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Setup Reduction Integration Model and Lot Size Determination in Export Coffee Processing Production Systems

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ABSTRACT

In the last 10 years, competition between companies (business entities) has become increasingly sharp. The company continuously strives to reduce production costs and improve the quality of its products. The development of cooperation with suppliers is one of the efforts made by many companies to achieve this goal. Currently no single company can manufacture its products without the involvement of suppliers. Collaboration in determining policies for supplying and manufacturing companies in terms of supply creates a production system network *(* PSN) that has a collaborative relationship *pattern* . This relationship creates an innovation in the manufacturing system which certainly brings benefits to both parties. Silver, Pyke and Peterson (1998) suggested the need for coordination in determining inventory policies between suppliers and manufacturers, with the aim of being able to make savings on the aspects of setup costs per unit, ordering costs per unit and transportation costs per unit. Determination of inventory policy as a result of cooperation between suppliers and manufacturers creates the need to determine the combined lot size. The research objective is to obtain a combined lot size determination model that takes into account the aspects of reducing setup and improving production quality. The results of demand forecasting in the future are the basis for calculations in production planning, inventory control and calculating the cost of procuring the most economical raw materials.

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1. INTRODUCTION

Coffee as a superior product from Lintong Nihuta District, needs to be improved. Production quality and price are determining entities in determining prices in international competition. Determining lot size and set-up time in a ready-to-export coffee production system is important to improve to reduce production costs. Meanwhile, not much research has been conducted on a production system network related to combined lot sizes that consider setup factors and production quality. This research starts from the simplest production system network, which consists of a single supplier and a single manufacturer to a single supplier and several manufacturers in a production system network. . In this regard, a combined lot size determination model is needed with reduced setup costs and improved production quality which minimizes the combined total cost.

The company where the research was conducted had not carried out calculations to determine the economical size of inventory and order lot sizes but still used instinct and experience. Demand forecasting is a very important aspect in determining the amount of inventory, lot size orders and inventory management. So it really needs a good planning by doing the most economical calculations and developing a mathematical model.

The research objective is:

1. Obtain a model for determining the size of ordering lots and supply of raw materials that take into account aspects of demand.
2. Forecast the magnitude of the level of sales
3. Prevent excess or shortage of raw material inventory with minimal inventory costs and is expected to provide maximum profits for the company
4. Maintain the smooth production process and avoid delays in product delivery

Theoretical Review

General review

Conventionally, supply companies and manufacturers solve inventory problems separately. This is because there is no agreement or cooperative agreement between manufacturers and suppliers, so that the problem of determining the inventory policy contained in the supplier company does not depend on the inventory policy of the manufacturing company, and vice versa (Goyal and Gupta, 1989). In the last 10 years, competition between companies (business entities) has become increasingly sharp. The company continuously strives to reduce production costs and improve the quality of its products. The development of cooperation with suppliers is one of the efforts made by many companies to achieve this goal. Currently no single company can manufacture its products without the involvement of suppliers.

The success of JIT (*Just-in-Time*) at Toyota Motor Company has spread across a wide range of industries. Based on a study conducted by Mehra and Inman (1992) there are four key factors for successful JIT implementation, namely JIT production strategy, JIT supply strategy, JIT education strategy and management. They suggest that the JIT production strategy, which includes reduced setup times and *'in-house'* lot sizes , as well as the JIT supplier strategy, which includes supplier lot sizes, are significantly and directly related to successful JIT implementation.

Porteus (1986) initiated research on the relationship between lot size and process quality in determining the minimization of total production costs. At the beginning of the production process is in a controlled status, but within a certain time interval (*elapsed time*) the process becomes out of control resulting in *non-conforming items* . In this case, Porteus (1986) assumes that state changes follow a geometric distribution for discrete problems, similar to Cheng (1991a, 1991b) and Prasetyo (2004). Furthermore, Lee and Rosenblatt (1987), used an exponential distribution with a mean of $1/\mu$ in the continuous case. The exponential distribution approach was also proposed by Zhang and Gerchak (1990), Kim, Hong and Chang (2001), Ben-Daya (2002), Hou and Lin (2004) and Misrianty (2005). Liou, Tseng and Lin (1994) and Wang (2005), while Kim and Hong (1999) assume that the deterioration process has 3 tendencies: constant, increases linearly and increases exponentially. . The EMQ model with *standby module* and gamma distribution was proposed by Hsieh and Lee (2005), while Huang (2002, 2004) and Lina (2004) on the JELS model. Based on a literature study, Goyal et al (1993) classified the production integration model and quality control strategy with quality improvement.

