overall trend in total Indonesian beef production from 1989 to 2018 exhibited a positive trajectory, with an average annual growth rate of 1.20%. This growth can be attributed to a variety of factors, such as expanding

domestic production capacity, increased investment in the livestock sector, and growing demand from an increasing population.

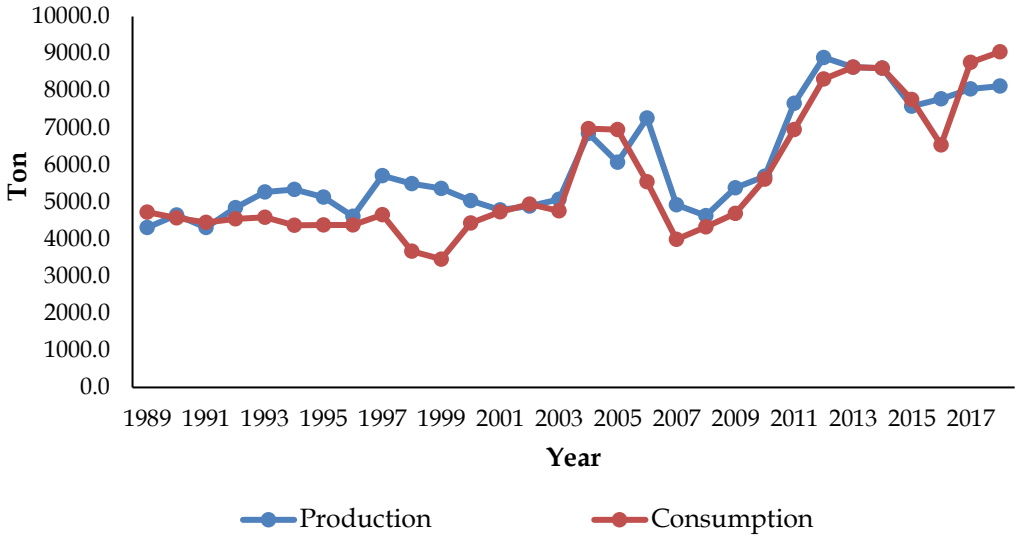

Figure 1.
Trends In Beef Consumption and Production Before COVID-19 in DIY

Source: (Central Bureau of Statistics, 2024)

The most substantial decrease in local beef production occurred in 2007, likely due to increased beef imports into Indonesia. Currently, domestic demand is fulfilled by both local and imported beef, including feeder cattle. While imports in 2004 originated mainly from Australia and New Zealand (Agustiar et al., 2023b), sources have diversified since 2007 to include the USA, Canada, Brazil, and Ireland, following risk assessments and audits for safety and halal compliance. Notably, feeder cattle imports remain restricted to Australia (Hadi et al., 2002) during that period.

Determinants of Beef Demand in the DIY Region

The F-test results, as detailed in Table 1. provide compelling evidence of a statistically significant relationship between the combined effects of income per capita, population growth, chicken meat price, and beef price on the demand for beef in the DIY region. The calculated F-statistic of 23.36343, with an associated p-value of less than 0.01, strongly refutes the null hypothesis that these independent variables collectively exert no influence on beef demand. This finding underscores the importance of incorporating these socioeconomic and market-related factors into a comprehensive model for accurately understanding and predicting the dynamics of beef consumption within the region.

Table 1. Empirical Estimates Of Factors Influencing Beef Demand In The DIY

Variable	Coefisien	t statistic
Constant (C)	6.582035	11.70323
Income per capita (Ln X_1)	0.485247	1.901731*
Population growth (Ln ΔX_2)	-0.549835	-0.572612 ns
Price of chicken meat (Ln X_4)	-0.152361	-1.426945 ns
Beef price (Ln X_5)	0.203940	2.600364**
R^2	0.875141	
F	23.36343	

Note : * means significant at 10% ($p < 0.10$), ** 5% ($p < 0.05$)
ns means is not significant different ($p > 0.10$)

Income effects

The empirical findings underscore the significant positive correlation between per capita income and beef demand ($p < 0.10$). The estimated coefficient of 0.485 suggests that a 1% increase in per capita income is associated with a 0.485% increase in the quantity demanded, thus affirming Puspitaningrum et al. (2018) classification of beef as a normal good. This implies that beef consumption exhibits an income elasticity of demand greater than zero, indicating that as consumers' incomes rise, their demand for beef not only increases but potentially shifts towards higher-quality cuts and premium products. This income-driven demand dynamic highlights the potential for beef consumption to further expand in tandem with economic growth and rising disposable incomes within the region.

