Optimizing Rice Distribution Model Using Linear Programming at West Java Bulog

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Abstract

Good distribution network management is a very important competitive advantage for a company. West Java Bulog is the representative of the government in distributing and distributing rice, which is a staple food commodity for the Indonesian people in general, of course, must pay attention to the optimal distribution pattern. In carrying out its operational processes, West Java Bulog will be assisted by 7 regional subdivisions spread throughout the West Java region who will handle rice in their respective working areas. This study aims to determine the planning path and the optimum amount of rice distribution from the West Java Bulog to districts and cities that can minimize distribution costs so that the costs incurred will reach the lowest point using the Linear Programming method. The analysis of this research was assisted by LINDO Software version 7.0 for Windows 10.0. From the results of this study, the optimization of rice distribution at the West Java Bulog, with the optimum total distribution cost of USD 124,272.

Keywords

Rice, Optimization, Distribution, Transportation Methods, Linear Programming.

Introduction

Food is anything that comes from biological and water resources, both processed and unprocessed, which is intended as food or drink for human consumption. In Indonesia, food is identical to rice. Food sufficiency for the community is a human right that must be fulfilled, and the government as the state administrator has the responsibility to fulfill it. This is in accordance with the mandate of Article 33 paragraph 3 of the 1945 Constitution which mandates the government as the state administrator to optimize the management of natural resources owned by the state for the prosperity of its people. Bulog which is a state institution tasked with implementing and controlling rice stocks in sufficient quantities through the policies it implements. Bulog has two tasks, namely public duties and commercial or business tasks. In public duties, Bulog carries out government assignments, namely business activities to provide goods and/or services needed by the community, while in commercial tasks, Bulog seeks to earn profits. Bulog as a SOE is still not optimal in carrying out its functions in terms of creating profit for the government. This can be seen in the trend that tends to be negative in the financial statements obtained by Bulog. Profits that are not maximized can be caused by several factors, one of which is an ineffective and inefficient distribution system. These conditions can result in uneconomic commodity selling prices making it difficult to compete and result in the erosion of company profits.

In the management of food availability, especially rice, distribution in the right amount and time is a crucial point. This is caused by the distribution process that is not appropriate and has a major impact on all aspects, especially profit for the company (Chaffey, 2009; Chopra & Meindl, 2007; Reza & Ullah, 2019). At this time the ability to manage distribution networks is a very important competitive advantage for a company. Distribution is a part of logistics, performing a fundamental function for a company. Distribution activities which include transportation activities can incur costs of 50% - 60% of the total logistics costs and the rest are components of costs in inventory. This is also reinforced by Frazelle (2002), that transportation is the most expensive logistics activity. The costs generated by this activity are more than 40% of the total logistics costs. Therefore, the distribution and transportation system must be designed as optimally as possible so that the minimum cost is obtained. West Java Bulog as an independent body in carrying out its functions, should pay attention to the efficiency of distribution costs in this case transportation costs in accordance with economic principles and transparent accountability. Therefore, in carrying out efficiency in transportation costs, West Java Bulog must know the best route and the optimum number of shipments so that transportation costs can be minimized. This is the basis for research on what is the best route and the optimum number of shipments as a form of optimization that can be carried out and applied to the distribution of rice.

Literature Review

Distribution is interpreted as a marketing activity that seeks to facilitate and facilitate the delivery of goods and services from producers to consumers, so that their use is in accordance with what is needed (type, quantity, price, place, and when needed). The concept of distribution is the activity of moving products from the source to the final consumer with distribution channels at the right time (Assauri, 2004). Meanwhile, according to Kotler (2003) distribution is a collection of organizations that make a process of distributing goods or services that are ready to be used or consumed by consumers (buyers). With this distribution activity, it is hoped that it can make the distribution of goods or services from producers to consumers easier to achieve by consumers and producers. This distribution activity can be an activity that is very helpful between producers and consumers because without this activity it will be very difficult to achieve marketing activities between producers and consumers directly or indirectly.

Optimization is one of the disciplines in mathematics that focuses on getting the minimum or maximum value systematically from a function, opportunity, or finding other values in various cases. Optimization is very useful in almost all fields in order to conduct business effectively and efficiently to achieve the target results to be achieved. Linear optimization is the determination of the extreme values of a linear function of maximization and minimization problems. In general, optimization problems are divided into two types of optimization with constraints and optimization without constraints (Nasendi & Anwar, 1985). The optimization problem with constraints is basically a matter of determining the various variable values of a function to be maximum or minimum by taking into account the existing limitations.

