Teknovasi

Jurnal Teknovasi
Volume 08, Number 02, 2021, 65 – 72
ISSN : 2540-8389

INVENTORY MODEL BETWEEN MANUFACTURERS AND DISTRIBUTORS INTEGRATED IN THE FERTILIZER PRODUCTION SUPPLY CHAIN

Khusnul Khotimah[1]*, Said Salim Dahda[2]

Universitas Muhammadiyah Gresik
*E-mail:said_salim@umg.ac.id , imaaijp@gmail.com

Submited : 17 Augustus 2020
Revision : 19 September 2020
Accepted : 01 October 2020

ABSTRACT

Along with the development of an increasing competitive industrial environment, it takes a disciplined supply chain management that aims to optimize the availability of products from a company. Thus, the balancing of planning, production and inventory figures of products is important in a business activity. The model of optimizing procurement and production sizes is integrated into a model that provides optimal results for all parties involved in the supply chain. This research proposes the development of a supply chain model of one manufacturer and 3 distributor components with the aim of minimizing total inventory costs (TIC) and determining the length of time of one production cycle so that producers can meet each distributor' s needs and achieve the best coordination between producers and distributors so as to allow for no delays in delivery and the total amount of optimal inventory costs to each distributor. A simple algorithm is used to determine the optimal cycle time and total cost of supply to each distributor. A simple algorithm is used to determine the optimal cycle time and total cost of supply to each distributor. At the end of this study came a numerical example of the use of models that have been built based on case study data of a fertilizer industry as a producer and 3 components of distributors, namely subsidies, in-house and commercial. The results of numerical examples that have been done show that the optimal distributor is subsidized with optimal production of 274,773 units for 4 working days to run one production cycle.

Keywords : Inventory Model, Supply Chain Management, Integrated Supply Chain, Optimal Production

INTRODUCTION

The production process is the most important form of activity in the implementation of production in a company, this is because the production process is a way, method or technique of creating an item or service. Thus, balancing the planning, production and inventory figures of products is an important thing in a business activity (Rahayu R et al., 2019). Along with the development of an increasingly competitive industrial environment, a disciplined supply chain management is needed which aims to optimize the availability of products from a company. The main focus of the supply chain is to control the flow of materials from suppliers, production, distribution facilities to the hands of customers effectively and efficiently (Shafieezadeh & Sadegheih, 2014).

In a company engaged in industry, the availability of product inventory is very important to support the success of the business, so it is necessary to carry out integrated inventory control to reduce the risk of product shortages. According to (Baroto, 2002), an integrated control can create effective coordination in achieving the successful operation of the manufacturing system. As for if the condition

If this cannot be achieved, the elements of each business will make independent decisions that benefit one of the parties.

According to (Goyal, 1977), supply chain management has a system that focuses on single and two-level supply chains. The single supply chain focuses on one chain system while the two-level supply chain focuses on optimizing inventory between suppliers and manufacturers or two stages of the chain system. According to (Sharma, 2009) to determine an optimum production in a two-stage chain system, a well-integrated inventory method or model is needed. Thus, good collaboration between producers and distributors is essential for businesses to succeed in today's increasingly competitive market (De Castro et al., 1997).

Meanwhile, there are several previous studies regarding different inventory models by considering coordination that is contrary to the mechanism and structure of the supply chain, as in the research conducted by (Widyadana & Wee, 2009), (Huang, 2004) and (Nobil et al., 2020) . The integrated supply chain model between manufacturers and distributors has created a mutually beneficial network between the two parties. However, there are several problems that often occur, such as the lack of effective coordination between producers and distributors (Chan & Kingsman, 2007). The research conducted by (Oktavia et al., 2017) proposes to create a new inventory model from the production stock approach. The advantage of the JELS approach is through the analysis of trade-off costs in relation to appropriate price adjustments from the perspective of each party's optimal position. One method that can be used to overcome these problems is to determine the number of production lots and maintain inventory using the Economic Order Quantity (EOQ) method. The main objective of using this method is to optimally combine total costs from an integrated perspective between producers and distributors (A Eynan, nd).

