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Optimization of sustainability, selling price, and minimum cost transportation in supply chain management of free-range meat chicken in Pasuruan Regency, Indonesia

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Abstract

The purpose of the study was to analyze the sustainability of supply of free-range meat chicken in Pasuruan Regency, Indonesia and to obtain an optimization model of selling price and transportation costs of the free-range meat chicken. Artificial neural networks was used to analyse the sustainability of free-range meat chicken supply while linear programming was used to optimize the selling price. In addition, Vogel's approximation was used to obtain the minimum total cost of transportation. The outcome of the analysis showed that the availability of free-range meat chicken in 2022 was estimated around 40, 016.67 tons with a selling price of IDR 28,100/kg. The minimum overall transportation cost was IDR 3,807,000/quintal.

1. Introduction

Broiler business in Indonesia are good prospects. This condition is shown by many opening of new restaurants and supermarkets, increasing population, increasing public awareness of nutritional fulfillment, increasing community needs at certain times such as birthday parties, wedding parties, the tendency of selling prices high at certain times such as the fasting month, Eid al-Fitr, Christmas and others. Increased public interest in running a business of free-range broiler is very influential in increasing community activities (Amenuri and Soekarno, 2010). The success of the management of a broiler is closely related to technical production, management and marketing (Rasyaf, 2002). These three things are very closely related to the supply chain. Borade and Bansod (2008) stated that the supply chain is a network of facilities and distribution channels which includes the procurement of raw materials, production, management and marketing.

The supply chain is closely related to the logistics system and inventory system. The term supply chain system is often interchangeable with logistical systems while the inventory system has been understood as an integral part of both. Vorst *et al*. (2007) and Simchi-Leci *et al*. (2000) stated that logistics is part of the supply chain process in terms of planning, implementing and controlling efficiently and effectively the flow and storage of materials, services and related information from point of origin to destination point in order to meet customer needs and satisfy the needs of stakeholders. Logistics aspects consist of customer service, transportation, storage, factory location selection, inventory control, ordering process, distribution, procurement, and demand forecast.

Supply chain research have been very diverse in the manufacturing and agro-industry sectors. The types of supply chains discussed also vary, from simple supply chains to complex networks. Various model completion techniques have also been applied ranging from operations research techniques to artificial intelligence. Production collaboration is often considered based on some of the results of previous studies in collaboration with external suppliers (Meixell and Gargeya, 2005) and the completion of the model needs to consider the use of efficient techniques to get a good solution (Shen, 2007). Advanced optimization techniques are becoming a new approach in the field of supply chain management. The

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application of genetic algorithms has been done by Sha and Che (2006), Keskin and Uster (2007), Aliev *et al*. (2007), and Radhakrishnan *et al*. (2009). Fuzzy logic is specifically applied by Petrovic and Petrovic (1999), while Rohde (2004) applied artificial neural networks combined with analytic methods. Heuristic techniques are also often used as Kagnicioglu (2006), while heuristics by Sabri and Beamon (2000) and Aghezzaf (2005).

Supply chain management practices are increasingly developing in various fields of industry. Vorst *ert al*. (2000) categorized supply chain management practices into three namely collaborative demand planning and procurement, production collaboration and logistics planning collaboration. Collaboration on-demand and procurement planning is developed from the inventory system. Giannakis and Croom (2004) assessed the three dimensions of strategic streams of supply chain management theory, namely synthesis, synergy and synchronization. The synthesis dimension is related to the physical structure of the supply chain, synergy is related to the interaction of decision makers in the supply chain and synchronization is related to the coordination and control of the operational processes along the supply chain. Santoso and Noval (2019) stated that supply chain management in a business entity must pay attention to the process of managing the flow of goods from upstream to downstream.

