

ANALYSIS OF COST OPTIMIZATION OF POTATO DISTRIBUTION IN GARUT REGENCY

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Abstrak

Manajemen rantai pasok telah menjadi konsep penting dalam dunia bisnis, sehingga rantai pasok itu sendiri menempati posisi penting dalam keputusan yang harus diambil oleh perusahaan. Tujuan penelitian ini adalah untuk mengetahui manajemen rantai pasok kentang yang ada di Kabupaten Garut dengan menawarkan skenario pendistribusian barang menggunakan metode transportasi. Penelitian ini menggunakan metode kuantitatif deskriptif, dengan berdasarkan waktunya adalah *cross sectional*. Data diambil melalui data sekunder, dan wawancara pada tiga direktur perusahaan dagang terbesar di daerah Garut Selatan. Terdapat tiga tujuan distribusi produk kentang yang berasal dari Garut yaitu pasar yang ada di Kota Jakarta, Kota Tangerang dan Kota Bogor. Teknik analisis data yang digunakan adalah model manajemen produksi dan metode transportasi. Hasil penelitian menunjukkan bahwa metode *least cost* memiliki nilai yang paling rendah dibandingkan dengan metode lainnya. Hasil menunjukkan bahwa biaya terendah adalah distribusi kentang dari perusahaan dagang 1 ke daerah Bogor.

Kata kunci: manajemen rantai pasok, biaya distribusi, metode transportasi

Abstract

Supply chain management has become an essential concept in the business world. Thus, the supply chain itself occupies an essential position in companies' decisions. This study aimed to determine the supply chain management of potatoes in Garut Regency by offering a scenario for the distribution of goods using the transportation method. This research uses a descriptive quantitative method, based on time; it is cross-sectional. The data were taken through secondary data and interviews with the directors of the three most significant trading companies in the South Garut area. There are three distribution destinations for potato products originating from Garut, namely markets in Jakarta, the city of Tangerang, and Bogor. Data analysis techniques used are production management models and transportation methods. The results showed that the least cost method had the lowest value compared to other methods. The results show that the lowest cost is the distribution of potatoes from trading company 1 to the Bogor area.

Keywords: supply chain management, distribution cost, transportation method

Introduction

Potato (*Solanum tuberosum* L.) is one of the national strategic horticultural crops; it can even be exported. Based on BPS data, the national potato harvest in 2018 reached 1.28 million tons from a harvested area of 68,683 hectares (Tribun News, 2020). Garut Regency is one of the regions in Indonesia that produces granola and Atlantic potatoes. Granola potatoes are included in the specifications as edible vegetable potatoes, while Atlantic potatoes are specified as industrial raw materials in the manufacture of potato chips

Potato farming in Garut Regency, especially in the South Garut region, is dominated by trading companies located in Cikajang District, Cigedug District, and Cisurupan District. According to

the Garut Regency Agriculture Service (2017), the three companies have the largest potato harvest area in the 2013-2017 period in Garut Regency. Cikajang sub-district has the highest average harvested area of 1,306 ha/year, although it has decreased from year to year. The area of land certainly affects the amount of potato production. Potato production in the Cikajang District has the highest production rate, with an average of 30,079 tons per year in 5 years. The highest production figure occurred in 2013, which was 35,435 tons per year, and the lowest was in 2017 with 27,904 tons. The decline in production every year certainly needs to be considered and studied from various aspects.

Product operation is one of the factors causing low production. Shen et al. (2020) explained that the operational problems of agricultural products could be solved in several stages, namely demand, production planning, inventory management, and transportation. It is essential to optimize production management in potato production activities because it helps ensure the availability and safety of food, especially those produced by South Garut. Transportation issues are the most significant cause of production problems in South Garut. Delivery locations spread over several areas that are pretty far away make transportation costs expensive; in addition, the limited number of transport fleets is a consideration for the company in the production process at trading companies.

This study offers a production management model scenario that includes demand forecasting, production planning, supply chain management, and delivery. In addition, this study aims to produce optimal paths and minimize distribution costs. By using the transportation method in selecting the optimal solution, the research is expected to provide input to trading companies in South Garut in order to optimize the transportation process for the potatoes they produce.