As for other studies, there are those who have developed a number of models such as that carried out by (Varyani et al., 2014), which in this study aims to obtain the optimal solution from the model inventory. According to (Sharma, 2009) to develop an EOQ model with a single product, an independent decision is treated under deterministic conditions and the level of retail demand is assumed to be constant. Meanwhile, the research conducted by (Banerjee et al., 2007) aims to develop a similar model that aims to minimize costs by coordinating between suppliers, production and distributors using a simple algorithm with a two-stage heuristic solution.

Another study conducted by (Banerjee, nd) uses many theories as a solution to problems involving buyers - suppliers, as a means to achieve successful implementation so as to get a decision based on a just in time (JIT) system, with a focus on materials to minimize chain costs. supply or maximize the profitability of the entire supply chain.

As for several studies that have been carried out previously, a difference was found, where the research was developed under the assumption of one producer, several distributors and one product. This assumption is very realistic in today's industrial world which has a supply chain of one producer and many distributors. As with some manufacturing companies that often work with several sellers as sellers of their products to reach wider distributors and other costs. From previous literature searches, it was found that most researchers only studied the supply chain between producers and distributors by considering several constraints that might arise. Therefore, This study attempts to create a mathematical model of a two-level supply chain consisting of one company and several distributors. The concept of sending products to each seller in turn in a cycle. In this case, the production cycle and one round each. Every retail is the same. This study also tries to build a model for the optimal cycle length and the optimal number of distributors to work with the company, so that it can determine the optimal number of stores and obtain the optimal production quantity that must be carried out by producers. The purpose of this research is to be able to meet every distributor's needs and achieve the best coordination between producers and distributors. Solution to problem The concept of sending products to each seller in turn in a cycle. In this case, the production cycle and one round each. Every retail is the same. This study also tries to build a model for the optimal cycle length and the optimal number of distributors to work with the company, so that it can determine the optimal number of stores and obtain the optimal production quantity that must be carried out by producers. The purpose of this research is to be able to meet every distributor's needs and achieve the best coordination between producers and distributors. Solution to problem The concept of sending products to each seller in turn in a cycle. In this case, the production cycle and one round each. Every retail is the same. This study also tries to build a model for the optimal cycle length and the optimal number of distributors to work with the company, so that it can determine the optimal number of stores and obtain the optimal production quantity that must be carried out by producers. The purpose of this research is to meet every distributor's needs and achieve the best coordination between producers and distributors. Solution to problem This study also tries to build a model for the optimal cycle length and the optimal number of distributors to work with the company, so that it can determine the optimal number of stores and obtain the optimal production quantity that must be carried out by producers. The purpose of this research is to be able to meet every distributor's needs and achieve the best coordination between producers and distributors. Solution to problem This study also tries to build a model for the optimal cycle length and the optimal number of distributors to work with the company, so that it can determine the optimal number of stores and obtain the optimal production quantity that must be carried out by producers. The purpose of this research is to be able to meet every distributor's needs and achieve the best coordination between producers and distributors. Solution to problem in this study accompanied by the best solution provided with several stages of experiments using simple algorithms and also numerical examples.

Definition of Inventory

According to (Sulaiman, 2015), Inventory is a thing in the form of resources that are stored in anticipation of the fulfillment of a demand for goods and also aims to support the smooth running of a production activity carried out by the company. There is an inventory function as follows (Sulaiman, 2015):

1. Decoupling Function
In this function, the company can fulfill demand without depending on suppliers or allow the company's internal and external operations to have an independence.
2. Economic Lot Sizing Function
Through this function the company can produce and purchase resources in quantities that can reduce the cost per unit so that this function needs a cost saving consideration.
3. Anticipation Function
In this function, the company can perform a forecasting of past data to carry out seasonal inventory in anticipation of fluctuations in product demand.