Budiman (2013) stated that the condition of the supply chain of free-range meat chicken that occurred during this time is the process of animal husbandry, bought by a contractor, entered the slaughterhouse, then distributed to supermarkets and through traders to end-users. Muhammad and Sumarauw (2014) added that the performance of chicken meat supply chain management will run well if they have a reserve breeder as an alternative to minimize production time by adding workers in the production section. Mongilala (2016) stated that the distribution flow of broiler supply chains on farms starts from breeders selling their livestock production to companies, then the company sells to contract partners who have ordered. The contractor then processes the live broilers and then distribute to contract traders, traders retailers, restaurants, supermarkets/ hypermarkets and sold directly to consumers.

The supply chain of free-range meat chicken in Pasuruan Regency currently involved three main actors, namely; breeder, collector, and chicken slaughterhouse. Preliminary survey results in showed that there were thirty free-range chicken farmers, five collectors, and fifteen units of active slaughtering chicken slaughtering in Pasuruan Regency. The fifiteen units of free-range meat chicken slaughtering business units every day gets their supply from five collectors as many as 25,000 heads (5000 heads/collectors). The collection of chicken ready for slaughter by the business unit can only be done by collectors. This activity occurs, because collectors have a partnership agreement between the farmer and the local chicken slaughtering business unit. The purpose of the study was to analyze the sustainability of supply of free-range meat chicken in Pasuruan Regency and to obtain an optimization model of selling price and transportation costs.

2. Materials and methods

This research was conducted in three districts (Beji, Gempol, Rejoso) of Pasuruan Regency, East Java Province, Indonesia. Data collection was carried out on fifty respondents consisting of thirty farmers, five collectors, and fifiteen small and medium enterprise (SME) free-range meat chicken producer. Analysis of Artificial Neural Network (ANN) was to analyze the sustainability of free-range poultry supply. Limitation of this study include forecasting the volume of sales of broilers for the continuation of supply in the next year and the iteration with ANN which is equal to 500.

The optimal selling price was obtained from the mathematical equation model obtained from the linear programming method based on the selling price of free-range meat chicken all the districts. According to Darmawan (2004), linear programming is a mathematical technique used to allocate limited resources between competing activities to maximize the value of the objective function. The LP model has three basic elements: (1) objective function, (2) constraints and requirements, and (3) activity or decision variables.

The minimization of transportation costs was obtained from the mathematical equation model obtained from the Vogel's Approximation Method (VAM) based on the cost of transporting. According to Darmawan (2004), transportation cost optimization was analyzed using VAM. Transportation problems relate to the distribution of a single product from several sources, with limited supply, to several destinations, with specific demands, at minimum transport costs. This method was used because it provided a better initial solution compared to other methods. After the initial solution was obtained, improvements were made to find the optimal solution with Stepping Stone and Modified Distribution (MODI). Both linear programming and VAM used the Win QSB program

3. Results and discussion

3.1 Supply

Data on the supply of free-range meat chicken during 2013-2017 is shown in Table 1.

Table 1 shows an increase in the availability of free-range meat chicken to free-slaughter chicken SMEs by 27.8% (8,878 tons). This increase is due to several things, namely; public awareness of nutrition and the many new opening of restaurants. The forecasting the availability of free-range meat chicken for 2018-2022 was based on 2013-2017 data using the Artificial Neural Network (ANN) method with backpropagation algorithm using 12 input layers, 12 hidden layers, and an output layer of 1. The results are shown in Table 2.

Table 1. Supply of free-range meat chicken in 2013-2017

Month	2013 (ton)	2014 (ton)	2015 (ton)	2016 (ton)	2017 (ton)
January	1,738	1,830	1,926	2,003	2,124
February	1,808	1,903	2,003	2,083	2,208
March	1,862	1,960	2,083	2,167	2,297
April	1,899	1,999	2,167	2,253	2,389
May	1,956	2,059	2,253	2,344	2,484
June	1,996	2,101	2,344	2,437	2,584
July	1,956	2,059	2,437	2,535	2,687
August	1,936	2,038	2,535	2,636	2,794
September	1,878	1,977	2,636	2,742	2,906
October	1,916	2,016	2,742	2,851	3,022
November	1,992	2,097	2,851	2,965	3,143
December	2,092	2,202	2,965	3,084	3,269
Total	23,030	24,242	28,944	30,102	31,908