This study presumes that there is significant income disparity in DIY, and a rise in beef prices might disproportionately affect lower-income groups, leading them to reduce consumption. Meanwhile, higher-income groups, less sensitive to price changes, could maintain or even increase their beef consumption, driving overall demand up. The previous study conducted by Muzayyanah et al. (2017) on household decision-making regarding animal protein consumption in Yogyakarta, Indonesia, categorized households into three income groups (low, middle, and high). The research concluded that household income significantly influenced animal protein consumption only among low-income households. This suggests that an increase in income leads to increased consumption of animal protein, particularly among low-income households who recognize its importance but face consumption constraints due to financial limitations. The study further indicates that a rise in income may result in an increase in the tendency of households to consume livestock-derived animal protein.

Population growth

The statistical analysis revealed a non-significant relationship between prior year population growth and beef demand ($p > 0.10$) within the DIY region. This suggests that changes in population size do not directly translate to fluctuations in beef consumption, thus indicating that population growth was not a primary driver of beef demand in this specific context.

Yogyakarta's prominence as a tourist destination and educational hub introduces a unique dynamic to its beef market. A significant portion of meat consumption is attributed to tourists through hotel, restaurant, and catering services, while a substantial student population, not registered as local residents, also contributes to demand (Nugroho & Putri, 2023; Wijaya et al., 2021). Consequently, the conventional relationship between population growth and increased demand does not hold true in this context.

Nurtini et al. (2018) observed that the price of cattle in Yogyakarta experiences a surge during year-end holiday periods, surpassing levels seen in non-holiday times. This increase is attributed to the influx of tourists into Yogyakarta, a popular destination second only to Bali, which drives up beef demand and consumption in tourist areas. Consequently, this heightened demand indirectly elevates cattle prices. This phenomenon underscores the importance of considering non-resident consumers in assessing regional demand for commodities like beef. In Yogyakarta, tourists and students form a substantial, yet transient, consumer base that significantly influences beef consumption patterns. This transient population, excluded from official population statistics, renders traditional population growth metrics inadequate for predicting beef demand fluctuations.

This paradoxical phenomenon in the DIY region can be attributed to its unique socioeconomic context as a major tourism and education hub. A diverse group of tourists and students with different incomes and backgrounds creates a consumer base with unique buying habits. These non-resident consumers, who may be less sensitive to price fluctuations due to temporary stays or higher disposable incomes, are likely to contribute to the observed positive relationship between price and demand. Additionally, the cultural significance of beef in certain cuisines and the association of beef consumption with higher social status may further explain this atypical behaviour (Tian et al., 2016). Further research investigating meat consumption patterns among tourists and students in Yogyakarta is warranted to determine whether these non-resident populations significantly contribute to beef demand in the region.

Chicken Meat Price

The study found no significant influence of chicken meat prices on beef demand ($p > 0.10$). This implies that consumers in DIY did not significantly substitute beef with chicken in response to price fluctuations in the latter.

Therefore, changes in chicken prices did not appear to be a determining factor in the demand for beef within the region. These findings are consistent with previous research by (Puspitaningrum et al., 2018), which also reported a lack of significant correlation between population growth and chicken prices on beef demand in similar contexts. This study contributed to the growing body of evidence suggesting that factors beyond population demographics and the price of substitute goods (by the insignificant impact of these factors on beef demand) play a more significant role in shaping beef demand patterns.

Several factors could explain the lack of a significant relationship between chicken meat prices and beef demand in Yogyakarta. The two meats might not be seen as perfect substitutes due to cultural preferences or distinct culinary uses (Marwanti et al., 2020). A strong cultural preference for beef—for instance, certain dishes are made exclusively with beef, not chicken—or other dominant factors like population growth and income levels might also overshadow the influence of chicken prices. Additionally, the price difference could be large enough that chicken price changes don't significantly impact beef consumption decisions, especially if beef is perceived as a premium product. Previous study by Ani and Antriyandarti (2019) on analysis of household demand for chicken meat in Yogyakarta stated that people's buying habits for chicken meat are not very sensitive to price changes.