METHOD

This research was conducted by using research methods in the form of literature studies and field studies with the object of research namely fertilizer production. The stages of research for the development of the settlement model are as follows:

- Step1: Model supply chain between manufacturers and distributors
- Step2: Creating inventory models between manufacturers and distributors
- Step3: Create a simple algorithm model to calculate the value of Demand
- Step4: Create a simple algorithm model to calculate the overall TC value of the existing components
- Step5: Perform numerical experiments to test whether the performance of the algorithm model is appropriate and integrated

RESULTS AND DISCUSSION

Supply Chain Model Between Manufacturers And Distributors

Figure 1 below shows a supply chain model between producers and consumers *distributor*.

Journal Teknovasi
Volume 08, Number 02, 2021, 65 – 10
ISSN : 2540-8389

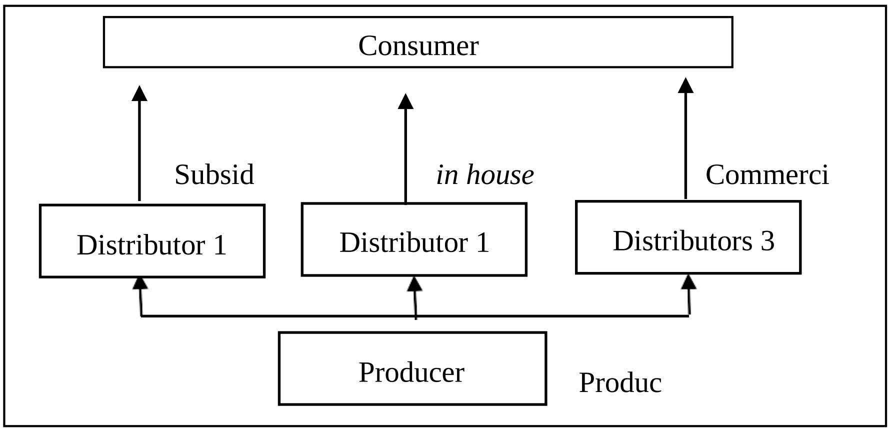


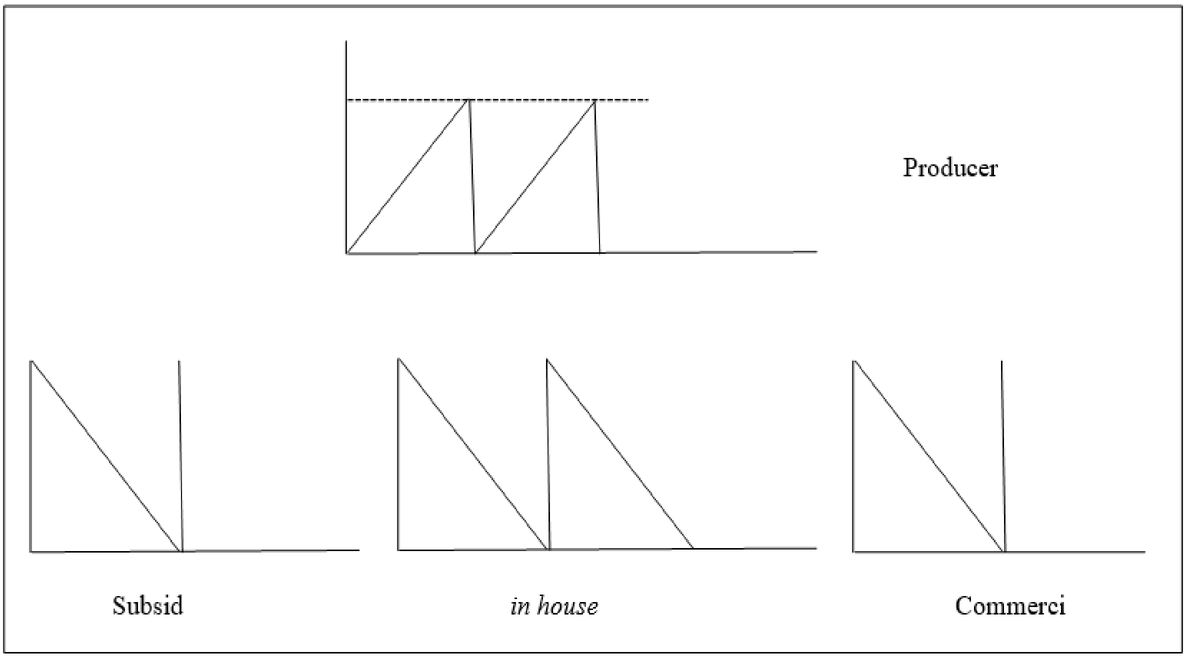
Figure 1. Supply Chain Model

From Figure 1 above, it can be seen that the producer will produce one product at a constant level of production and send the product to each distributor. Delivery will be carried out in stages, for example, the first batch of goods is sent to the first distributor, the second batch of goods is sent to the second distributor, and so on.

Determining the optimal production cycle time is very important for every manufacturing company to achieve effective coordination between manufacturers and each distributor. For example, in fertilizer producers who act as suppliers, most of which have a certain distance from their consumers, producers of course require distributors to be able to distribute or reach their consumers broadly and thoroughly. Producers carry out the production process according to the number of market needs or consumer demand, after the production process is complete, the factory will distribute their products to each distributor in stages, as described in the conditions that occur, it can be said as a role in intermediary between producers and consumers. Distributors make continuous sales.

Inventory Model in One Production Cycle

In Figure 2. below is an inventory model for manufacturers and distributors in one production cycle.



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Volume 08, Number 02, 2021, 65 – 10