The transportation method is a special form of linear programming. This method is used to distribute an item from the producer to a number of destination areas so that the costs incurred are minimized. The definition of transportation model according to Taha (2005) is a special part of a linear program that discusses the transportation of commodities from source to destination with the aim of finding transportation patterns that can minimize total transportation costs in meeting supply and demand limits. This model deals with the lowest-cost plan for delivering a product from a manufacturer to a number of destinations. The transportation model seeks to determine a plan for the transportation of an item from the source area to a number of destinations (Prihastuti, 2012). The data in this model include: (1) the level of supply from the source area and the amount of demand from each destination; (2) transportation costs per unit of goods from source to each destination. According to Tarliah & Dimyati (1999), the special characteristics of transportation problems are: (1) there are source and destination areas; (2). the quantity of commodities or goods distributed from the production source area and demanded by each particular destination; (3). Commodities sent or transported from a source to one destination are in accordance with the demand or capacity of the source; (4) the cost of transportation from a source to a certain destination. A transport model of a network with m sources and n destinations. A source and a destination are represented by a node. An arc that connects a source and a destination represents the route of delivery of the goods. The quantity supplied at source i is a_1 and the demand at destination j is b_1. The unit cost of transportation between source i and destination j is C_{ij}. Assume that X_{ij} represents the number of goods shipped from source i to destination j.

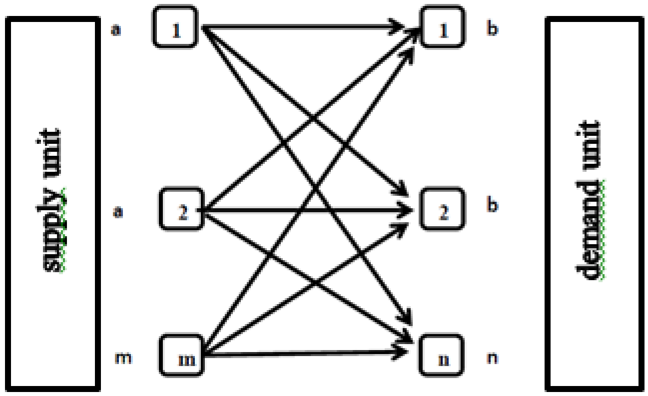

Figure 1 Network Transport Model with m sources and n destinations

According to Nasendi & Anwar (1985), Linear Programming (LP) is essentially an analytical planning point using a mathematical model, with the aim of finding several alternative combinations to solve problems and then selecting the best alternative. The selection of the best alternative is closely related to the allocation of limited resources and funds in order to achieve the company's goals or objectives optimally. In order for a problem faced to be compiled and formulated into a linear programming model, there are five conditions that must be met, namely: (1) the objectives of the problems faced or to be achieved must be clear and firm; (2) there must be one or more comparable alternatives; (3). the resources analyzed are limited; (4) functions and constraints must be quantitatively formulated into the model; (5) between the variables that form the objective and constraint functions must meet the functional relationship or the relationship of attachment. There are several basic assumptions that underlie LP, namely, linearity, proportionality, additivity, disvisibility, deterministic, and resource decision variables can be calculated.

Previous research that is relevant to this research that is being carried out at this time includes Bosona et al., (2011), research using transportation methods and a linear programming approach to minimize shipping costs and provide an overview of the LPF flow route from producers to consumers who provide solutions most optimal. Fagoyinbo et al., (2011) who researched profit maximization using the simplex method with a linear programming approach, the purpose of this research is to determine the best allocation of raw material resources with the aim of maximizing profits (Jamaludin et al., 2021; Akindipe, 2014). Fagoyinbo & Ajibode (2010), researched resource minimization using a linear program, the purpose of this research is to find the best decision making.

Distribution optimization researched by Apaydin & Gonullu (2007) states that one technique that can be used to minimize distribution costs is the transportation method, with this method the transportation route can also be optimized. Likewise, research conducted by Zaenuri (2012) concluded that the cost of distributing LPG can be drunk using the transportation method and with a linear programming approach. Distribution costs alone can be reduced by about 20%. Akay (2004), with research stating that the linear programming method can provide a feasible and efficient alternative solution in determining a good route design. The linear programming method has also been carried out by Murugan & Manivel (2009), in their research they analyzed the application of LP as a production problem decision-making technique in companies that produce textiles and non-textiles. The purpose of this research is to maximize profit by determining the allocation of material costs raw materials, labor allocation costs and overhead.

