

Determination of Supply Strategy for Beef Price Stability in Balikpapan: Game Theory Approach

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Informasi Artikel

Riwayat Artikel

Diserahkan : 02-11-2023

Direvisi : 11-11-2023

Diterima : 12-11-2023

Kata Kunci:

Ketersediaan; Sapi;
Stabilitas Harga; Teori
Permainan.

Keywords :

*Availability, Beef, Game
Theory, Price Stability.*

ABSTRAK

Pemenuhan ketersediaan daging sapi perlu diperhatikan untuk menjaga keseimbangan antara pasokan dan permintaan. Pasalnya, pasar kerap mengalami fluktuasi harga akibat ketidakseimbangan stok. Penelitian ini bertujuan untuk mengetahui strategi yang paling efektif dengan pendekatan game theory untuk menjamin ketersediaan daging sapi dan menjaga stabilitas harga di Balikpapan, dimana Balikpapan selalu mendatangkan daging sapi dari luar daerah, baik daging sapi lokal maupun impor. Penelitian ini memberikan wawasan berharga mengenai pentingnya kolaborasi antara pihak-pihak yang terlibat, yaitu pedagang daging sapi lokal dan importir. Penelitian ini juga menjadi panduan bagi para pengambil keputusan di industri daging sapi untuk mencapai keseimbangan optimal antara pasokan dan permintaan. Hasil yang diperoleh melalui analisis strategis murni menunjukkan adanya situasi persaingan antara pedagang lokal dan importir daging sapi. Kedua belah pihak menerapkan strategi yang sama untuk mempertahankan tingkat stok 100%, sehingga menghasilkan nilai permainan menjadi 55.673.262.189.

ABSTRACT

Fulfillment of beef availability needs to be considered to maintain a balance between supply and demand. This is because the market often experiences price fluctuations due to stock imbalances. This research aims to identify the most effective strategy using a game theory approach to guarantee the availability of beef and maintain price stability in Balikpapan, where Balikpapan always brings in beef from outside the area, both local and imported beef. This research provides valuable insight into the importance of collaboration between the parties involved, namely local beef traders and importers. This research also serves as a guide for decision makers in the beef industry to achieve an optimal balance between supply and demand. The results obtained through pure strategic analysis indicate a competitive situation between local traders and beef importers. Both parties adopted the same strategy to maintain a 100% stock level, which resulted value of the game is 55,673,262,189.

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INTRODUCTION

Balikpapan, located in East Kalimantan, is a business and industrial center, the third largest city after Samarinda and Kutai (BPS, 2022). According to data from the Disdukcapil of Balikpapan, the population in this city has grown from 619,983 people in 2017 to 718,423 people in 2022. This significant population growth impacts increasing people's need for food. One of the increasing food needs that occurred in Balikpapan is the consumption of beef. Beef is a product of beef cattle farming and is one of the animal food commodities (Komalasari, 2018). There are two types of beef available, namely local and imported beef. The physical quality of beef, such as color, texture, fat (marbling), taste, and aroma, can be evaluated on local and imported beef. Imported beef is imported from abroad and sold domestically (Gunawan, 2017). Balikpapan citizen has a significant factor in the increasing demand for beef, generally consume animal protein. This demand is divided into two types, namely local and imported beef. In this context, there are two types of competition between local and imported traders, indicating that the two groups of traders must face quite tight competition. This can be seen in figure 1 below.