Table 2. Supply of free-range meat chicken in 2018-2022

Month	2018 (ton)	2019 (ton)	2020 (ton)	2021 (ton)	2022 (ton)
January	2,775.78	3,311.09	3,334.37	3,334.72	3,334.72
February	2,95398	3,323.69	3,334.56	3,334.72	3,334.72
March	3,132.80	3,330.66	3,334.66	3,334.72	3,334.72
April	3,220.32	3,332.73	3,334.69	3,334.72	3,334.72
May	3,250.64	3,333.31	3,334.70	3,334.72	3,334.72
June	3,280.53	3,333.87	3,334.71	3,334.72	3,334.72
July	3,303.53	3,334.28	3,334.72	3,334.72	3,334.72
August	3,319.71	3,334.57	3,334.72	3,334.72	3,334.72
September	3,325.70	3,334.64	3,334.72	3,334.72	3,334.72
October	3,327.65	3,334.62	3,334.72	3,334.72	3,334.72
November	3,331.53	3,334.69	3,334.72	3,334.72	3,334.72
December	3,333.33	3,334.69	3,334.72	3,334.72	3,334.72
Total	38,555.52	39,972.85	40,016.02	40,016.66	40,016.67

Error = 0.011376
MSE = 331.008701
MAE = 12.480307

Table 2 shows the value of MAE at 12, 48 and the value of MSE of 331.00. MSE value is said to be very good if the resulting error value is less than 10%, good if the resulting error value is between 10 - 25%, while the value is not good if the resulting error value is more than 25%. The value of testing results with epoch 100 generated an error value of 0.01 (1%), meaning that the ANN results are categorized very well so that the best parameters obtained indicated that this model is suitable for predicting the availability of free-range meat chicken with good MSE value. ANN analysis results showed an increase in the availability of free-range meat chicken during 2018-2022 by 1,461.15 tons (3.65%) from 2018 by 38,555.52 tons to 2022 by 40,016.67 tons.

3.2 Demand

Data on demand for free-range meat chicken in free-slaughter chicken SMEs during 2013-2017 is shown in Table 3.

Table 3 shows an increase in demand for free-range meat chicken at free-slaughter chicken SMEs by 45.55% (25,864 tons). This increase is due to several things, namely; public awareness of nutrition and the many new opening of restaurants. The calculation of demand for free-range meat chicken for 2018-2022 was based on 2013-2017 data using the Artificial Neural Network (ANN) method with a backpropagation algorithm using 12 input layers , 12 hidden layers , and an output layer of 1. The results are shown in Table 4.

Table 3. Demand of free-range meat chicken during 2013-2017

Month	2013 (ton)	2014 (ton)	2015 (ton)	2016 (ton)	2017 (ton)
January	2,333	2,456	2,586	3,329	4,286
February	2,427	2,554	2,689	3,462	4,457
March	2,500	2,631	2,770	3,566	4,591
April	2,550	2,684	2,825	3,637	4,683
May	2,626	2,764	2,910	3,746	4,823
June	2,679	2,820	2,968	3,821	4,920
July	2,625	2,763	2,909	3,745	4,821
August	2,599	2,736	2,880	3,707	4,773
September	2,521	2,653	2,793	3,596	4,630
October	2,571	2,707	2,849	3,668	4,723
November	2,674	2,815	2,963	3,815	4,912
December	2,808	2,956	3,111	4,006	5,157
Total	30,912	32,538	34,251	44,098	56,776

Table 4 shows MAE values of 52, 25 and MSE values of 4731.73. The value of testing results with epoch 100 generated an error value of 0.05 (5%), meaning that the ANN results are categorized very well, so that the best parameters obtained indicate that this model is suitable for predicting demand for free-range chicken with MSE values of good value. ANN analysis results showed an increase in demand for free-range meat chicken during 2018-2022 by 497.73 tons (0.8%) from 2018 by 62,318.77 tons to 2022 by 62,816.5 tons.