Definition of Inventory (*Inventory)*

According to *Chase, Jacob* and *Aquilano, "* Inventory *(inventory)* is the supply of various types of goods or resources used in an organization". Meanwhile, according to Freddy Rangkuti "Inventories are materials, parts provided, materials in process contained in the company for the production process, as well as finished goods or products provided to meet requests from consumers or customers at any time."

Inventory Type

In the manufacturing system, inventory consists of 2 forms as follows:
Judging from the type, there are 4 types of inventory in general, namely:

a. Raw Material Inventory

b. Inventory of Semi-finished Materials
c. Finished Goods Inventory
d. Supplies of Auxiliary Materials

Judging from its function, there are 5 kinds of inventory, namely:

1. Inventory in lot size *(lot size stock)*
2. Backup inventory *(safety stock)*
3. Anticipation *stock*
4. Pipeline inventory *(pipeline stock)*
5. Stock up

The factors that affect the supply of raw materials are:

a. Estimated Use of Raw Materials
   Before the company purchases raw materials, it is appropriate for the company's management to prepare an estimate for the use of raw materials for the purposes of the production process.
b. Raw material prices
   The price of raw materials to be used is one of the determining factors of how much funds must be provided by the company if the company is going to hold a certain number of raw material supplies.
c. Inventory Costs
   In relation to inventory costs, there are three types of inventory costs, namely storage costs, ordering costs, and fixed inventory costs. Storage costs are inventory costs which increase in number if the number of units of material stored in the company is greater. Ordering costs are inventory costs which increase in number the greater the frequency of ordering raw materials. Fixed inventory costs are inventory costs whose amount is not affected either by the number of units stored or by the frequency of ordering raw materials by the company.
d. Spending Policy
   The spending policy implemented by a company will affect the implementation of raw material inventory within the company.
e. Material Usage
   It is better to carry out regular analysis, so that the pattern of absorption of these raw materials will be known. With this analysis, it can be seen whether the forecasting model used as the basis for estimating the use of this material is in accordance with actual usage or not.
f. Waiting time
   Waiting time is the grace period required between the time an order for the raw material is executed and the arrival of the ordered raw material. If you do not take into account the waiting time, there will be a shortage of raw materials (even though they have been ordered) because the raw materials have not yet come to the company.
g. Raw Material Purchasing Model
   The raw material purchasing model used by the company is very influential on the raw material inventory owned by the company. Different purchasing models will result in different optimal purchase amounts.
h. Safety Supplies
   To overcome the shortage of raw materials, a safety stock is held. Safety stock is carried out when there is a shortage of raw materials, or delays in the arrival of raw materials purchased by the company.
i. Repurchase
   In making a repurchase, of course the management concerned will consider the length of waiting time required in purchasing these raw materials, so that there is no shortage or accumulation of raw materials.

Inventory Function

The main function of inventory is to act as a buffer/connector between production and distribution processes to gain efficiency. Another function is as a price stabilizer against fluctuations in demand.

Common problems encountered in inventory control in general:

1. Quantitative issues, namely matters relating to the determination of inventory policy, in the form of how many items to order, when the order is made, how much is the safety stock, and which inventory control method is most appropriate.

2. Qualitative issues, namely matters related to the inventory operating system that will ensure the smooth management of the inventory system such as what types of goods are owned, where the goods are located, how much is being ordered, and who supplies each item.

