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Demand Analysis for Large Animal and Poultry Meat in Indonesia: An ARDL Perspective

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Abstract

This study examines the growing demand for large livestock and poultry meat in Indonesia, reflecting changing consumption patterns and economic growth. However, this phenomenon faces challenges such as price fluctuations between provinces, declining per capita income, and supply-demand gaps that affect access to and consumption of animal protein. Utilizing panel data from 34 provinces covering the period from 2015 to 2022 and employing an Autoregressive Distributed Lag (ARDL) model, this study analyzes the short- and long-run relationships in meat demand. The results indicate that in the short run, meat prices and per capita income significantly influence demand, while tuna prices have no noticeable effect. In the long run, meat prices, per capita income, and fish prices as substitutes affect meat demand. This study contributes to the development of the livestock sector in Indonesia, provides information for farmers to plan production, and advises the government to educate the public about protein sufficiency and conduct market operations to stabilize prices and maintain meat availability. The findings are expected to help fulfill the current and future demand for meat from large livestock and poultry in Indonesia.

1. Introduction

The livestock sector plays a vital role in the global food system and economic development. As a major provider of animal protein, livestock meat significantly contributes to food security and community nutrition, which are essential for human growth and development [1, 2]. The subsector is a crucial pillar of poverty alleviation and agricultural development, providing income and employment for hundreds of millions of people worldwide [3–5]. The multidimensional impact of livestock on human and natural systems reflects the complexity of the sector. Therefore, an in-depth understanding of the interactions between factors that influence demand, such as income, prices, and consumer preferences, is crucial. These analyses are needed to ensure the sustainability and efficiency of the livestock sector in meeting people's nutritional needs in the future, while considering economic and environmental aspects [6, 7].

The demand for livestock meat in Indonesia is not daily, as meat is classified as a luxury item. The demand for livestock meat in Indonesia continues to increase year by year, while the price of livestock meat also tends to rise [8, 9]. In this context, the price of fish as a substitute good is also an important factor. Data shows fluctuations in fish prices, with an increasing trend. Other studies have shown that the demand for livestock meat is influenced by its price: if the price increases, demand decreases,

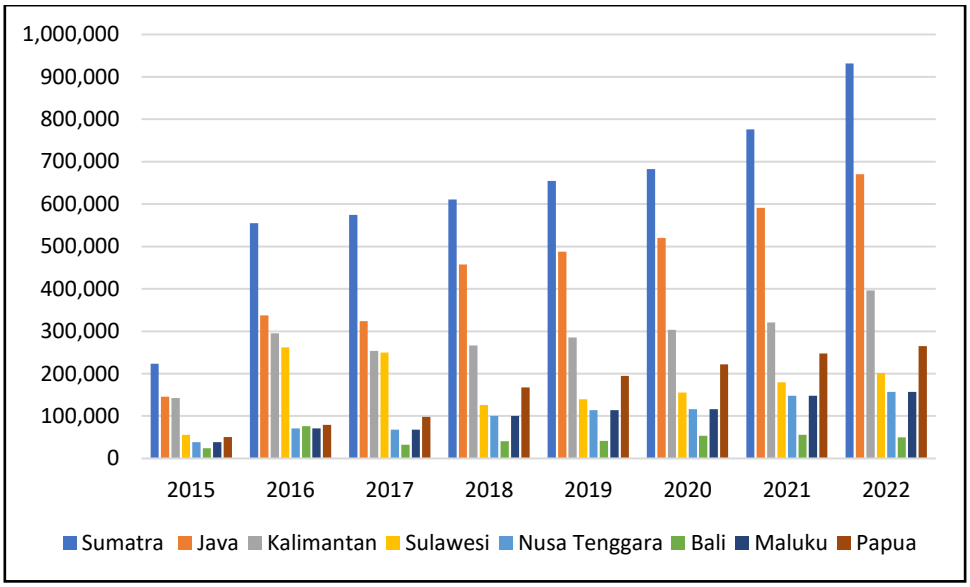

Figure 1. Expenditures on large livestock meat and poultry by island in Indonesia, 2015–2022, in thousand rupiah.
Note: Data retrieved from Statistics Indonesia [10]

leading people to choose substitute goods [11–13]. In addition, people's income affects the demand for meat: if income increases, the demand for livestock meat also increases [14]. However, the trend of increasing demand and prices is met with a decrease in per capita income [15, 16].