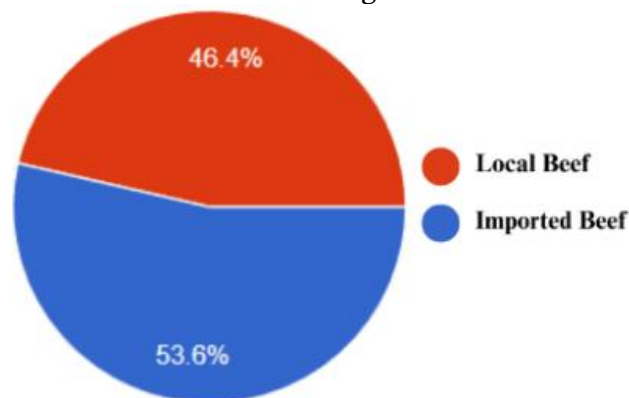


Figure 1. Percentage of Beef Enthusiasts in Balikpapan

Based on Figure 1, the majority of the population in Balikpapan prefers imported beef, influenced by price as the primary consumer factor in choosing beef, based on Figure 2. The beef demand in Balikpapan is influenced by price, instead of quality. If local beef prices are more affordable, the demand for it will be high. However, if imported beef prices are lower, the demand for local beef will probably decrease. This reflects competition between local and imported beef traders to meet market demand at competitive prices.

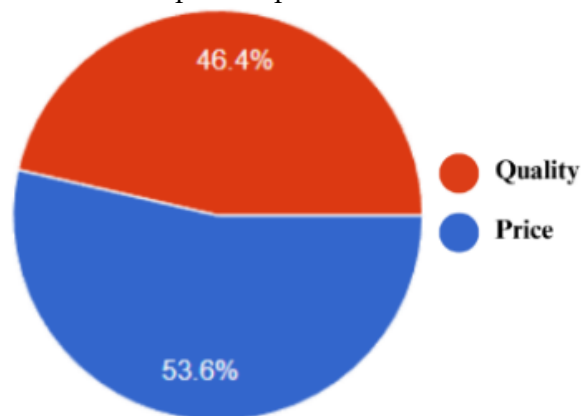


Figure 2. Consumer Preferences in Balikpapan: Price vs. Quality of Beef

According to Ibn Taymiyyah (1996), prices can increase due to a decrease in the supply of goods, resulting in a lack of inventory. Therefore, the price stability of local and imported beef in Balikpapan is influenced by the suitability between the availability and consumption of beef as an animal food requirement for the community. Figure following shows the average beef selling price in the City of Balikpapan in 2016-2022, shown in Table 1.

Table 1 Selling Price of Beef in Balikpapan

Year	Selling Price of Beef (Rp/Kg)	
	Local	Import
2018	125.000	100.000
2019	130.000	100.000
2020	130.000	106.500
2021	135.000	116.500
2022	150.000	120.000

Source: Processed data (2023)

This research uses a game theory approach by considering the problems and facts mentioned regarding the players' decisions in maintaining beef supply availability to maintain market price stability. This approach involves traders with the same goal, namely maintaining price stability. Game theory studies the strategic behavior of two or more players involved in interactions, where one player's strategic decisions can influence the other players' strategic choices. These players aim to maximize their profits or minimize their losses (Siswanto, 2007). In this collaboration, local and imported beef traders can work together to ensure adequate availability of beef to maintain market price stability efficiently, that benefits both parties. By using the cooperative game theory approach, decision-making will result in optimal strategies in supply planning, thereby supporting sustainable supply and stability of beef prices in the City of Balikpapan. The strategy that is considered optimal is based on the pay-off value, which has the maximum (maximum) or minimum (minimum) yield expectation. By using this optimal value in strategy making, it can be predicted that after the game is over, maximum profit or minimal loss will be obtained (Saifuddin et al., 2018). Several studies have been carried out by applying the concept of game theory, including research conducted (Jenar, 2015) developing a reserve inventory system to maintain the stability of sugar prices. The study conducted by (Huda, 2022) analyzes the use of cooperative game theory models in the context of e-wallet competition by using the Markov chain as an optimal strategy. Furthermore, research conducted by (Melati, 2017) explores a game theory approach to optimize the allocation of gas and coal generation costs. Among the competition, the writer chooses local beef traders and beef importers.

Based on theoretical, empirical, and practical gap this study aims to find the optimal strategy and value of games from local beef traders and beef importers in fulfilling availability to maintain beef price stability in Balikpapan using a game theory approach.