Inventory System Cost

Inventory costs can be divided into:

1. Purchase cost, is the purchase price/unit if the item is obtained from an external source or production cost/unit if the item is made by the company.
2. Procurement costs, divided into two, namely:

Ordering costs are all expenses incurred to bring in goods from outside.

   a. Manufacturing costs *(setup costs)* are all expenses incurred in preparing to produce goods.
   b. Holding costs are costs that increase as the amount of inventory increases.

Storage costs include:

a) Cost of having inventory
b) Warehouse fee
c) Cost of damage and depreciation
d) Cost expiry
e) Insurance costs
f) Other costs
g) Stockout costs can result in lost sales if there is no inventory of customer orders for this type of product.

The cost of inventory shortages is measured from:

- Unfulfilled quantity
- Fulfillment time
- Emergency procurement costs
- Systemic costs, including:
  - The cost of designing and planning the inventory system
  - The cost of procuring equipment (eg computers)
  - The cost of training the personnel used to operate the system

Method e - Inventory Control Method e

In general, inventory control methods are divided into:

1. Method e statistical control *(statictical inventory control)* method tries to find the optimal answer in determining:
   a. Economic order quantity *(EOQ)*
   b. When the order is made *(reorder point)*
   c. Safety reserve *(safe stock)*
2. Planning material requirements *(Material Requirement Planning)*
   This material requirements planning method is used for dependent requests .
3. Kanban method
   This method is one of the operationalization of the concept of *Just In Time* (JIT). The main difference between this system and the previous system lies in the difference characteristics of the 'balance' used to set the production schedule.

Economic Order Quantity (EOQ)

The number of orders that minimizes the total cost *of inventory* is referred to as EOQ *(Economic Order Quantity*). During order acceptance, the *inventory level* is Q units. Units are taken from *inventory* at a constant average demand, which is represented by a negative slope line. When *inventory* reaches the reorder point, new orders are made for Q units. After a fixed period of time, all orders are received and stored in *inventory*. If the amount of inventory does not meet the requirements, the total cost *of inventory* can be calculated by the formula:

$$TC(Q) = PR + \frac{CR}{Q} + \frac{HQ}{2}$$

Where :

R = Demand per year in units
P = purchase cost of the item
C = message cost per message
H = PF = holding cost per unit per year
Q = lot size or number of orders in units
F = annual holding cost as a fraction of unit cost

To get the cost of the minimum lot size (*EOQ*), from the total cost equation above, by reducing it to the lot size (Q), make it equal to zero:

$$\frac{\partial TC(Q)}{\partial Q} = \frac{H}{2} - \frac{CR}{Q^2} = 0$$

By solving the equation for Q, we get the EOQ equation:

$$Q^* = \sqrt{\frac{2CR}{H}} = \sqrt{\frac{2CR}{PF}} \rightarrow economic\ order\ quantity$$

With order intervals:

$$T = \frac{1}{m} = \frac{Q^*}{R} = \sqrt{\frac{2C}{HR}}$$

The reorder point is the time between ordering and receipt of an order, called the lead time, or delivery time, which can be as short as hours or as long as months. And decision-when want to order.

Reorder points are obtained from determining the requests that will appear during the *lead time period.* When the inventory position (on hand + ordered - backorder) reaches the reorder unit point the order will be placed at Q^* units (*EOQ*)

The equation below gives *the reorder point* :

When *the lead time is* in days, weeks and months then:

$$B = \frac{R\,l}{360} \qquad B = \frac{R\,l}{52} \qquad B = \frac{R\,l}{12}$$

Where :B= reorder point

R = the number of requests

l = waiting time

Minimum total cost per year is found by substituting Q* for Q in the equation for total cost per year."

$$TC(Q^*) = PR + HQ^*$$

Maximum Inventory *(Maximum Inventory)*

The assumptions and terms of the *backorder model* are identical to the basic *EOQ* but there are some exceptions as follows:

- There are times when there is a surplus of inventory
- There are times when there is a shortage of supplies
- Each cycle takes the same time
- The cost of *"backordering"* per unit per year is constant
- *Backorders* and inventories are filled simultaneously