Research Method

The research method used is a descriptive quantitative method using a production management model, and researchers can provide an overview of the company seen from the transportation cost data issued. The research period is January – May 2021. The survey was conducted by observing shipping activities and conducting interviews with each director of a trading company at the three most significant trading companies in South Garut. The data is generated from the monthly reports of each company by presenting the average shipments per month for the last five years (2016-2021). The data were then analyzed using the complete transportation method, which is presented as follows:

Initial solution

Heizer et al. (2017) stated that it is one of the most accessible transportation methods, but the results are not necessarily optimal. In this NWC method, the source and destination locations are sorted from left to right and top to bottom in a data matrix map. The next step is the least cost method. The least cost method is a method that makes allocations based on the lowest cost.

Optimal solution

At the optimal solution stage, it consists of Vogel's Approximation Method (VAM), stepping stone and modified distribution (MODI). Stepping Stone helps the VAM method in moving the solution to the optimal solution. MODI was used to validate the findings by seeking the optimal degree. The results calculated using MODI are taken from the results of the initial solution, namely the least cost.

Results and Discussion

Demand forecasting

The general model in potato production management in Garut Regency starts from forecasting demand for potatoes; this forecast helps estimate how much demand in the future will undoubtedly be related to potato demand from the market. The demand for forecasting in this production management model has goals ranging from short term, medium term, to long term (Siddh et al., 2015). In forecasting demand, of course, related to the supply of inputs that must be in the warehouse to maintain the demand for potatoes desired by consumers, market demand is an opportunity to identify potato needs from the market (Scott & Kleinwechter, 2017).

Furthermore, trading companies use market research when identifying market opportunities. After the research is complete, the company must measure and estimate how many potatoes consumers need. In addition, it also analyzes the growth and profit potential in every market opportunity using forecasting to facilitate production planning.

Production planning

Production planning in potato production management activities includes the implementation of the potato production process starting from the procurement of seeds, land preparation, fertilization, pest and disease eradication, harvesting, post-harvest, and distribution of results as well as the involvement of financial institutions (Palupi et al., 2021). Before being distributed, another step must be done, namely, a sorting or selection process for potatoes to be distributed, ranging from good quality to medium and poor quality. Then the next stage is packaging using boxes, and after packaging, the next step is shipping to various areas, such as Bogor, Jakarta, and Tangerang

Supply Chain Management

In production management and forecasting demand and production planning, there is also supply chain management used as a product distribution flow pattern that can replace the distribution optimally; the pattern concerns distribution activities, production schedules, and logistics (Mishra & Dey, 2018). Figure 1 describes the distribution pattern of potatoes production in Garut Residence.

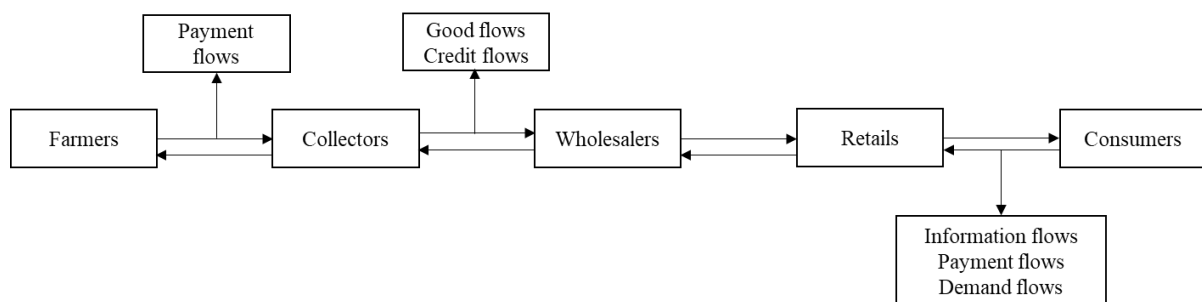


Figure 1
Distribution pattern of potatoes production in Garut Residence

From the farmer, the potato harvest will be bought by the collectors. And then wholesalers buy the potatoes from the collectors. For price issues, potatoes are very volatile depending on consumer demand, besides the current season. At harvest time and the rainy season, potato prices tend to decrease. During the harvest season, the supply of potatoes will be high, and of course, the regions will also harvest at the same time, making prices go down. Meanwhile,

during the rainy season, potato production decreased, which is easily damaged, decreasing the quality of the potatoes. As for other factors that caused the decline in potato prices, among others, because of the ample supply of potatoes from various regions, lack of demand for potatoes from Garut Regency resulted in many potatoes in the market, and import policy. In addition, bad weather factors certainly have an impact on potato production (Devaux et al., 2021; Jovovic & Velimirovic, 2016).