Research Methods

The research method used in this study is a quantitative descriptive method with a Linear Programming approach. Conceptual definition is the meaning of the concept used to facilitate research. Conceptual definitions used include: (1) the decision variable is an equation which is the most optimal final result, the result is a certain number target whose maximum or minimum value is kilograms or tons; (2) the objective function variable is an inequality or mathematical equation that reflects the goal to be achieved which will be measured in rupiah units; (3) the constraint function variable shows the mathematical function that becomes a constraint in maximizing or minimizing the objective function that will use kilograms or tons of measurement units.

The population in this study were all prosperous rice sent from the regional division of Bulog West Java to all cities and regencies in the working area of each subdivision. Sampling is saturated sampling because all the population is used as a sample. Secondary data obtained from company documents Bulog regional division of West Java and BPS West Java region as well as from other sources related to research variables will be collected in tabulation and grouped according to the variables. The data will then be processed according to the needs so that it can be applied to the research variables. Technical data analysis uses Linear Programming (LP) which will include data, namely: Distribution cost data, which includes transportation costs from Subdivision in each division, or data on the distance between warehouse locations, data on demand / shortage of rice stocks respectively cities and regencies in West Java, data on the procurement of rice stocks for each Subdivision. In general, the LP mathematical model can be stated as follows:

Purpose Function :
Minimize Transport Fees :

$$\sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} X_{ij}$$

Constraint Function :
Procurement Constraints :

$$\sum_{j=1}^{n} X_{ij} \leq S_i$$

Demand Constraints :

$$\sum_{i=1}^{m} X_{ij} = D_j$$

Information: S_i = The amount of rice procurement in the ith Subdivision (Ton); D_j = The jth city/district rice demand (Ton); C_{ij} = The cost of transportation from the Subdivision (i) to the destination city/district j (Rp/Ton); X_{ij} = The amount of rice transported from subdivision - i to the jth destination district and city (Ton).

The steps involved in data processing are as follows: (1) analysis of transportation methods; (2) data sampling analysis; (3) resolve transportation problems with LP and LINDO software; (4) determine the optimal solution; (5) draw conclusions.

Results

The process of distributing rice by the West Java Bulog is based on the division of the work area of the subdivisions in 7 districts and cities such as Bandung, the Karawang, Subang, Cirebon, Indramayu, Cianjur and Ciamis. Rice procurement in West Java is influenced by external factors such as the area of rice planted area, harvested area, pest attack rate, season, land productivity and harvest distribution. As a result, rice procurement will fluctuate from time to time. This condition will cause the allocation of rice distribution from surplus areas to minus areas of rice supply (Soekartawi, 2007). The level of distribution of the subdivision is determined by the number of budgetary and non-budgetary groups included in its working area. The distribution costs from each subdivision to the district cities in their respective working areas, the amount of procurement and demand are as described in Table 1.

Table 1 Distribution, Procurement and Demand Costs in 2019

Destination	Bandung	Cianjur	Cirebon	Indramayu	Karawang	Subang	Ciamis	Procurement (tons)
Karawang	25,749	33,795	42,302	30,807	2,299	20,691	53,567	31,969
Bekasi	35,405	34,715	52,647	40,462	9,656	30,347	58,165	30,559
Sukabumi	22,070	7,357	51,957	64,372	39,543	9,656	49,888	38,946
Cianjur	14,944	4,828	44,831	57,245	33,795	8,966	42,761	41,791
Garut	14,484	29,427	36,094	48,509	40,229	27,818	17,013	36,083
Bogor	29,657	17,013	59,544	71,959	22,070	42,761	57,475	38,589
Tasikmalaya	24,369	39,313	27,588	40,003	50,118	37,704	3,908	36,234
Ciamis	27,818	42,761	23,680	36,094	53,567	41,152	4,828	18,687
Bandung	6,897	14,944	41,382	42,302	25,749	13,334	27,818	66,549
Kuningan	37,934	52,877	8,047	20,461	50,348	43,911	15,633	17,499
Cirebon	29,887	44,831	8,276	12,415	42,302	35,864	23,680	38,394
Majalengka	20,921	35,864	14,024	18,852	46,670	34,255	19,312	19,716
Sumedang	10,346	25,289	19,542	31,956	25,749	14,024	29,887	14,675
Indramayu	42,302	57,245	12,415	4,368	30,807	23,450	36,094	34,452
Subang	13,334	8,966	35,864	23,450	20,691	5,288	41,152	24,836
Purwakarta	16,093	22,760	45,980	29,887	9,656	11,035	40,462	9,574
Pangandaran	46,440	59,705	34,485	45,980	62,073	49,658	14,254	5,567
Depok	38,393	21,381	54,256	52,187	19,771	32,646	66,441	8,139
Cimahi	4,828	13,104	48,049	45,750	19,082	26,439	29,657	3,749
Banjar	37,474	47,267	25,289	38,853	53,337	39,543	5,748	1,917
Procurement	53,728	44,253	145,518	82,616	72,647	49,854	11,168	517,926