This paper is structured as follows. Section 2 reviews the literature review as the main thrust of the research. Section 3 describes the methodology used in this study, followed by Section 4 presents the results and discussion of each step of solving game theory. Finally, conclusions and recommendations for further research are presented in Section 5. The object of study is based on the problems that have been described.

According to Akhmad (2014), game theory was introduced by mathematician John von Neuman and economist Oskar Morgenstern in 1944. Game theory adopts a mathematical approach to describing competition and conflict between various interests. This theory was developed to analyze decision-making processes that involve optimal strategies from different competitive situations involving two or more parties with interacting interests (Juanda & Suciati, 2011). Game theory uses a mathematical approach to analyze competition and conflict between interests. Strategy in games consists of well-defined actions, and although some games offer multiple plans, in some situations, each player only has two different strategies. Rewards (payoffs) are the final results for each player resulting from the matrix (payoffs), and it is assumed that the players are trying to achieve the highest reward they can get (Akhmad, 2014).

The matrix is formed based on the secondary data collected in this study. Even though the data comes from 2016-2020, a forecasting method is used due to the limited secondary data collection until 2020. Three forecasting methods are used: moving averages (MA), weighted averages (WMA), and exponential Smoothing. Moving Average is a forecasting method that uses the Average of recent data to predict future values. This method transforms the time series into a smoother average data series, reflecting fundamental trends or cycles in data patterns over time (Rosdiani, 2018). The Weighted Moving Average is a method similar to the moving average but

with the addition of a weighting coefficient. The weighting coefficient value can be determined freely, but the last period's weighting coefficient is generally double the previous period's (Tampubolon, 2018).

Exponential Smoothing is a short-term forecasting method that assumes data fluctuations around a relatively stable average (Yunika & Sugiono, 2017).

The three forecasting methods are compared based on the lowest MAPE value using the POM QM software, which is used for calculations in management decision-making (Firdaus, 2016). Matrix formation begins with a price matrix, where regression is performed on the supply and selling price data to form the selling price matrix formula. Linear regression is a statistical method used to measure the relationship between two variables and predict variable values more accurately (Katemba & Djoh, 2017). Next, a profit matrix is formed, which refers to the entrepreneur's net income after deducting production costs (Lipsey et al., 1990). The formation of the payoff matrix is carried out based on the results of the profit matrix. A pure strategy settlement can occur if the payoff matrix has been formed. Pure strategy is a game where each player has one optimal strategy with the same game value. A pure strategy is found when a saddle point is found, namely the meeting point between the minimax and maximin concepts (Siswanto, 2007). The maximin-minimax method is used to find the maximum value among the minimum values in each row strategy to minimize losses and to find the minimum value among the maximum values in each column strategy to maximize profits (Supranto, 2013). Once the saddle point on the pure strategy solution is found, a sensitivity analysis is performed to evaluate the impact of supply conditions changes on the settlement outcome.

METHODS

This type of descriptive-analytical research aims to describe the results of the analysis of an object of research. In this study, the authors used quantitative data obtained secondary from the Department of Agricultural Food, City of Balikpapan, the Department of Animal Health, Province of East Kalimantan, and interviews. Figure 3 shows the stages in solving game theory in this study.