In May 2021, the average price of potatoes in some areas in West Java Province is IDR 9,000/kg, but in Garut Regency it reaches IDR 14,000/kg. The transportation cost factor also influences the high price of potatoes. Before the potato distribution process, the packaging was carried out; then, secondary packaging was given in the form of waring sacks by the collectors. The next stage is to carry out transactions from collectors and wholesalers, then deliver to retailers. The delivery routine is usually in the afternoon; the potatoes can arrive at night thus the potatoes could be sold by retailers in the market in the morning.

Furthermore, there is a flow of information, payments, and requests from consumers to retailers, from retailers providing information to wholesalers who oversee the goods from farmers (Kasimin & Desparita, 2021). Then from wholesalers, information regarding the required market demand is conveyed to farmers. As for the flow of payments, wholesalers usually make payments when the farmers deliver the goods, and there is no delay in payment (Barrowclough et al., 2019).

Delivery

This stage is critical in the potato distribution channel. The destinations for potato marketing from trading companies in Garut Regency include Jakarta City (300 km distance), Tangerang City (390 km distance), and Bogor City (400 km distance). Each trading company sends potatoes every day, as for every ton of potatoes sent according to the production capacity of farmers. Farmers' production decisions related to market demand cause a trade-off between the performance of vegetable production by farmers and buyer satisfaction in various markets, especially the market that is the market destination of potato marketing in the production center. The potato marketing transportation network from the Garut Regency trading company to the destination location is presented in Figure 2.

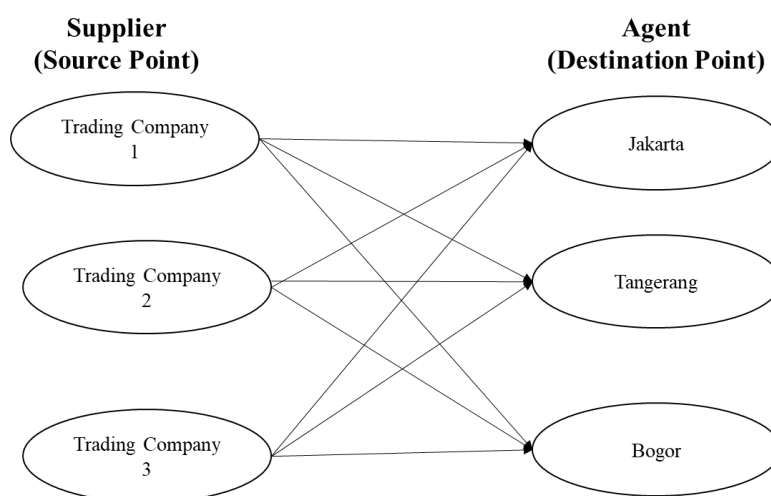


Figure 2.
 Potato marketing transportation network

Supply-Demand

Table 1 shows a breakdown of the number of requests for each trading company and supply capacity in the destination. From Table 1, it can be seen that there are 20 tons of dummies. That condition was set because the total agricultural capacity of trading companies is 480 tons, smaller than the market demand of 500 tons. The highest cost occurred in the shipping route from trading company 1 to the market in Tangerang City, amounting to IDR 440 K/ ton. Moreover, the cheapest cost occurs from trading company 3 to the market in Bogor City, which is IDR 183 K/ ton. In comparison, the dummy is set at the cost of zero rupiahs (IDR 0). Adding a dummy will not affect the method to find the optimal solution.

Table 1
 Initial data with dummy (in hundreds of thousands per ton)

To From	Bogor	Jakarta	Tangerang	Supply (ton)
Trading Company 1	233	340	440	180
Trading Company 2	216	320	420	150
Trading Company 3	183	330	400	150
Dummy	0	0	20	
Demand (ton)	190	160	150	500

Table 2 shows the calculation of transportation cost before minimizing process. The delivering cost from trading company 1 to Jakarta is IDR 54.4 M/month and the smallest fee is the delivering cost from trading company 3 to Bogor City is IDR 3.66 M/month. By using calculations before being minimized, the minimum costs for the potato distribution process are obtained, as follows:

$$Z = (160 * \text{IDR } 340 \text{ K}) + (20 * \text{IDR } 440 \text{ K}) + (150 * \text{IDR } 216 \text{ K}) + (20 * \text{IDR } 183 \text{ K}) + (130 * \text{IDR } 400 \text{ K}) + (20 * \text{IDR } 0) = \text{IDR } 151.26 \text{ M/month.}$$