The main obstacle to meat consumption in society is its relatively high price compared to other protein sources such as eggs, tempeh, and fish. Factors such as high production costs, complex supply chains, and high demand contribute to the high price of meat [17]. When meat prices rise, consumers tend to switch to more affordable protein alternatives, reflecting the economic principle of maximizing utility within budget constraints [6]. This phenomenon not only affects meat consumption patterns but also impacts the market dynamics of substitute products. While protein alternatives can fulfill basic needs, the differences in nutritional profiles between meat and its substitutes need to be considered in the context of public health. This shift in consumption has broad implications, ranging from economic to nutritional, which are important to consider in food and health policy [18, 19].

Based on Figure 1, the demand for livestock meat in Indonesia has shown an increasing trend from 2015 to 2022 across the main islands, though with varying growth rates [20]. Sumatra consistently has the highest demand, followed by Java, while Kalimantan ranks third. Papua exhibits the most consistent growth, averaging around 18% per year. Sulawesi, Nusa Tenggara, and Maluku fall into the middle tier with similar growth patterns, while Bali, despite a significant spike in 2016, has the lowest overall demand and inconsistent growth [21].

Most islands experienced significant spikes from 2015 to 2016, with Sulawesi recording the highest increase of 368%. After this period, growth patterns became more stable, with average annual growth ranging from 7% to 13% for most islands. Despite some fluctuations and declines in certain years, particularly in Bali and Sulawesi, the overall trend indicates an increase in demand for livestock meat across Indonesia [22]. Generally, all islands show an increasing trend in demand for livestock meat from 2015 to 2022, though with varying growth rates and fluctuations. The differences in growth patterns and demand levels between islands reflect the diversity of economic, demographic, and cultural factors [10].

The high or low income of the community and the price of goods reflect the purchasing power of the community, which affects the amount of demand [23, 24]. According to theory, demand is influenced by the price of the goods themselves, other goods (substitutes), and per capita income [25, 26]. When prices decrease, demand increases, and the effect of a decrease in price is greater than the effect of a decrease in the income elasticity of demand [27]. Understanding the interaction between income, price, and income elasticity of demand is crucial for projecting future demand for animal-based foods [28].

To date, the demand for meat from large livestock and poultry in Indonesia has been low. Factors such as the price of livestock meat, the price of substitute goods like eggs, tempeh, and fish, and people's income can affect the demand for livestock meat [29]. Higher prices for livestock meat typically result in lower demand. This is compounded by the low income of the community, which makes large livestock and poultry meat less likely to be a

primary source of protein. However, demand for meat increases during religious holidays and major events [30].

Another issue is that Indonesia still relies on meat imports from other countries to meet its domestic consumption needs, despite the country's significant potential to develop its livestock sector and become more self-sufficient and sustainable [31]. Domestic meat production capacity in the livestock sector is often inadequate to meet high consumer demand [32]. Factors such as limited large-scale land for livestock businesses, animal diseases, and restricted livestock technology inhibit the economic progress of the sector [33]. Addressing these issues requires a comprehensive strategy involving various stakeholders, including the government, farmers, related industries, and communities, to achieve a self-sustaining livestock sector in Indonesia [34, 35].

Although many studies have analyzed factors affecting meat demand, such as price, income, and substitutes, inconsistencies remain in the results and methods used. Some studies demonstrate a significant effect of certain variables, while others do not find the same effects [36]. For instance, regarding meat prices, some studies show an influence on meat demand. Raihan and Harmini (2023) [37] found that the price of meat affects its demand, similar to the findings of Chalidin et al. [29]. However, research on per capita income's impact on meat demand yields mixed results. Komarek et al. [28] found that meat demand increases with higher income and decreases with lower income. In contrast, Andini et al. [38] reported that both high and low incomes influence the purchasing power for meat. Conversely, Khotimah and Ulfa [39] found that per capita income has no effect on meat demand.