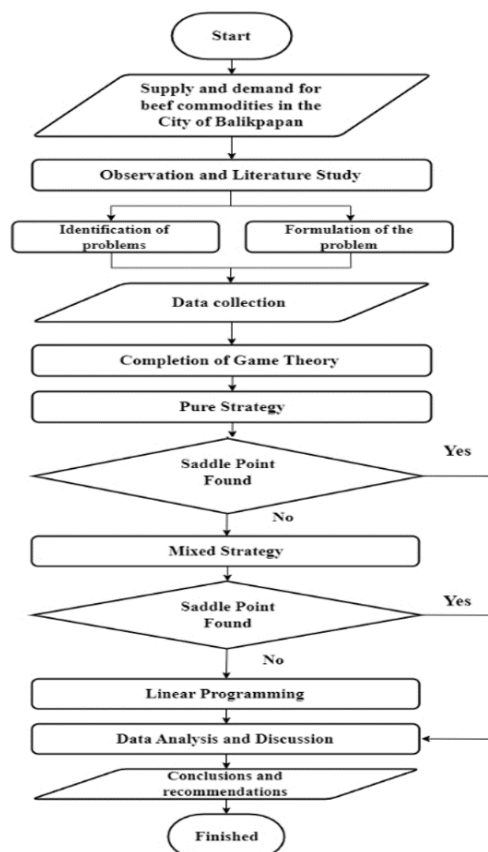


Figure 3. The solving stages

Table 2 Supply and Demand Price of Beef in Balikpapan

Year	Local				Import			
	Supply of Beef (Kg)	Selling Price (Rp/Kg)	Purchase Price (Rp/Kg)	Operating Costs (Rp/Kg)	Supply of Beef (Kg)	Selling Price (Rp/Kg)	Purchase Price (Rp/Kg)	Operating Costs (Rp/Kg)
2016	2.050.000	115.000	NA	NA	834.000	NA	NA	NA
2017	1.843.000	120.000	NA	NA	1.160.000	NA	NA	NA
2018	1.891.000	125.000	NA	NA	2.108.000	100.000	NA	NA
2019	1.556.000	130.000	NA	NA	3.609.000	100.000	NA	NA
2020	1.692.000	130.000	NA	NA	1.893.000	106.500	NA	NA
2021	NA	135.000	51.343	45.829	NA	116.500	72.657	37.745
2022	NA	150.000	57.375	47.579	NA	120.000	75.000	42.000

Source: Processed data (2023)

The table 2 shows fluctuations in beef supply, both local and imported, from 2018 to 2020; local supply has decreased in value from 1,891,000 kg in 2018 to 1,692,000 kg in 2020, in contrast to the import supply in 2018 with a value of 2,108,000 kg experienced a significant increase of 3,609,000 kg in 2019, but decreased in the following year, namely 2020, to 1,893,000 kg. The purchase price for local beef is Rp. 46,700 per kg in 2018, which increased in the following year, namely in 2020, to Rp. 56,100 per kg. The purchase price of imported beef has fluctuated from Rp. 72,657 in 2021 has increased to Rp 75,000 per kg in 2022.

Forecasting

Forecasting in this study was carried out to see predictions of future local meat supply using the POM-QM application for Windows by applying time series methods such as Moving Average, Weighted Moving Average, and Exponential Smoothing. The best forecast method is the method which has the lowest MAPE (Mean Absolute Percentage Error).

Game Attributes

Table 3 Supply Strategy

Supply Strategy	Variables Used	
	Local Beef Trader (Player 1)	Beef Importer (Player 2)
25% (S1)	p ₁	q ₁
50% (S2)	p ₂	q ₂
75% (S3)	p ₃	q ₃
100% (S4)	p ₄	q ₄

Source: Processed data (2023)

Based on the Table 3, determination of the matrix first determined the attributes of the variables to be used. There are four scenarios or supply strategies, namely supply strategies of 25%, 50%, 75%, and 100%, which are assumed to supply beef in the market. This scenario applies to both players.

Formation of The Profit Matrix

Profit is the net Income received by a company after deducting production costs, or it can be referred to as the entrepreneur's profit which means the difference between gross income and production costs. The formula for calculating total receipts:

$$TR = Q \cdot p_q \dots \dots \dots (4)$$

Where:

TR = Total receipts

Q = Number of products sold

P_q = Price per unit of product

$$I = TR - TC \dots \dots \dots (5)$$

Where:

I = Income (profit)

TR = Total Revenue (total revenue)

TC = Total cost (total cost)

RESULTS AND DISCUSSION

In this study, forecasting of local and imported supply beef stocks was carried out using the Moving Average (MA), Weighted Moving Average (WMA), and Exponential Smoothing (ES) methods using the POM-QM for Windows application. Forecasting results show that the WMA method was chosen because it has the lowest MAPE, namely 0%, with an estimated local and import supply respectively are 1,856,550 kg/year and 1,692,450 kg/year in the coming year. The WMA method with 5-period weighting was chosen because it emphasizes the latest data and produces forecasts responsive to changes in stock trends. This helps local beef traders in planning procurement by anticipating fluctuations in demand.