The company has prepared resources to facilitate the demand from those needed to supply resources and expertise in operations to meet demand needs. Companies that ask for help increase value by asking for

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help (Christopher and Gattorna 2005; Jüttner *et al.*, 2007). Integrating demand and supply processes helps companies prioritize and guarantee fulfillment based on shared generation, dissemination, interpretation and application of real-time customer demand and ongoing supply needs.

Table 4. Demand of free-range meat chicken during 2018-2022

Month	2018 (ton)	2019 (ton)	2020 (ton)	2021 (ton)	2022 (ton)
January	5,152.94	5,231.38	5,234.62	5,234.71	5,234.71
February	5,176.35	5,232.63	5,234.67	5,234.71	5,234.71
March	5,189.75	5,232.98	5,234.65	5,234.71	5,234.71
April	5,202.57	5,233.45	5,234.63	5,234.70	5,234.71
May	5,206.06	5,232.74	5,234.54	5,234.69	5,234.71
June	5,206.63	5,231.99	5,234.48	5,234.69	5,234.71
July	5,184.74	5,230.61	5,234.43	5,234.69	5,234.71
August	5,176.35	5,230.71	5,234.48	5,234.70	5,234.71
September	5,173.42	5,231.46	5,234.55	5,234.70	5,234.71
October	5,199.57	5,233.11	5,234.64	5,234.71	5,234.71
November	5,218.59	5,234.08	5,234.69	5,234.71	5,234.71
December	5,230.81	5,234.58	5,234.71	5,234.71	5,234.71
Total	62,318.77	62,790.70	62,815.08	62,816.42	62,816.50

Error = 0.048218
MSE = 4731.734846
MAE = 52.252267

3.3 Optimization model for selling chicken meat

Pricing is the most important attribute where a company is implementing its competitive strategy. Therefore, price is recognized as one of the most sensitive factors between the relationship between suppliers and customers (Li and Liu, 2006). Analysis of the optimal selling price will provide positive support for the development of free-range meat chicken in Pasuruan Regency. However, this study is limited by the calculation of the profits received by the slaughter of free -range chicken in the studied districts. The average selling price was used as a basis for linear programming (LP) modeling. The solution to the optimal selling price coefficient value received by free-slaughter chicken SMEs in Pasuruan Regency is shown in Table 5.

Table 5 shows the optimal selling price of free-range meat chicken which is IDR 28,100/kg. Altenburg (2006) revealed a new fact about supply chain management that occurred in developing countries, namely the existence of a fundamental shift in the function of marketing the products produced by producers, as an initial step to improve the ability of companies with several implications for developing countries. Among them, minimizing the company's involvement in determining the value chain in carrying out the production process in accordance with applicable standards. The competitiveness of each company chain may go up or down, because in developing countries each company chain is still in the growing stage. Renegotiating for-profit and risks and are conveyed to customers, retailers, wholesalers, producers and distributors, and do not cover the possibility of affecting the level of efficiency by decreasing or increasing the quality of the value chain, inventory levels and prices of goods and services. Batt (2004) stated that the existence of SCM in the development of agro-industry is very necessary, because in the agro-industry sellers and traders play a very important role in determining the selling price received by consumers. The quality and cost of transportation are the most basic things in determining the selling price.

Price negotiation through offers provides an alternative to coordinating the supply chain in an intuitive cooperative game structure (Iyer and Villas-Boas, 2003). Pricing for supply chain participants has been achieved through bargaining, where profits can be optimally shared between producers and retailers (Li *et al.*, 2002; Yue *et al.*, 2006).