The table above provides an overview of the pattern of rice procurement by West Java Bulog. The purchase of rice was carried out through farmers' partners (MKP), the Procurement Task Force and the Grain and Rice Processing Unit (UPGB) belonging to Bulog spread across West Java. The trend of rice procurement is different for each Subdivision. The lowest rice procurement was the Cianjur subdivision, which amounted to 44,253 tons, while the highest rice procurement was carried out by the Cirebon subdivision, which was 145,518 tons. This is directly proportional to the large population so that rice consumption also increases. The procurement of rice referred to here is the procurement of rice carried out by the Subdivision in the Province of West Java. The procurement of rice carried out by the Subdivision is related to the government's policy to provide national rice stocks and support the determination of market prices. The market price fixing policy is the government's effort to protect producer farmers, especially during the harvest season. In accordance with the law of supply and demand, the level of demand for products that remains while the supply level increases will cause supply which tends to push prices down (Jamaludin et al., 2020). The greater the supply that occurs, the effect on price declines will be even greater. The government will buy rice to absorb the supply that occurs so that prices are expected to move to their original equilibrium point. In accordance with the principle of domestic rice procurement, the government is obliged to buy farmers' rice if the market price is lower than the market price set by the government.

The demand for rice in each district and city in West Java is different from one another. One of the goals and functions of Bulog is the distribution of rice for poor. The supply of rice in each Bulog warehouse is adjusted to the distribution of prosperous rice in its working area, so that the distribution of prosperous rice can be guaranteed. The need for rice in West Java, in this case rastra rice for each beneficiary household, is 15 kg/month. The total need for prosperous rice for the regional division of West Java is 517,926 Kg. The highest demand came from the city/regency of Bandung with 66,599 tons, followed by Cianjur Regency with 41,791 tons and the city/regency of Sukabumi with 38,946 tons.

The results of the implementation of the Linear Programming model are the output of the mathematical model based on the constraints of procurement and demand to get the optimal solution. In analyzing the output of LINDO Version 7.0 for Windows, there are 3 (three) analyzes to be carried out, believe primal analysis (reduced cost), dual analysis (slack/surplus) and sensitivity analysis.

Reduced Cost Value

Reduced cost is the cost of changing the optimal value of the objective function if a number of products, in this case rice, should not be sent but instead shipped from certain sources. If a product that has a reduced cost is more than zero, then the delivery activity from that source is not profitable (Ghodsypour & O’brien, 2001; Nelwan et al., 2013). However, if the reduced cost is equal to zero, it means that the delivery of the product is profitable. The reduced cost value in the LINDO ver 7.0 for Windows 10 output is shown in Table 2.

Table 2 Reduced Cost (Primal Analysis)

Variable	Value	Reduced Cost
X24	44253	0
X310	145518	0
X414	82616	0
X51	72647	0
X615	49854	0
X11	53728	0
X710	11618	0

Table 2 showed that the shipping quantum that can minimize distribution costs are X24, X310, X414, X51, X615, X11, and X710. The reduced cost value for all shipments from source to destination in the table above is 0, so distribution costs will be minimum.

Dual Analysis (Slack/Surplus)

Dual analysis is carried out to determine the assessment of existing resources and assess decisions by assessing slack or excess which shows that the addition of one unit of resource will increase the value of the objective function by the value of its dual value. The slack variable will relate to the constraint and represent the amount of excess of the right side of the constraint compared to the left side, while the surplus variable is the excess of the left side compared to the right side. If the slack or surplus value is greater than zero and the dual value is equal to zero, then the variable or resource can be categorized as an excess resource or not a constraint. The dual analysis of LINDO output results is presented in Table 3.