Table 4 Recapitulations of Local Meat Supply Forecasting Output

Method	2021	MAPE
MA	1806400	8,452%
WMA	1856550	0%
ES (0,1)	1941771	16,119%
ES (0,2)	1857811	14,319%
ES (0,3)	1794187	12,718%
ES (0,4)	1747459	11,298%
ES (0,5)	1714688	10,04%
ES (0,6)	1693427	8,927%
ES (0,7)	1681731	8,95%
ES (0,8)	1678147	9,28%
ES (0,9)	1681723	10,026%

Source: Processed data (2023)

Tabel 5 WMA weighting on local meat supply

Year	Supply	Weight
2016	2.050.000	0,10
2017	1.843.000	0,15
2018	1.891.000	0,20
2019	1.556.000	0,25
2020	1.692.000	0,30
Total	9.032.000	1,00

Source: Processed data (2023)

Tabel 6 Recapitulations of Imported Meat Supply Forecasting Output

Method	2021	MAPE
MA	1920800	1,836%
WMA	1692450	0%
ES (0,1)	1316609	48,343%
ES (0,2)	1686254	41,871%
ES (0,3)	1955273	38,251%
ES (0,4)	2135223	41,071%
ES (0,5)	2236825	43,53%
ES (0,6)	2270223	45,665%
ES (0,7)	2244474	47,472%
ES (0,8)	2168055	49,006%
ES (0,9)	2048609	50,283%

Source: Processed data (2023)

Tabel 7 WMA Weighting on Imported Meat Supply

Year	Supply	Weight
2016	834.000	0,10
2017	1.160.000	0,15
2018	2.108.000	0,20
2019	3.609.000	0,25
2020	1.893.000	0,30
Total	9.604.000	1,00

Source: Processed data (2023)

Selling Price Matrix

At this stage, the selling price matrix based on table 8 below. The following are the stages in making the price matrix :

Calculate local and imported meat supply for each of the four strategic percentages. It is known that local and imported supplies were 1,856,550 kg and 1,692,450 kg, respectively. Player 1

$$\begin{aligned}\text{Strategy 1} &= \% \times \text{local supply} \\ &= 25\% \times 1.856.550 = 464.138\end{aligned}$$

$$\begin{aligned}\text{Strategy 2} &= \% \times \text{local supply} \\ &= 50\% \times 1.856.550 = 928.275 \text{ etc.}\end{aligned}$$

Player 2

$$\begin{aligned}\text{Strategy 1} &= \% \times \text{import supply} \\ &= 25\% \times 1.692.450 = 423.113\end{aligned}$$

$$\begin{aligned}\text{Strategy 2} &= \% \times \text{import supply} \\ &= 50\% \times 1.692.450 = 846.225 \text{ etc.}\end{aligned}$$

The players fill in the matrix column values by calculating formula for local beef traders and formula for beef importers. Input supply from each of the four supply strategies.

Player 1

$$\begin{aligned}\text{Scenario 1} &= -0,0024 \times \text{supply} + \text{Rp } 134.170 \\ &= -0,0024 \times 464.138 + 134.170 \\ &= 133,064\end{aligned}$$

$$\begin{aligned}\text{Scenario 2} &= -0,0024 \times \text{supply} + 134.170 \\ &= -0,0024 \times 928.275 + 134.170 \\ &= 131.957 \text{ etc.}\end{aligned}$$

Player 2

$$\begin{aligned}\text{Scenario 1} &= -0,0058 \times \text{supply} + 119.259 \\ &= -0,0058 \times 423.113 + 119.259 \\ &= 116.802\end{aligned}$$

$$\begin{aligned}\text{Scenario 2} &= -0,0058 \times \text{supply} + 119.259 \\ &= -0,0058 \times 846.225 + 119.259 \\ &= 114.344 \text{ etc}\end{aligned}$$

Increasing supply only sometimes positively impacts selling prices in the market. The difference in selling price between Player 1 and 2 shows the difference in strategy and effectiveness in supply management. Player 1 consistently has higher selling prices, indicating a competitive advantage in supply management. There is a correlation between the level of player supply and changes in market selling prices. A decrease in supply tends to increase the selling price, while an increase in supply can cause a reduction in the selling price. Next, make a profit matrix based on the predetermined selling price.