Inconsistencies also occur regarding the impact of fish prices as a substitute on meat demand. Research by Chalidin et al. [29] and Munawarah [21] both found that the price of fish affects meat demand. However, Lesmana [40] reported that the price of eggs, another substitute good, does not influence meat demand. These inconsistencies may arise from differences in populations with diverse socio-economic, cultural, and geographical characteristics, which can affect consumption patterns and responses to income changes. Additionally, most studies focus on short-run analyses, leaving long-run dynamics and shifts in consumer preferences underexplored [41].

This study aims to examine and analyze the demand for large livestock and poultry meat in Indonesia in both the short and long run. The urgency of this research is increasing due to the importance of meat as a source of animal protein and its role in national food security, particularly in light of rising meat prices, declining per capita income, and changing consumption patterns. By gaining an in-depth understanding of the factors influencing meat demand, this research is expected to provide valuable insights for policymakers in formulating effective strategies to stabilize prices, increase domestic production, and ensure equitable access to animal protein across all levels of society. Additionally, this research aims to contribute to the development of more sustainable and affordable meat alternatives, thereby supporting national food security and promoting healthier consumption patterns.

The rest of this paper is organized as follows: Section 2 presents the types and sources of data, variable definitions, and analysis methods. Section 3 describes the results of the Autoregressive Distributed Lag (ARDL) estimation, including the stationary test, cointegration test, determination of the optimum lag, and the stability test of the ARDL model. Finally, Section 4 provides a conclusion of the study, along with policy recommendations and study limitations.

2. Materials and Methods

2.1. Data and Variable

The data used in this study is balanced panel data, which occurs when each object has the same number of time observations [42]. Using balanced panel data can make it easier to understand dynamic changes in both the short and long run. This data is obtained secondarily and includes time series data from 2015 to 2022. The data range is limited due to data availability. Cross-sectional data is taken from 34 provinces in Indonesia, sourced from Statistics Indonesia [10] and the National Strategic Food Price Information Center [43].

Based on Table 1, the dependent variable of this study is the demand for meat, including both large livestock and poultry meat. The first independent variable is meat production, which also includes both large livestock and poultry meat. The second independent variable is population. The third independent variable is the price of meat, including both large livestock and poultry meat.

2.2. Autoregressive Distributed Lag (ARDL)

This study uses a quantitative research method, the ARDL model, which can explain reciprocal relationships in both the short and long run. The ARDL model combines Autoregressive (AR) and Distributed Lag (DL) methods. "Lag" refers to past values that are used to predict future values. The AR method uses past data points of the dependent variable, while the DL method incorporates

Table 1. Dependent and independent variable synopsis.

Variable Status	Symbol	Variable Name (Units)	Variable Definition	Sources
Dependent	DLM	Demand for Livestock Meat (million rupiah)	Refers to the willingness of consumers to purchase meat products at various price levels within a given time period, proxied by average per capita expenditure [10].	Statistics Indonesia [10]
Independent	POM	Price of Meat (per kilogram in thousand rupiah)	Refers to the cost assigned to a specific quantity of meat in the market [43].	The National Strategic Food Price Information Center [43]
	IPP	Income per Capita (million rupiah)	Refers to the average income earned per person in a given area during a specified time period, proxied by Gross Regional Domestic Product (GRDP) per capita [44].	Statistics Indonesia [44]
	POF	Price of Fish (per kg in thousand rupiah)	Refers to the cost of fish products in relation to their role as an alternative to meat [43].	The National Strategic Food Price Information Center [43]

past values of the independent variables to model their effects on the dependent variable [45–47].

The purpose of this study is to examine and analyze the impact of the independent variables on the dependent variable in both the short and long run using the ARDL approach. One of the advantages of the ARDL method, compared to other methods, is that it is unbiased and can be applied to studies with limited observations [48, 49]. The basic function of this study is written in Equation 1.

$$DLM = f(POM, IPP, POF) \quad (1)$$

Where DLM represents the demand for livestock meat, POM is the price of meat, IPP is income per capita, and POF is the price of fish.

The ARDL method allows for the simultaneous estimation of short-run and long-run effects while overcoming violations of the autocorrelation assumption [45]. The ARDL econometric model representing this relationship is provided in Equation 2. In the equation, Δ represents the first difference, β_1 to β_4 are the short-run coefficients, ECT_{t-1} is the error correction term in the first lag, and φ_1 to φ_4 are the long-run coefficients. Here, t denotes timeframe, j represents provinces, i indicates the order of lag, and ε is the error term.