Beef Price

Contrary to conventional economic theory, the analysis revealed a statistically significant and positive relationship between beef price and beef demand ($p < 0.05$). A 1% price increase was associated with a 0.203% increase in quantity demanded, a finding that deviates from the typical inverse relationship between price and demand observed in most markets. As a result, the positive price elasticity of demand for beef in the DIY region highlights the importance of considering regional specificities and consumer heterogeneity when analyzing market dynamics. It also underscores the potential impact of non-resident consumers on local markets, particularly in regions with significant tourism or educational sectors.

This anomaly contradicts the findings of (Kusumaningrum et al., 2021) for other regions, where higher prices were found to dampen demand. The findings of (Utami et al., 2019) study underscore the importance of price as a key determinant of beef demand, even in regions where tourism is not a major economic driver. The observed price elasticity of demand (-4.701) suggests that beef consumption in Jember is elastic, meaning that consumers are responsive to price changes.

Determinants of Beef Supply in the DIY

The empirical analysis revealed a robust relationship between beef price, cattle population growth, chicken meat production, and the number of cattle slaughtered in abattoirs, and the supply of beef in the DIY region. The F-statistic of 18.60839 ($p < 0.01$) underscores the collective significance of these variables in shaping beef supply dynamics. Despite the slightly higher uncertainty, the 10% significance level still suggests that income per capita is a relevant factor to consider when analyzing or predicting beef demand in Yogyakarta, although it's slightly less robust than findings at lower significance levels. There's a slightly higher chance that the observed relationship might not hold true in a different sample or under slightly different conditions.

Table 2. Empirical Estimates Of Factors Influencing Beef Supply In The DIY

Variable	Coefisien	t statistic
Constant (C)	12.09411	8.766632
Beef price (Ln X_5)	0.075768	1.850370 *
Cattle population growth (Ln ΔX_6)	0.403679	2.260409 **
Chicken meat production (Ln X_7)	0.004152	0.129922 ns
Number of cattle slaughtered in abattoir (Ln X_8)	-0.425377	-3.933868 ***
R^2	0.848082	
F	18.60839	

Note : * means significant at 10% ($p < 0.10$), ** 5% ($p < 0.05$), *** 1% ($p < 0.01$)
ns means is not significant different ($p > 0.10$)

Beef Price

Notably, the analysis indicates a significant positive impact of beef price on beef supply ($p < 0.10$). This finding is consistent with the fundamental economic principle of the law of supply, which posits a positive correlation between price and quantity supplied. Specifically, the estimated coefficient suggests that a 1% increase in beef price leads to a 0.075% increase in the quantity of beef supplied. This implies that higher prices incentivize producers to increase their output, thereby bolstering the overall beef supply in the market. This result highlights the importance of price signals in guiding production decisions within the beef industry. The responsiveness of supply to price changes suggests that producers are attentive to market signals and adjust their production levels accordingly. This dynamic interplay between price and supply contributes to the overall stability and efficiency of the beef market in the DIY region.

Cattle Population Growth

The analysis revealed a significant positive correlation between cattle population growth and beef supply ($p < 0.05$) in DIY. A 1% increase in the cattle

population was found to result in a 0.403% increase in beef supply, reinforcing the intuitive expectation that a larger cattle population, ceteris paribus, would yield higher beef production. This finding aligns with previous research by Kibona et al. (2022), which also identified a positive relationship between cattle population and subsequent beef supply in other contexts.

This study's findings highlighted the importance of cattle population management in ensuring a stable and sufficient beef supply in DIY. Given the positive relationship between cattle population growth and beef supply, policies aimed at supporting and incentivizing cattle farming could be crucial for meeting the growing demand for beef in the region. Additionally, the lack of a significant relationship between chicken meat production and beef supply underscores the need for targeted interventions specific to the beef industry, rather than relying on potential spillover effects from other livestock sectors.

Chicken Meat Production

Conversely, chicken meat production did not exhibit a statistically significant impact on beef supply ($p > 0.10$). This suggests that fluctuations in chicken production levels do not influence the decisions of beef producers or slaughterhouses in DIY regarding their supply of beef. This lack of correlation could be attributed to various factors, such as distinct production cycles, different target markets, and independent decision-making processes for beef and chicken production.

Cattle Slaughtered In Abattoir

The analysis revealed a counterintuitive and statistically significant negative relationship between the number of cattle slaughtered at abattoirs (RPH) and the subsequent beef supply ($p < 0.01$). Specifically, a 1% increase in cattle slaughter was associated with a 0.425% decrease in beef supply, a finding that challenges the conventional expectation of a positive correlation between these two variables.