Table 2
Calculations before minimizing process (in hundreds of thousands per ton)

To From	Bogor	Jakarta	Tangerang	Supply (ton)
Trading Company 1	²³³	³⁴⁰ 160	⁴⁴⁰ 20	180
Trading Company 2	150 ²¹⁶	³²⁰	⁴²⁰	150
Trading Company 3	20 ¹⁸³	³³⁰	⁴⁰⁰ 130	150
Dummy	20 ⁰	⁰	⁰	
Demand (ton)	190	160	150	500

The next step is calculation the initial solution using NWC that is presented in Table 3. The shipping cost from trading company 1 to Bogor is IDR 41.94 M/month, from trading company 2 to Jakarta is IDR 48 M/month and from trading company 3 to Tangerang is IDR 60 M/month. By using calculations before being minimized, the minimum costs for the potato distribution process are obtained, as follows:

$$Z = (180 * \text{IDR } 233\text{K}) + (150 * \text{IDR } 320 \text{ K}) + (150 * \text{IDR } 400\text{K}) + (10 * \text{IDR } 0) + (10 * \text{IDR } 0) = \text{IDR } 149.94 \text{ M/month.}$$

Table 3
North West Corner matrix (in hundreds of thousands per ton)

To From	Bogor	Jakarta	Tangerang	Supply (ton)
Trading Company 1	180 ²³³	³⁴⁰	⁴⁴⁰	180
Trading Company 2	²¹⁶	150 ³²⁰	⁴²⁰	150
Trading Company 3	¹⁸³	³³⁰	150 ⁴⁰⁰	150
Dummy	10 ⁰	10 ⁰	⁰	20
Demand (ton)	190	160	150	500

The Least Cost matrix is shown in Table 4. By using calculations before being minimized, the minimum costs for the potato distribution process are obtained, as follows:

$$Z = (40 * \text{IDR } 233\text{K}) + (140 * \text{IDR } 440\text{K}) + (150 * \text{IDR } 320\text{K}) + (150 * \text{IDR } 183 \text{ K}) + (10 * \text{IDR } 0) +$$

$(10 * \text{IDR } 0) = \text{IDR } 146.37 \text{ M/month.}$

Table 4
Least Cost matrix (in hundreds of thousands per ton)

To From	Bogor	Jakarta	Tangerang	Supply (ton)
Trading Company 1	40 ²³³	³⁴⁰	140 ⁴⁴⁰	180
Trading Company 2	²¹⁶	150 ³²⁰	⁴²⁰	150
Trading Company 3	150 ¹⁸³	³³⁰	⁴⁰⁰	150
Dummy	⁰	10 ⁰	10 ⁰	20
Demand (ton)	190	160	150	500

Table 5 is the Vogel Approximation Method (VAM) matrix. From trading company 1 sources, 20 tons of potatoes are allocated for Bogor and the Jakarta area of 160 tons/month. From source trading company 2, 150 tons of potatoes are allocated each month for the Tangerang area. From sources trading company 3 is allocated 150 tons of potatoes each month for the Bogor area. Thus, the total cost of shipping potatoes is:

$$Z = (20 * \text{IDR } 233\text{K}) + (160 * \text{IDR } 340 \text{ K}) + (150 * \text{IDR } 420 \text{ K}) + (150 * \text{IDR } 183\text{K}) + (20 * \text{IDR } 0) = \text{IDR } 149,51 \text{ M/month.}$$

Table 5
Vogel Approximation Method matrix (in hundreds of thousands per ton)

					<i>First Iteration</i> →	
↓ <i>Second Iteration</i>	<div>To From</div>	Bogor	Jakarta	Tangerang	Supply (ton)	
	Trading Company 1	20 ²³³	160 ³⁴⁰	⁴⁴⁰	180	107
	Trading Company 2	²¹⁶	³²⁰	150 ⁴²⁰	150	104
	Trading Company 3	150 ¹⁸³	³³⁰	⁴⁰⁰	150	117
	<i>Dummy</i>	⁰	⁰	⁰	20	
	Demand (ton)	190	160	150	500	
		17	20	20		