The workflow of this study follows several steps, as shown in Figure 2. First, the stationarity of the data is tested using the Phillips-Perron (PP) unit root test. Second, the Johansen cointegration test is applied to examine the existence of a cointegration relationship in the panel data. Third, the optimal lag length is determined using the Akaike Information Criterion (AIC) to guide further analysis. Next, the ARDL estimation of short- and long-run effects serves as the main reference for the empirical findings of this study [50]. Finally, conclusions and policy recommendations are provided based on the study's findings.

3. Results and Discussion

3.1. Descriptive Statistics

This section discusses the research data used, including the demand for large livestock and poultry meat, livestock meat prices, per capita income, and fish prices from 2015 to 2022. Table 2 provides a descriptive overview of the data, including the average (mean), median, maximum value, minimum value, and standard deviation.

On average, Indonesians spend Rp54.906 million per year on the consumption of large livestock and poultry meat, with the average price of meat being Rp122,481 thousand per kilogram. When the price of meat decreases by Rp91,000 thousand per kilogram, the demand for meat increases by Rp205,886 million, while a price increase of Rp198,000 thousand leads to a decrease in demand by Rp4.784 million. This decrease in meat demand correspondingly increases the demand for fish as a substitute good, with an average price of Rp24,625 thousand per kilogram. Fluctuations in meat demand are also influenced by changes in per capita income. Indonesia's average income is Rp41,900 million per year. When income rises by Rp183,598 million, meat demand increases, while a decrease of Rp15,988 million reduces meat demand.

$$\Delta DLM_{it} = \alpha_0 + \sum_{j=1}^{q} \beta_1 \Delta DLM_{it-j} + \sum_{j=1}^{p} \beta_2 \Delta POM_{it-j} + \sum_{j=1}^{p} \beta_3 \Delta IPP_{it-j} + \sum_{j=1}^{p} \beta_4 \Delta POF_{it-j} + \pi ECT_{t-1} + \varphi_1 DLM_{it-1} + \varphi_2 POM_{it-1} + \varphi_3 IPP_{it-1} + \varphi_4 POF_{it-1} + \varepsilon_{it} \quad (2)$$