The observed negative relationship between cattle slaughter rates and beef supply in Yogyakarta necessitates further investigation. In this study, beef production is measured as the combined weight of carcasses and edible portions derived from both registered (in slaughterhouses or during Qurban) and unregistered slaughtering activities (Central Bureau of Statistics Yogyakarta, 2024). Unregistered slaughtering, often occurring outside controlled environments, may lead to diminished meat quality or increased wastage, effectively reducing the usable beef supply even with higher slaughter numbers. Additionally, temporal fluctuations in the proportion of registered versus unregistered slaughtering could introduce inconsistencies in the data, thereby obscuring the actual impact of slaughter rates on the final beef supply reaching the market. Consequently, a simple increase in slaughter numbers may not

directly correspond to a proportional increase in available beef for consumers in Yogyakarta.

This finding challenged the conventional economic wisdom that increased production typically leads to higher revenue growth, as posited by (Mella, 2018). It underscores the unique complexities of the DIY beef market, where producers appear to prioritize price stability over maximizing output. This behavior might be driven by various factors, including market structure, information asymmetry, and risk aversion among producers. The negative relationship between slaughter rates and beef supply in DIY suggests that policies aimed at increasing beef production through higher slaughter rates might not necessarily yield the desired outcome. Instead, interventions focusing on demand-side factors, such as consumer education and market diversification, might be more effective in ensuring a sustainable and balanced beef market (Charlebois et al., 2016; Mesinger and Ocieczek, 2020; Soler and Thomas, 2020).

Cyclical Price Dynamics of Beef Market in DIY

The equilibrium analysis of the beef market in the DIY region focused on the dynamic interplay between price, quantity supplied, and the amount demanded, assuming ceteris paribus conditions for all other influencing factors. This methodological approach aligns with the Cobweb Model, a theoretical framework that elucidates the cyclical nature of price and quantity adjustments in agricultural markets, particularly for products with a time lag in production, such as livestock.

As detailed in Tables 3 and 4, this model reveals the intricate relationship between beef prices and both demand and supply in the DIY market. The empirical findings not only provide insights into the specific price elasticities of demand and supply, but also shed light on the underlying market mechanisms that contribute to equilibrium price formation.

Table 3. Results Of Regression Of Beef Price To Beef Demand In DIY

Variable	Coefisien	t statistic
Constant (C)	4038.580	13.62580
Beef price (LnX_5)	0.035566	7.425991***
R^2	0.864787	
F	51.16596	

Note : *** means significant at 1% ($p < 0.01$)

Table 4. Results Of Regression Of Beef Price To Beef Supply In DIY

Variable	Coefisien	t statistic
Constant (C)	5020.263	12.12342
Beef price (LnX_5)	0.025921	3.798355***
R^2	0.699853	
F	18.65358	

Note : *** means significant at 1% ($p < 0.01$)

After finding the regression coefficients, the equilibrium price and quantity in the beef market were found by equating the demand and supply functions. This is done because it is a basic economic principle that when the quantity demanded (Q_{Dt}) is equal to the quantity supplied (Q_{St}) in a given period, the market is in equilibrium. This analytical approach, grounded in classical microeconomic theory, facilitates the determination of the market-clearing price and quantity at which the opposing forces of supply and demand intersect. The resulting equilibrium values can be seen in the following equation:

$$\begin{aligned}
\mathrm{LnQ_{Dt}} &= 4{,}038.580 + 0.0356\,\mathrm{LnX_5} \\
\mathrm{LnQ_{Ds}} &= 5{,}020.263 + 0.0259\,\mathrm{LnX_5} \\
\mathrm{LnQ_{Dt}} &= \mathrm{LnQ_{St}} \\
4{,}038.580 + 0.0356\,\mathrm{LnX_5} &= 5{,}020.263 + 0.0259\,\mathrm{LnX_5} \\
0.0356\,\mathrm{X_5} - 0.0259\,\mathrm{X_5} &= 5{,}020.263 - 4{,}038.580 \\
0.0097\,\mathrm{X_5} &= 981.683 \\
\mathrm{X_5} &= 101{,}204.433 \text{ IDR/kg}
\end{aligned}$$