In the stepping stone method, the most optimal results can be seen from the results of the initial

solution, which is seen from the lowest value contained in the Least Cost method. This value is then analyzed further in the following stages:

$$\text{Iteration 1: } +1b - 1c + 2c - 2b = 340 - 440 + 420 - 320 = 0$$

$$\text{Iteration 2: } +2a - 2b + 3b - 3a = 216 - 320 + 300 - 183 = 13$$

$$\text{Iteration 3: } +1a - 1c + 2c - 2b + 3b - 3a = 233 - 440 + 420 - 320 + 300 - 183 = 10$$

$$Z = (40 * \text{IDR } 233\text{K}) + (140 * \text{IDR } 61.6 \text{ K}) + (150 * \text{IDR } 183 \text{ K}) + (150 * \text{IDR } 320\text{K}) \\ = \text{IDR } 146.37 \text{ M.}$$

Table 6
Stepping Stone matrix (in hundreds of thousands per ton)

To From	Bogor	Jakarta	Tangerang	Supply (ton)
Trading Company 1	40 233	340	140 440	180
Trading Company 2	216	150 320	420	150
Trading Company 3	150 183	330	400	150
Dummy	0	10 0	10 0	20
Demand (ton)	190	160	150	500

Note:

→ First Iteration → Second Iteration → Third Iteration

Table 7 shows the MODI matrix. The last stage is the MODI calculation with the following steps:

1. Determines whether $(m + n - 1)$ the number of filled cells. The initial table for the least cost method can be seen in Table 4, the number of filled cells in the table above $(m+n-1)$ where m is the row and n is the column. Thus, the result: $4 + 3 - 1 = 6$, because the number of cells filled with 6 is followed by the next step.
2. Evaluation of non-basic variables by assuming one of U or V with any certain integer, for example: $U_1 = 0$ therefore it can be calculated:
 - a. $C = V + U$
 $233 = V + 0$
 $V_1 = 233$
 - b. $440 = V_3 + 0$
 $V_3 = 440 - 320$
 $= 120$
 - c. $183 = 233 + V_1$
 $V_1 = 50$
3. Evaluation of non-basic variables by calculating the value from each source to the destination location as follows:
 $U_1 \rightarrow V_2 = 340 - 340 - 0 = 0$

$$U_2 \rightarrow V_1 = 216 - 233 - 120 = -137$$

$$U_2 \rightarrow V_3 = 420 - 440 - 120 = -140$$

$$U_3 \rightarrow V_2 = 300 - 320 - 50 = -70$$

$$U_4 \rightarrow V_3 = 400 - 440 - 50 = -90$$

Table 7
MODI matrix (in hundreds of thousands per ton)

To From	a (V ₁ =233) Bogor	b (V ₂ =320) Jakarta	c (V ₃ =440) Tangerang	Supply (ton)
Trading Company 1	40 ²³³	³⁴⁰	140 ⁴⁴⁰	180 U ₁ = 0
Trading Company 2	²¹⁶	150 ³²⁰	⁴²⁰	150 U ₂ = 120
Trading Company 3	150 ¹⁸³	³³⁰	⁴⁰⁰	150 U ₃ = 50
Dummy	⁰	⁰	⁰	20
Demand (ton)	190	160	150	500

Since there is no positive value, the Table 7 is optimal using manual processing. Thus, there is a minimum cost in the Bogor City with a total demand of 190 tons/month and can meet the demand of 180 tons at the cost of lowest distribution compared to other cities, as for the number with using the least cost method of IDR 146,370,000/month from all trading companies. The value is similar to the optimal cost for Stepping Stone and MODI methods. Compared to not using the transportation method, the costs incurred by the company each month reach IDR 151,260,000/month or a difference of IDR 4,890,000 (saving 3.23%). This finding proves that the least cost method and the optimal solution are the lowest cost (Wang et al., 2015).

Conclusion

Based on the activities that have been carried out by observing and analyzing transportation problems and applying transportation models and settlement techniques related to research, the method that produces the minimum cost is the least cost compared to other methods, in addition to testing optimization with stepping stone and MODI method produces a total cost whose results are the same as the initial solution, namely the least cost. Therefore it means that the shipping costs are optimal. Trading companies in Garut Regency can distribute goods in partnership/together as a solution to minimize shipping costs. This study has not considered data before and after the pandemic. Future research can consider the type of longitudinal research, where the reliability of the method data can be proven. Future research can also develop the application of hybrid genetic algorithms (Wang et al., 2015) by combining the cost function and the simplex method to make the process of finding the optimal solution more effective.

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