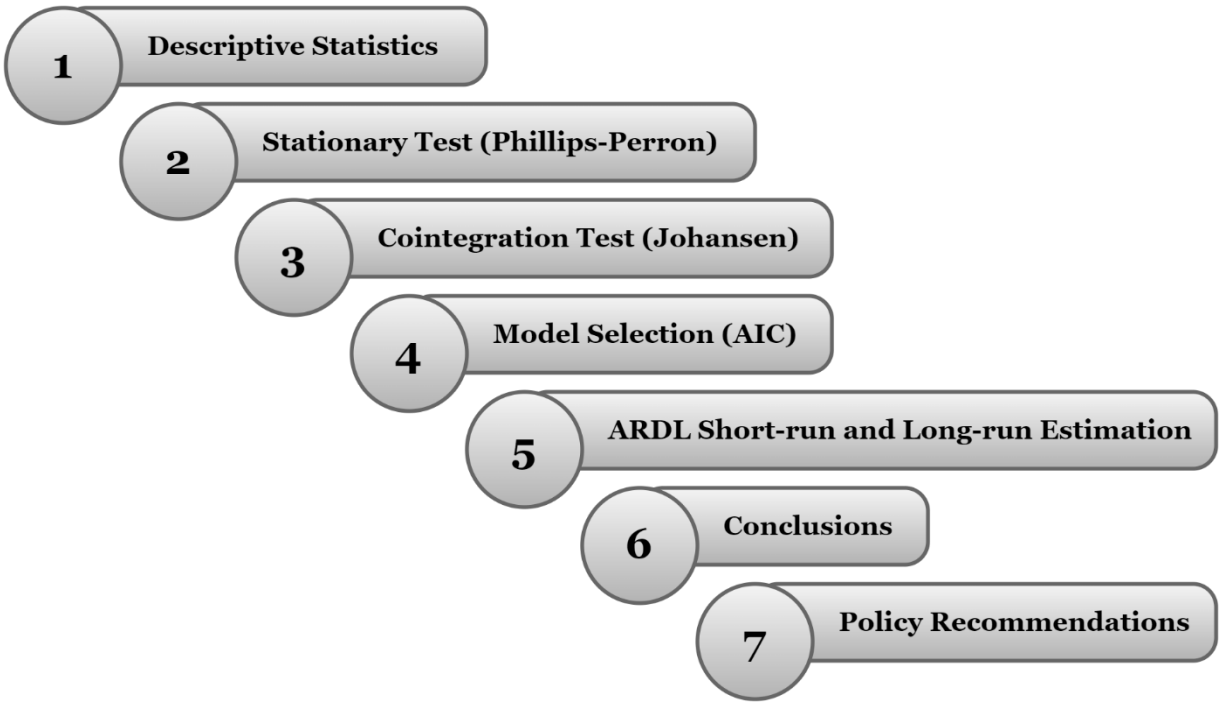

Figure 2. Workflow of the study.

Table 2. Descriptive statistics.

Variable	Mean	Median	Max.	Min.	Std. Dev.
DLM	54.906	46.918	205.89	4.7840	38385
POM	122.48	118.00	198.00	91.000	16948
IPP	41.900	32.940	183.59	11.088	31493
POF	24.625	24.205	39.625	15.988	4704.2

3.2. Stationary Test

The unit root test using the Phillips-Perron method is employed to determine the stationarity of the data. Stationarity is crucial in ARDL analysis, as it ensures accurate results and meaningful interpretation of the relationships between variables in both the short and long run. Non-stationary data can lead to misleading statistical relationships, reflecting general trends or spurious correlations rather than true economic relationships. Therefore, ensuring data stationarity is a critical step before conducting ARDL analysis. Data is considered stationary if the probability value is smaller than the 5% significance level.

Table 3 shows that three variables—demand for livestock meat, price of meat, and price of fish—are non-stationary at the I(0) level, with probabilities of 1.0000, 0.9997, and 1.0000, respectively, which are well above the standard significance level, indicating non-stationarity at this level. In contrast, the income per capita variable does not exhibit unit roots and is stationary at the I(0) level. After first differencing (I(1)), all variables that were previously non-stationary became stationary at the 1% significance level. This indicates that although some variables required differencing to achieve stationarity, the overall dataset eventually fulfills the stationarity requirements necessary for further analysis, such as in an ARDL model.

3.3. Cointegration Test

A cointegration test is conducted to determine whether a long-run relationship exists between the independent and dependent variables. This study employs the Johansen test for cointegration [51]. The results in Table 4 indicate cointegration between the variables in the ARDL model at the 1% and 5% significance levels, confirming the existence of a long-run relationship between the variables.

3.4. Determination of Optimum Lag for ARDL Model

Lag length in the ARDL model is used to capture the influence of time intervals on observations [52]. Determining the optimum lag is crucial in ARDL analysis as it helps eliminate autocorrelation issues in the study [53].

The results of the optimum lag test, shown in Figure 3, indicate that the model with the lowest Akaike Information Criterion (AIC) value is ARDL (2,2,2,2). This model specifies a maximum lag length of 2 for both the

Table 3. Results of the Phillips-Perron (PP) unit root test.

Variable	Level I(0)		First Difference I(I)	
	Prob.	**Conclusion**	**Prob.**	**Conclusion**
DLM	1.0000	Not Stationary	0.0000*	Stationary
POM	0.9997	Not Stationary	0.0000*	Stationary
IPP	0.0000*	Stationary	0.0000*	Stationary
POF	1.0000	Not Stationary	0.0000*	Stationary

Note: * indicates significance at the 1% level.

Table 4. Results of the Johansen cointegration test.

Hypothesized No. of CE(s)	Fisher Stat.* (From Trace Test)	Prob.	Fisher Stat.* (From Max-Eigen Test)	Prob.
None	351.10*	0.0000	241.00*	0.0000
At most 1	176.00*	0.0000	137.80*	0.0000
At most 2	101.90*	0.0049	95.620**	0.0153
At most 3	63.770	0.6229	63.770	0.6229

Note: * and ** indicate significance at the 1% and 5% levels, respectively.