Table 3 Slack or Surplus (Dual Analysis)

Row	Slack or Surplus	Dual Price
2	0	0
3	0	-4828
4	0	-8047
5	0	-4368
6	0	-2299
7	0	-5288
8	0	0

Sensitivity Analysis

The analysis explains the extent to which the objective variable and the value of the right hand side of the constraint variable may change without affecting the optimal value. Sensitivity analysis consists of analysis of the sensitivity of the objective variable coefficient which explains the change in the value of the objective variable that does not change the optimal value of the decision variable. The effect of changes can be seen from the minimum sensitivity interval (allowable decrease) and the maximum sensitivity interval (allowable increase). The sensitivity analysis of the constraints and objectives variables can be seen in Table 4.

Table 4 Constraint Sensitivity Analysis

No	Variable	RHS Value*	Allowable Increase	Allowable Decrease	Status
1	Supply	53728	Infinity	53728	Less Sensitive
2	Supply	44253	Infinity	44253	Less Sensitive
3	Supply	145518	Infinity	145518	Less Sensitive
4	Supply	82616	Infinity	82616	Less Sensitive
5	Supply	72647	Infinity	72647	Less Sensitive
6	Supply	49854	Infinity	49854	Less Sensitive
7	Supply	11618	Infinity	11618	Less Sensitive
*RHS=Righthand side					

Based on the results of the data tabulation of the procurement constraint variable, all of them are less sensitive to the optimization of distribution costs, which in this case is minimization. The average maximum sensitivity interval is about 65.747. In the sensitivity analysis of demand variables, all cities/districts are less sensitive to changes in the optimization of objectives, it can be seen that there is no minimum sensitivity interval that is in the infinity status.

With the constraints and assumptions used by the transportation model, and mathematical modeling with Linear Programming and data processing with the help of LINDO, the results obtained in the form of planning the distribution of rice from each Subdivision to districts and cities in West Java, as presented in Table 5.

Table 5 Results of Rice Distribution Optimization in West Java

Code	Origin (subdrive)	Destination	Volume(ton)	Cost (IDR/ton)	Total Cost (IDR)
X24	Cianjur	Cianjur	41,791	4,828	201,766,948
X310	Cirebon	Kuningan	17,499	8,047	140,814,453
X414	Indramayu	Indramayu	34,452	4,368	150,468,336
X51	Karawang	Karawang	31,969	2,299	73,496,731
X615	Subang	Subang	24,836	5,288	131,475,544
X11	Bandung	Karawang	31,969	25,749	823,169,781
X710	Ciamis	Kuningan	17,499	15,633	273,561,867
					1,794,753,660

The results of the analysis of Table 5 can be explained that distribution costs can be optimized if the Cianjur subdivision makes deliveries to the Cianjur. The Cirebon subdivision will distribute it to the Kuningan. For the Subdivision Indramayu, distribution will be carried out to Indramayu. The Karawang subdivision will make deliveries for Karawang. Furthermore, the Subang subdivision will distribute it to Subang. Bandung subdivision will make deliveries to the Karawang area and the last one is the Ciamis subdivision which will deliver to Kuningan. The volume of rice transported will be in accordance with the number of needs because the overall amount of supply is greater than the amount of demand. Then the most optimum distribution costs with the condition that all requests are met with the best route is USD 124,272.

Conclusion

The distribution of rice carried out by Bulog, the West Java subdivisions, will reach a minimum cost if the Cianjur subdivision delivers to the Cianjur and Cimahi, the Cianjur subdivision supplies the Bogor and Cianjur, Cirebon Subdivision distributes to the Cianjur. For the Indramayu subdivision, distribution will be carried out to Indramayu. The Karawang subdivision will make deliveries for Karawang. Furthermore, the Subang subdivision will distribute it to Subang. The Bandung subdivision will make deliveries to the Karawang and the last one is the Ciamis subdivision which will deliver to Kuningan. The volume of rice transported will be in accordance with the number of needs because the overall amount of supply is greater than the amount of demand. Then, the most optimum distribution costs with the condition that all requests are met with the best route is USD 124,263.

The optimum volume of rice sent to each city and regency area, which is sent from the Subdivision Cianjur to Cianjur, is 41.791 tons. The Cirebon subdivision sent to the destination of Kuningan 17,499 tons. Indramayu subdivision sent to the destination of Indramayu 34,452 tons. Karawang subdivision sent to Karawang a total of 31,969 tons. The Subang subdivision will send to Subang as much as 24,836 tons, and the Bandung subdivision will send to Karawang with a shipping volume of 31,969 tons. Lastly, the Ciamis subdivision will deliver 17,499 tons to Kuningan.

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