The X_5 value of 101,204.433 IDR/kg was the equilibrium of the price between beef demand and supply in DIY, while the value of the quantity of goods demanded and supplied was generated through the price of a substitute into the following demand equation:

$$\begin{aligned}
\mathrm{LnQ_{Dt}} &= 4{,}038.580 + 0.0356\,\mathrm{LnX_5} \\
\mathrm{Q_{Dt}} &= 4{,}038.580 + 0.0356\,(101{,}204.433) \\
\mathrm{Q_{Dt}} &= 7{,}641.457 \text{ ton}
\end{aligned}$$

Q_{Dt} value is substituted into the following supply equation:

$$\begin{aligned}
\mathrm{LnQ_{St}} &= 5{,}020.263 + 0.0259\,\mathrm{LnX_5} \\
\mathrm{Q_{St}} &= 5{,}020.263 + 0.0259\,(101{,}204.433) \\
\mathrm{Q_{St}} &= 7{,}641.457 \text{ ton}
\end{aligned}$$

The derived equilibrium equation reveals that the beef market in the DIY region achieves equilibrium when the price reaches 101,204.433 IDR/kg and the quantity transacted is 7,641.457 tons. This equilibrium point signifies the intersection of the demand and supply curves, where the quantity demanded by consumers precisely matches the quantity supplied by producers. At this price

level, there is no excess demand or supply, resulting in a market-clearing outcome. This equilibrium price serves as a critical benchmark for understanding the market dynamics and evaluating the impact of various factors on both consumers and producers in the DIY beef market.

The dynamics underlying the aforementioned market equilibrium can be better understood through an elasticity analysis. The calculation of these elasticities can be expressed as follows:

$$E_D = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta X_5}{X_5}} = \frac{\Delta Q}{\Delta X_5} \text{ x } \frac{X_5}{Q}$$

$$E_D = 0.0356 \text{ x } \frac{101{,}204.433}{7641.457}$$

$$E_D = 0.471$$

$$E_S = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta X_5}{X_5}} = \frac{\Delta Q}{\Delta X_5} \text{ x } \frac{X_5}{Q}$$

$$E_S = 0.0259 \text{ x } \frac{101{,}204.433}{7641.457}$$

$$E_S = 0.343$$

The calculated elasticity values revealed that the beef demand elasticity in DIY is greater than the supply elasticity (0.471 > 0.343). However, both values are below 1, indicating that neither beef demand nor supply in DIY is price elastic. This aligns with (Gori et al., 2015) assertion that when demand elasticity exceeds supply elasticity, the market will naturally gravitate towards equilibrium in terms of both price and quantity. Moreover, the calculated elasticities i.e. $E_D > E_S$, indicated beef market a convergent fluctuation pattern in the beef market, as per the Cobweb Model. This implied that a cyclical adjustments in the price and quantity of beef gradually stabilizing towards a long-run equilibrium (Poitras, 2023). Figure 2 illustrates the Cobweb Model's depiction of price and quantity adjustments in the beef market, leading to equilibrium.

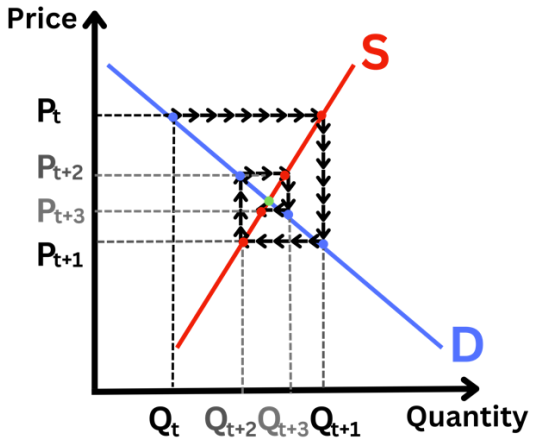

Figure 2.
Illustration Of Fluctuation Convergent Based On Cobweb Model Of Market Equilibrium

Source: Adapted from Policonomics (2017)

The market commences at the intersection of supply (S) and demand (D) curves, point (P_t, Q_t). Due to production lags, producers base supply decisions on prior prices. If P_t exceeds equilibrium, producers increase supply to Q_{t+1}, anticipating sustained high prices. This creates a surplus, as supply surpasses demand at P_{t+1}. To rectify this, prices fall to P_{t+2}, prompting increased consumer demand (Q_{t+2}), though still below supply. Prices further decrease to P_{t+3}, with demand rising to Q_{t+3} and producers reducing supply. The iterative process, characterized by diminishing fluctuations due to demand's relative inelasticity compared to supply, drives the market towards equilibrium, where quantity supplied matches demand, and prices stabilize. Thus, the Cobweb Model illustrates how lagged supply responses lead to progressively smaller price and quantity fluctuations until market equilibrium is achieved, with the convergence rate dictated by the relative elasticities of supply and demand.