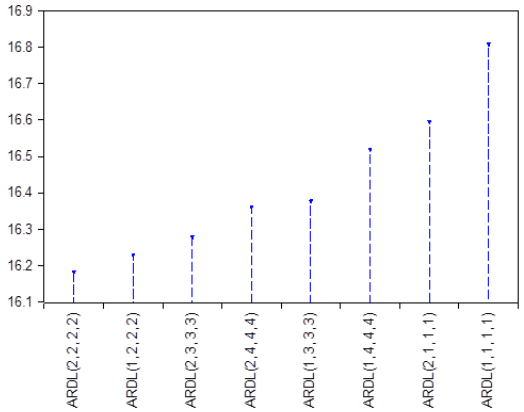

Figure 3. Results of Akaike information criteria.

dependent and independent variables. The lag structure (2,2,2,2) is considered optimal for the ARDL model in this analysis because it has the lowest AIC value [54], reflecting the best balance between model fit and complexity.

3.5. The Results of ARDL Estimation

The ARDL estimation results for the short run, presented in Table 5, show that the coefficient on the Error Correction Term (ECT) is -0.0945 with a probability value of 0.0095, which is significant at the 1% level. This coefficient indicates that approximately 9.45% of the imbalance in the DLM is corrected each quarter, reaching full equilibrium within about 35 quarters or 8.75 years due to shocks in the POM, IPP, and POF variables.

In the short-run ARDL results, POM has a positive effect on DLM with a probability value of 0.0001, but a negative effect in the previous period, with a probability value of 0.0003. An increase in IPP has a negative effect on DLM with a probability value of 0.0028, but a positive effect in the previous period, with a probability value of 0.0084. Changes in POF have no significant effect on DLM, with probability values of 0.4990 in the current period and 0.1242 in the previous period.

In terms of the magnitude of the impact, an increase of Rp1,000 in POM results in an increase in DLM of 0.3066 per kilogram. However, in the previous period, a Rp1,000 increase in DLM causes a decrease of -0.1668 per kilogram. Additionally, a decrease in IPP by Rp1 million in the current period leads to a reduction in DLM of -9.9897 per kilogram. Conversely, an increase in IPP by Rp1 million in the previous period results in an increase in DLM of 5.8663 per kilogram.

In the long run, as shown in Table 6, POM negatively affects DLM with a coefficient value of -0.1104 and a probability value of 0.0379, which is significant at the 5% level. Conversely, IPP and POF have positive effects on DLM, with coefficient values of 0.0938 and 1.1109, and probability values of 0.0094 and 0.0019, respectively, both significant at the 1% level.

3.6. Discussion

In the short run, the demand for livestock meat has a positive effect on the price of meat. This outcome aligns with the positive demand curve, which explains how price influences demand. In the short run, demand for livestock meat may increase due to factors such as a lack of close substitutes, a sudden rise in income per capita, and shifts in consumer preferences [55]. Conversely, in the previous period, the price of meat negatively impacted meat demand, consistent with the law of demand—when prices rise, demand typically falls, and vice versa. The short-run demand for livestock meat can also be influenced by price changes like promotions or discounts available at that time [56].

In the long run, changes in the demand for livestock meat negatively affect meat demand. According to demand

Table 5. Results of short-run ARDL estimation.

Variable	Coeff.	t-stat.	Prob.
ΔDLM(-1)	0.1021*	5.9685	0.0000
ΔPOM	0.3066*	3.9353	0.0001
ΔPOM(-1)	-0.1668*	-3.6351	0.0003
ΔIPP	-9.9898*	-2.9951	0.0028
ΔIPP(-1)	5.8663*	2.6431	0.0084
ΔPOF	-0.3846	-0.6764	0.4990
ΔPOF(-1)	0.5323	1.5394	0.1242
C	-1.9551	-0.3867	0.6991
ECT	-0.0945*	-2.5996	0.0095

Note: * indicates significance at the 1% level.

Table 6. Results of long-run ARDL estimation.