EOQ formula for this model:

$$Q = \sqrt{\frac{2CR}{H}}\sqrt{\frac{H+K}{K}}$$

$$dengan: C = ongkos\ pesan$$
$$R = banyaknya\ per\min taan$$
$$H = ongkos\ penyimpanan$$
$$K = ongkos\ kekurangan\ persediaan$$

Inventory surplus formula:

$$I = \sqrt{\frac{2CR}{H}}\sqrt{\frac{K}{H+K}}$$

Total annual inventory cost formula:

$$TC = H\frac{I^2}{2Q} + C\frac{R}{Q} + K\frac{(Q-1)^2}{2Q}$$

EOQ with a finite production *rate*

EOQ model assumes that the quantity ordered is received all at the same time in a single quantity (Q). The products that companies buy and manufacture themselves do not always live up to this assumption. Order quantities are received in smaller quantities in line with the progress of production. Products purchased or self-produced have a production level that is greater than the level of demand. This model is important because the assumption that the quantity of orders received all at the same time is often inaccurate. The assumptions of this model that are different from the basic model can be detailed as follows:

1. Order quantities are not all filled at the same time but are available in smaller quantities at constant production or fulfillment levels.
2. The level of demand is large relative to the level of production.
3. As long as production is carried out, the level of inventory fulfillment is equal to the level of production minus the level of demand
4. As long as the number of units is produced, the maximum inventory level is less than the amount due to usage during fulfillment.
5.

The formulation of this *EOQ* model or also known as *the Economic Production Quantity (EPQ)* :

$$Q = \sqrt{\frac{2CR}{H}\sqrt{\frac{P}{P-d}}}$$

While the formulation of total inventory costs:

$$TC = H\frac{Q}{2}\left(\frac{p-d}{p}\right) + C\frac{R}{Q}$$

$$dengan;\ p = banyaknya\ per\min taan\ per\ tahun$$
$$d = banyaknya\ produksi\ per\ hari$$

Definition of Forecasting

Forecasting is the use of past data from a variable or set *of* variables to estimate its value in the future. Forecasting is an important part for every business organization and for every management decision making which is very significant. Forecasting is the basis for the company's long-term planning.

Forecasting can be said as a function of time, which can be formulated mathematically as:

$Ft = f(t)$

Because of the interrelationships between parts of the organization, good/bad forecasts will affect the performance of the organization.

Forecasting functions in an organization include:

- Determine resource requirements what is needed
- Addition of resources
- Scheduling of existing resources

The characteristics of good forecasting so that it can be applied, namely :

1. Accuracy

The main goal of forecasting is to produce accurate predictions. Forecasts that are too low result in inventory shortages, *back orders*, lost sales or lost customers. Forecasts that are too high result in excess inventory and additional operating costs.

2. Yes

The costs to develop forecasting models and perform forecasting will become significant as the number of products and other data becomes larger. Accuracy can be increased by developing more complex models with consequent increased costs, so there is *a trade off* between cost and accuracy.

3. Simplification

The main advantage of using simple forecasting is the ease of forecasting. If difficulties occur with simple methods, the diagnosis is easy. In general it is better to use the method according to forecasting needs.

Forecasting Principles

Plossi proposed 5 forecasting principles that need to be considered, namely:

1. Forecasting involves errors *(errors)* .
2. Forecasting should use forecasting error benchmarks .
3. Forecasting product families is more accurate than forecasting individual products (items) .
4. Short term forecasts are more accurate than long term forecasts .
5. If possible, calculate demand rather than forecast demand .

Forecasting Procedure

Forecasting is done by following good and correct procedures, namely as follows:

1) Define forecasting objectives .
2) Create a scatter diagram (Plot Data).
3) Choose at least 2 methods that meet the forecasting objectives and fit the data plot .
4) Compute the parameters of the forecast function .
5) Calculate the forecasting error *(Iforecast error)* that occurs .
6) Choose the best method with the smallest error.
7) Perform forecast verification .

Forecasting Method

There are two methods used in forecasting, namely:

1) Qualitative Method

Qualitative methods can be classified into:

a. *Individual Opinions*

This method is based on personal opinion/thoughts. Usually carried out by people with direct interest (private companies).