3.4 Model of minimization of transportation costs for free-range meat chicken

Transportation analysis is very necessary in developing SCM free-range meat chicken because transportation is used to regulate the distribution of sources that provide products to the places that need it optimally. The mode of transportation in the studied districts are rental pick-up type with a transport capacity of 3 quintals. The variable transportation costs include;

Table 5. The coefficient value and optimal selling price

	Beji District	Gempol District	Rejoso District		RHS
Maximize	5000	5500	5800		
Pasuruan Regency	100	100	100	<=	500
Malang City	100	100	100	<=	500
Sidoarjo Regency	200	100	200	<=	700
Surabaya City	500	200	300	<=	1500
Gresik Regency	200	100	100	<=	600
Pontianak City	200	100	100	<=	500
Palangkaraya City	300	0	0	<=	500
Solution	0	3	2		28,100

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Table 6. Total minimum transportation costs

From	To	Shipment (quintal)	Cost/quintal (xIDR1000)	Shipment cost (xIDR1000)
Beji District	Malang City	5	50	250
Beji District	Sidoarjo Regency	7	50	350
Beji District	Surabaya City	3	65	195
Gempol District	Surabaya City	12	70	840
Gempol District	Gresik Regency	6	77	462
Gempol District	Pontianak City	2	138	276
Rejoso District	Pasuruan Regency	5	50	250
Rejoso District	Pontianak City	3	148	444
Rejoso District	Palangkaraya City	5	148	740
Total cost				3,807

rental pick up , gasoline, road user charges, porters and shipping costs. Table 6 shows the value of the matrix solution resulting from the allocation of free-range meat chicken using the VAM method.

Table 6 shows the total minimum transportation cost of free-range meat chicken per quintal of IDR 3,807,000/ quintal. The calculation of total minimum transportation costs is obtained from the allocation of free-range meat chicken using the VAM method into the mathematical model. Transportation is a function of moving goods from the place of goods produced to the place of goods consumed. In relation to transportation, members of distribution channels need to pay attention to transportation decisions. The options in transportation affects the product pricing, the shipping performance (on time) and the condition of the goods when they arrive at their destination. In general, the distributor chooses a transportation model based on cost criteria.

The role of distribution and transportation networks is vital. This distribution and transportation network is closely related to suppliers, customers, production, thus allowing products to move from the location where they are produced to the location of consumers/users who are often limited by great distances (Gansterer *et al*., 2014). The ability to deliver products to customers in a timely manner, in the appropriate amount and in good conditions will determine whether the product will ultimately be competitive in the market (Pujawan and Mahendrawati, 2005).

Traditionally, distribution networks are expressed as a series of physical facilities such as warehouses and transportation facilities and the operation of each of these facilities tends to be separated from one another (Chopra and Meindl, 2001). Various types of losses caused by irregular distribution channels can be minimized through good coordination between partners in the supply chain that includes customers by forming alliances or sharing information and knowledge to create a competitive collaborative and save supply chain costs (Hult *et al*., 2007). The pressure of collaborative competition and the need for high customers forced companies to make various improvements in distribution and transportation activities (Bartholdi and Gue, 2005).

In transportation/shipping management, we usually distinguish between those who own goods and those who deliver. The owner of the goods whose interests the goods are sent for is usually referred to as a shipper, while the party in charge of shipping (for example a shipping service company) is called a carrier. Which mode of transportation is best used can be different when viewed from different angles (carrier angle vs. shipper angle). Some things that are usually used as a basis for evaluating the mode of transportation (Chen *et al*., 2006) are, 1) from the point of view of the carrier, the things that need to be considered are the costs involved, starting from the cost of transportation equipment, costs fixed operations (terminal or airport costs), and variable operational costs (such as fuel costs) and 2) From the shipper's side, consideration can be based on various costs incurred in the supply chain, including costs other than those directly related to transportation, but as a consequence from the selection of the transportation mode.

4. Conclusion

The results of the supply of free-range meat chicken in 2022 will amount to 40,016.67 tons with a demand for 62,816.50 tons. The optimal selling price of free-range meat chicken based on LP analysis is IDR 28,100/kg and the minimum total transportation cost of free-range meat chicken is IDR 3,807,000/quintal .

Conflict of interest

The authors declare no conflict of interest.

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