Variable	Coeff.	t-stat.	Prob.
POM	-0.1104***	-1.6664	0.0970
IPP	0.0938*	3.7285	0.0002
POF	1.1109*	12.714	0.0000

Note: * and *** indicate significance at the 1% and 10% levels, respectively.

theory, a lower price of meat leads to an increase in meat demand over time. Meat demand can be strongly influenced by seasons and religious or cultural holidays, during which people are more likely to meet their meat consumption needs [57]. Since meat is considered a luxury item in Indonesia, many people cannot afford to consume it daily and opt for other goods as substitutes for meat protein [17].

In the short run, income per capita negatively impacts the demand for livestock meat. This may be due to factors like a sudden increase in income, which is more likely to be allocated to savings or investment rather than immediate consumption, particularly if people are uncertain about the sustainability of the income increase [58]. In contrast, the previous period showed a positive relationship, where an increase in income led to an immediate rise in meat consumption due to greater financial ability to purchase meat as a luxury item [59].

Over the long run, income per capita has a significant effect on the demand for livestock meat. As income rises over time, people tend to allocate more of their budget to diverse and high-quality foods, including meat, especially during holidays. Demand theory suggests that an increase in income leads to a corresponding rise in the demand for goods. Therefore, demand for livestock meat is closely linked to income per capita; higher income enhances consumer purchasing power. Income serves as a resource that influences meat purchases, although meat consumption may not occur daily but rather at specific times [60].

The price of fish has no effect on the demand for livestock meat in the short run, as prices remain rigid and do not significantly impact demand. Price changes cannot quickly adjust to shifts in demand, thus failing to influence demand in the short run [61]. However, in the long run, the price of fish as a substitute good does affect the demand for livestock meat. Fish is a suitable protein source that can replace meat, and its sustainable availability and affordable price positively impact public demand for daily consumption [48]. This finding is consistent with the law of demand, which states that as the price of goods decreases, demand increases. Since the price of fish is lower than that of meat, a lower price of fish leads to higher demand for fish. When meat prices rise, consumers may seek more affordable alternatives like fish for their daily needs. The price of salted anchovies, for example, serves as a substitute that influences the demand for livestock meat. Through mechanisms such as substitution, changes in income and purchasing power, shifts in consumption patterns, and availability effects, the price of fish can shift consumer preferences from beef to fish.

4. Conclusions and Policy Recommendations

The ARDL estimation results indicate that in the short run, livestock meat prices and per capita income significantly influence meat demand in Indonesia. However, the price of fish does not have an effect in the short run due to its rigidity—price changes do not significantly alter the amount demanded. The price of meat from large livestock and poultry affects meat demand, suggesting that lower meat prices lead to higher demand in the long run. Additionally, per capita income in Indonesia has a long-term impact on meat demand. As incomes increase over time, Indonesians tend to allocate more of their budget to diverse and higher-quality foods, such as meat. The price of fish, as a secondary good, has a positive long-term effect on meat demand because fish serves as a suitable protein source and is often used as a substitute for meat.

Based on these findings, several specific and comprehensive policy recommendations can be proposed. The Ministry of Trade and the Ministry of Agriculture should collaborate to develop a more effective meat stock management system, including upgrading cold storage facilities, improving the distribution network, and implementing a dynamic minimum-maximum price policy to stabilize meat prices over the long term. Additionally, the Ministry of Agriculture should focus on strengthening local livestock development by providing fiscal incentives for farmers, offering technological support to enhance productivity, and intensifying livestock breeding programs to reduce reliance on imports and increase the availability of domestically produced meat. Furthermore, the Food Security Agency should promote the diversification of protein sources by developing and supporting programs that encourage the consumption of more affordable alternatives, such as fish and plant-based proteins. This could be achieved through public education campaigns, subsidies for producers of alternative proteins, and the inclusion of diverse protein options in government food assistance programs.

This study has some limitations that should be acknowledged. First, the time span analyzed (2015–2022) is relatively short and may not fully capture long-term trends. Additionally, the study focuses on a few key variables, leaving out other factors that may influence the demand for livestock meat in Indonesia. The use of aggregate provincial-level data may not accurately reflect variations in demand at the micro or household level. Future research should consider extending the analysis period, incorporating additional variables such as consumer preferences or socio-cultural factors, and using more granular data. Addressing these limitations would enhance the robustness of the findings and provide a more comprehensive understanding, which could guide more precise policy decisions and further research efforts.

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