ISSN : 2540-8389

Figure 2. Inventory Model in One Production Cycle

The mathematical model developed in this study is based on the following assumptions:

a. Sole manufacturer and multiple distributors
b. The amount of production is greater than the number of requests
c. No product shortage conditions are allowed
d. Manufacturers carry out shipments in stages and at once as much as Q0
e. Producers are not experiencing financial constraints, limited capacity and limited storage
f. Cost information, such as set-up costs and inventory costs are constant and known
g. Not paying attention/taking into account costs and delivery times
h. The needs of each distributor are known to be different, constant and deterministic

Simple Algorithm Model for Calculating Demand Value

The notation used in making the mathematical model carried out in this study is as follows:

P= Production rate (units/year)Q=
Number of finished products (units)
t= Production cycle time (days)
TIC= Total inventory cost
D= Number of product requests
(units/year)Di= Number of requests for
product i (units)
Dtotal = Number of product requests for all components
(distributors)Cr= Ordering fee per order
Ch= Storage cost per unit Cri=
The cost of ordering the product i
Crp= Manufacturer order fee
Chi= Cost of storing product i Chp=
Producer storage cost
n= Number of distributors (units)

As for the explanation above, the purpose of this research is to meet every distributor's need by trying to optimize the whole system between producers as suppliers and distributors in order to achieve optimal coordination, so this research is more focused on getting the length of one production cycle (t) and the total cost inventory by applying a simple algorithm to get the most optimal solution. The inventory model from the manufacturer can be seen in Figure 3 as below:

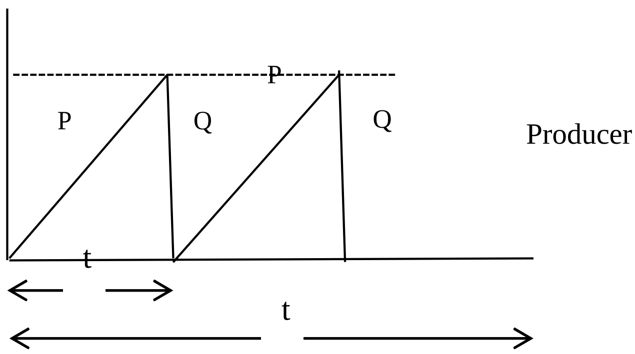

Figure 3. Manufacturer Inventory Model

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Volume 08, Number 02, 2021, 65 – 10
ISSN : 2540-8389

From Figure 3 above, it can be seen that the producer does production (P) constantly with the maximum amount of inventory after that the producer will make deliveries to the distributor gradually as much as Q until the remaining inventory runs out, namely during period t. The cycle time of one production is shown in the notation t.