Convergent price fluctuations in the local beef market, for consumers, would result in reduced price volatility, facilitating more predictable budgeting and purchasing decisions. While initial price oscillations may occur, prices would ultimately stabilize at the equilibrium level, affording consumers greater long-term price certainty. This enhanced stability could also stimulate increased beef consumption as consumers gain confidence in its affordability. On the one hand, convergent price fluctuations would signal a more stable market environment for producers, mitigating uncertainty and enabling enhanced production planning. While initial price adjustments may be necessary, producers would ultimately adapt to the equilibrium price, ensuring sustained

profitability. This stability could further stimulate investment in production capacity, potentially fostering long-term growth within the local beef industry (Widiati, 2015).

Consequently, the authors offer targeted policy recommendations to address the specific issues revealed in this analysis. The positive price elasticity of demand suggests that consumers in Yogyakarta might be less price-sensitive, possibly due to the influence of tourists and students. This creates an opportunity for policies aimed at demand management. The government could consider implementing awareness campaigns to educate consumers about sustainable consumption patterns and the environmental impact of beef production. Promoting alternative protein sources or encouraging reduced beef consumption could help manage demand and mitigate price volatility. The counterintuitive negative relationship between slaughter rates and beef supply indicates that producers prioritize price stability over maximizing output. This suggests a need for policies that support producer incomes and reduce price risks. The government could explore mechanisms like price stabilization funds or insurance schemes to protect producers from sharp price declines. Additionally, investments in infrastructure and technology could help improve productivity and reduce production costs, enabling producers to better respond to market signals.

The study also highlights the importance of cattle population management. Policies that incentivize sustainable cattle farming practices and improve herd health could contribute to a more stable and predictable beef supply. The government could also consider collaborating with research institutions to develop breeding programs that enhance the productivity and resilience of local cattle breeds. Finally, the unique dynamics of the DIY beef market, influenced by tourism and a large student population, call for targeted interventions. The government could work with the tourism and hospitality sectors to promote sustainable food sourcing practices and encourage the use of locally produced beef. Additionally, educational programs could raise awareness among students about the importance of responsible consumption and the impact of their food choices on the local market.

This research contributes to the understanding of price dynamics and market equilibrium in the context of a local beef market, demonstrating the applicability of the Cobweb Model in explaining cyclical adjustments in price and quantity. The findings highlight the importance of considering both demand-side factors (income) and supply-side factors (cattle population, slaughter) in policy formulation. Furthermore, the convergent price pattern suggests that market interventions aimed at stabilizing beef prices could be effective in the long run.

CONCLUSION AND SUGGESTION

Conclusion

The analysis indicates that income per capita, population growth, chicken meat price, and beef price collectively influence beef demand in DIY. Similarly, beef price, cattle population growth, chicken meat production, and the number of cattle slaughtered in abattoirs jointly affect beef supply in DIY. The calculated $E_D > E_S$ indicates a convergent fluctuation pattern in the beef market. This implies cyclical adjustments in price and quantity, gradually stabilizing towards a long-run equilibrium. These price fluctuations, in turn, drive adjustments in the quantity of beef produced. This cyclical relationship between price and production aligns with the Cobweb Model, which posits that producers respond to price signals with a time lag, leading to iterative adjustments in supply and subsequent price changes.

Suggestion

Identifying key demand and supply factors, such as income, cattle population, and slaughter numbers, provides guidance for targeted interventions. For instance, policies aimed at increasing the cattle population and managing slaughter practices can help stabilize supply, particularly by addressing the counterintuitive negative relationship between slaughter rates and beef supply. Furthermore, The convergent price pattern suggests that long-run market interventions aimed at stabilizing beef prices could benefit both consumers and producers by reducing price volatility and promoting market predictability. Further research is needed to explore additional factors influencing beef demand, including cultural preferences and the availability of alternative protein sources, to enhance understanding of consumer behavior and inform more effective demand-management strategies.

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