Tabel 8 Selling Price Matrix

Beef Importer (Player 2)									
Local Beef Trader (Player 1)		423.113 (kg) (25%)		846.225 (50%)		1.269.338 (75%)		1.692.450 (100%)	
	464.138 (25%)	Rp 133.064	Rp 116.802	Rp 133.064	Rp 114.344	Rp 133.064	Rp 111.886	Rp 133.064	Rp 109.428
	928.275 (50%)	Rp 131.957	Rp 116.802	Rp 131.957	Rp 114.344	Rp 131.957	Rp 111.886	Rp 131.957	Rp 109.428
	1.392.413 (75%)	Rp 130.850	Rp 116.802	Rp 130.850	Rp 114.344	Rp 130.850	Rp 111.886	Rp 130.850	Rp 109.428
	1.856.550 (100%)	Rp 129.743	Rp 116.802	Rp 129.743	Rp 114.344	Rp 129.743	Rp 111.886	Rp 129.743	Rp 109.428

*Source: Processed data (2023)***Tabel 9 Profit Matrix**

Beef Importer (Player 2)									
Local Beef Trader (Player 1)		423.113 (25%)		846.225 (50%)		1.269.338 (75%)		1.692.450 (100%)	
	464.138 (25%)	61.759 x 10 ⁶	49.420 x 10 ⁶	61.759 x 10 ⁶	96.760 x 10 ⁶	61.759 x 10 ⁶	142.020. x 10 ⁶	61.759 x 10 ⁶	185.201. x 10 ⁶
	928.275 (50%)	122.492 x 10 ⁶	49.420 x 10 ⁶	122.492 x 10 ⁶	96.760 x 10 ⁶	122.492 x 10 ⁶	142.020. x 10 ⁶	122.492 x 10 ⁶	185.201. x 10 ⁶
	1.392.413 (75%)	182.197 x 10 ⁶	49.420 x 10 ⁶	182.197 x 10 ⁶	96.760 x 10 ⁶	182.197 x 10 ⁶	142.020. x 10 ⁶	182.197 x 10 ⁶	185.201. x 10 ⁶
	1.856.550 (100%)	240.874 x 10 ⁶	49.420 x 10 ⁶	240.874 x 10 ⁶	96.760 x 10 ⁶	240.874 x 10 ⁶	142.020. x 10 ⁶	240.874 x 10 ⁶	185.201. x 10 ⁶

Source: Processed data (2023)

Before making the profit matrix in Table 9, the essential operation of the calculation is carried out using the profit formula, with the input supply and price of each being adjusted to the players' strategies. The primary operational stages of forming a profit matrix are:

1. The players know the operating costs and the purchase price in 2021.
2. Calculating the profit from formula by inputting the supply of each strategy and the price of the selling price matrix.

Player 1

$$\begin{aligned}
 S1 &= \text{supply} \times \text{price} - (\text{operating costs} + \text{purchase price}) \\
 &= 464.138 \ 133.064 - (45.829 + 51.343) \\
 &= 61.759.822.380
 \end{aligned}$$

$$\begin{aligned}
 S2 &= \text{supply} \times \text{price} - (\text{operating cost} + \text{purchase price}) \\
 &= 928.27 \ 131.957 - (45.829 + 51.343) \\
 &= 122.492.267.009 \text{ etc}
 \end{aligned}$$

Player 2

$$\begin{aligned}
 S1 &= \text{supply} \times \text{price} - (\text{operating costs} + \text{purchase price}) \\
 &= 423.113 \ 116.802 - (37.745 + 72.657) \\
 &= 49.420.185.048
 \end{aligned}$$

$$\begin{aligned}
 S2 &= \text{supply} \times \text{price} - (\text{operating costs} + \text{purchase price}) \\
 &= 846.225 \ 114.344 - (37.745 + 72.657) \\
 &= 96.760.546.817 \text{ etc.}
 \end{aligned}$$

3. Compare the results of player I and player II, then mark the color for the players who get the minimum value on the profit of each strategy.