Numerical Experiments To Test Algorithm Model Performance

Numerical experiments were conducted to test whether the performance of the cycle algorithm model was appropriate and well integrated between producers and distributors. Numerical experiments will also result in the length of one production cycle (t) and the total cost of inventory. The numerical example in this study consists of one producer distributing their products to 3 component distributors, namely subsidies, in-house and commercial. The demand for each type of distributor is known to differ from one distributor to another with the amount of the aggregate demand level remaining the same. There are several known variables as follows:

1 = $15/unit/year
2 = $20/unit/year
3 = $17/unit/year
1 = $750/setup
2 = $100/setup
3 = $850/year
⍰ = $25/unit/year
⍰ = $110/setup
n= 3
1 = 220,460 tons/year
2 = 317,447 tons/year
3 = 225,638 tons/year
P= 769,785 tons/year
Q= 762 tons/year

The following results are the application of a simple algorithm as described previously:

Table 1. Calculation of Cycle Time and Inventory Cost

n	QA (tons)	T (day)	ti (day)	D per year (tons)	D per day (tons)	qi (units)	TIC ($)
			Producer				
-	762,000		0.99	763,545	2092	-	$9,447,899
			n = 1 (Subsidy)				
1	762,000	4.07	1.15	220,460	604	274.773	$1,905,651
			n = 2 (in house)				
2	762,000		0.80	317,447	870	104,266	$2,540,125
			n = 3 (Commercial)				
3	762,000		1.13	225,638	618	277,981	$2,159,755
Overall TIC							$16,053,430

Source: Processed Data (2021)

Based on the numerical experiments in this study which are listed in table 1, there were 3 trials based on 3 distribution components, namely subsidies, in-house and commercial. From the three trials, the production cycle value for the subsidy was 1.15 days, for in-house 0.80 days and for commercial 1.13 days. In three experiments, the value of TIC n = 1 was $1,905,651 and the value of TIC n = 2 was $2,540,125 and the value of TIC n = 3 was $2,159,755. Three times the experiment showed an increase in the value of TIC as in TIC n = 1 of $ 1,905,651 and the value of TIC n = 2 of $ 2,540,125. In contrast to the next experiment which showed a decrease in the value of TIC, as in TIC n = 2 of $ 2,540,125 and the value of TIC n = 3 of $ 2,159,755. From the results of these calculations, it can be concluded that the increasing number of requirements for each component of the distributor results in the increasing value of TIC. However, it is inversely proportional to the cycle of production time where the increasing number of needs for each component of the distributor, the faster the production cycle that occurs so that the ability to supply goods will also be more optimal. So based on the results obtained from this numerical experiment, it shows that with the number of 3 distributor components, the company takes 4 working days to run one production cycle. Meanwhile, to be able to meet the three distributors, the company must produce and deliver respectively 274,773 products for the first distributor, 104,266 products for the second distributor and 277,981 products for the third distributor. The fulfillment of distributor demand is obtained based on the number of distributor needs that differ from one distributor to another, these needs can be seen in the numerical experiment table above.

CONCLUSION

As for this research, the development of a two-level supply chain model is carried out by one producer with 3 distributor components, namely subsidies, in-house and commercial. This study aims to minimize the total inventory cost (TIC) by integrating the inventory model of both parties. The model development is carried out to obtain the length of one production cycle (t) so as to allow no delays in delivery and the optimal amount of total inventory costs to each distributor. This research allows manufacturers to determine effective coordination of distributor components, so that manufacturers are able to calculate the optimal amount of production and delivery to each distributor.

The results obtained indicate that the optimal distributor is a subsidy with optimal production of 274.773 units for 4 working days to run one production cycle. The selection of the optimal distributor is determined from the lowest TIC value of the three experiments that have been carried out, namely the TIC value n = 1 of $1,905,651. The numerical experiments that have been carried out have also shown that future research can develop by taking into account other factors that influence the process of minimizing the total cost of production which is the initial goal of the research.

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