In the profit matrix results, local beef traders (player 1) earn a minimum profit of 6, while beef importers (player 2) earn a minimum profit of 10. Then, the difference between Player 1 and Player 2 profits is calculated based on the profit matrix. This calculation aims to form a payoff matrix that will be used in further analysis.

Payoff matrix

The formation of the payoff matrix, in table 10, is an essential step in analyzing a strategy game between players 1 and 2. By calculating the profit difference based on the previous profit matrix, we can describe the competition between the two players. The payoff matrix is a visual Table 11, showing how Player 1's and Player 2's profits change depending on their chosen strategy. Payoff matrix analysis helps evaluate strategy and understand interactions between players.

Table 10 Payoff Matrix

		Beef Importer (Player 2)			
		423.113 (25%)	846.225 (50%)	1.269.338 (75%)	1.692.450 (100%)
Local Beef Trader (Player 1)	464.138 (25%)	12.339.637.332	-35.000.724.437	80.261.152.525	123.441.646.933
	928.275 (50%)	73.072.081.962	25.731.720.193	19.528.707.895	-62.709.202.303
	1.392.413 (75%)	132.777.051.669	85.436.689.900	40.176.261.812	-3.004.232.596
	1.856.550 (100%)	191.454.546.454	144.114.184.685	98.853.756.597	55.673.262.189

Table 11 Strategy Matrix

		Beef Importer (Player 2)				Min. Row	Maximin
		423.113 (25%)	846.225 (50%)	1.269.338 (75%)	1.692.450 (100%)		
Local Beef Trade r (Play er 1)	464.138 (25%)	12.339.637.332	-35.000.724.437	80.261.152.525	123.441.646.933	123.441.646.933	55.673.262.189
	928.275 (50%)	73.072.081.962	25.731.720.193	19.528.707.895	62.709.202.303	62.709.202.303	
	1.392.413 (75%)	132.777.051.669	85.436.689.900	40.176.261.812	3.004.232.596	3.004.232.596	
	1.856.550 (100%)	191.454.546.454	144.114.184.685	98.853.756.597	55.673.262.189	55.673.262.189	
Max. Column		191.454.546.454	144.114.184.685	98.853.756.597	55.673.262.189		
Minimax		55.673.262.189					

 = Saddle Point

By solving a strategy matrix that looks for the smallest value in each row and the most considerable value in each column, we can determine the maximum and minimum values of the payoff matrix. Table 11 shows that the maximum value is 55,673,262,189, which is the maximum value among the minimum values in each row and can be considered as the lower limit of the game (V). In addition, there is also a minimax value of 55,673,262,189, which is the minimum

among the maximum values in each column and can be considered the upper limit of the game (V). Thus, it can be concluded that $= V$ indicates a saddle point in the payoff matrix. It was found that the optimal strategy for both players was to stock meat at 100% of the year's demand. In this calculation, player one stocks up to 1,856,550 kg of meat per year, while player two stocks up to 1,692,450 kg. Both can maximize their profits by stocking the quantity of meat covering the entire year's demand.

CONCLUSION

The conclusion based on the completion of the research results is as follows: This study has shown based on the research conducted and discussed in the previous chapter: Based on the completion of game theory using pure strategy, the game value of the two players is 55,673,262,189. The optimal strategy for local traders is to use the "p4" strategy with a supply of 1,856,550 kg per year, which generates a profit of Rp 240,874,731,502. Meanwhile, the optimal strategy for beef importers is to use the "q4" strategy with a supply of 1,692,450 kg per year, which generates a profit of IDR 185,201,469,312

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