Forecasts are made based on what is in the mind of the forecaster.

b. *Expert Opinions*

This method is forecasting carried out by people who are experts/who are engaged in the field concerned.

c. *Delphi* method

Basically this method refers to the 2nd method (*expert opinion)* , only this method can be external, by inviting experts from other similar companies.

2) Quantitative Method

Quantitative methods can be classified into two techniques:

4. Periodic Series Technique *(Time Series)*

Requests depend only on time and treat the system like a black box and no effort is made to find out the factors that influence the behavior of the system.

The basis of this method is that future demand patterns are identical or the same as past requests. This method is suitable for short or medium term forecasting.

Several *Time Series methods:*

- Average method
- Moving average method
- *Exponential smoothing* method
- Regression method
- Decomposition method
- *The box-Jenskin* method

b) *(Causal)* Techniques

With the existence of a causal relationship between the input and output of a system.

Some *causal methods* consist of:

- Input-output method *(liontif model)*
- *Econometric* method : *dt=f(economic variable)*
- Multivariate regression method

Forecasting is influenced by more than one causal variable.

Dt' = f (quality, price, promotion, distribution)

The time series and *causal series methods* have their own advantages and disadvantages.

- Periodic series models can often be used easily for forecasting
- *Causal* Model can be used with greater success for decision making and discretion.

To be able to use the quantitative method there are three conditions needed, namely:

a. There is information about past circumstances
b. This information can be identified in the form of data
c. It can be assumed that the pattern of relationships that existed in the past will continue in the future

Measures of Forecasting Error

If several forecasting models are suitable for certain conditions, it is necessary to determine which model is better (unusual) or if there is only one model that is suitable, then another model is needed as a comparison to see the effectiveness of the model. This process is known as forecasting error.

The magnitude of the error in the i-period (ei) is expressed as: $e_i = X_i - F_i$, with: e_i = error in period i

X_i = actual data for period i

F_i = forecasting value for period –i

The error measurement statistics used are :

A. *Standard Error of Estimate (* Error Level)

The size of *the standard error* can be calculated by the formula:

$$S = \sqrt{\frac{(Y' - Y_i')^2}{n - f}}$$

$Dimana:$

$S = s\tan dard\ error$

$Y' = demand\ yang\ diramalkan$

$Y_i' = demand\ nyata$

$n = banyaknya\ data$

$f = derajat\ kebebasan\ yang\ besarnya\ tergantung\ kepada\ bentuk\ persamaan$

$= 1 : untuk\ data\ kons\tan$

$2 : untuk\ data\ linier,\ dan\ 3 : untuk\ data\ kuadratis$

Request Pattern Function Verification

As with the startup process, verification also has certain stages in its implementation:

1. Calculating *the Moving Range (MR)*

$$MR = |e_t - e_{t-1}|$$

With n : the number of periods
Ft : demand forecast for period t
Xt : past real demand data in period t

2. Calculating the average Moving Range (MR)

$$(\overline{MR}) = \sum \frac{MR}{n-1}$$

Note : for period n there are n - 1 moving range

3. Calculates the upper class limit and the lower class limit

$$BKA = +2{,}6\overline{MR}$$

$$BKB = -2{,}6\overline{MR}$$

4. Make a Moving Range Chart and carry out *an Out of Control Test,* the areas observed in *this Out of Control Test* : $\pm \frac{2}{3} UCL$

$$\pm \frac{1}{3} LCL$$

If an *out of control condition is encountered*, what must be done is to check whether the cause of the *out of control condition* is known or not.
And if the cause is known, then just let the condition *get out of control* and the forecasting function can still be used:
If the cause is not known, then:

a. Create a new forecasting function, with new functions using data for the base period.

b. Create a new forecasting function by eliminating data that causes *out of control conditions.* So here processing data with the amount of data that has been reduced, here you may use forecasting function patterns that have been made.

2. RESEARCH METHOD

The formulation of the methodology which is the stage of model development in an effort to achieve research objectives can be seen in the following figure:

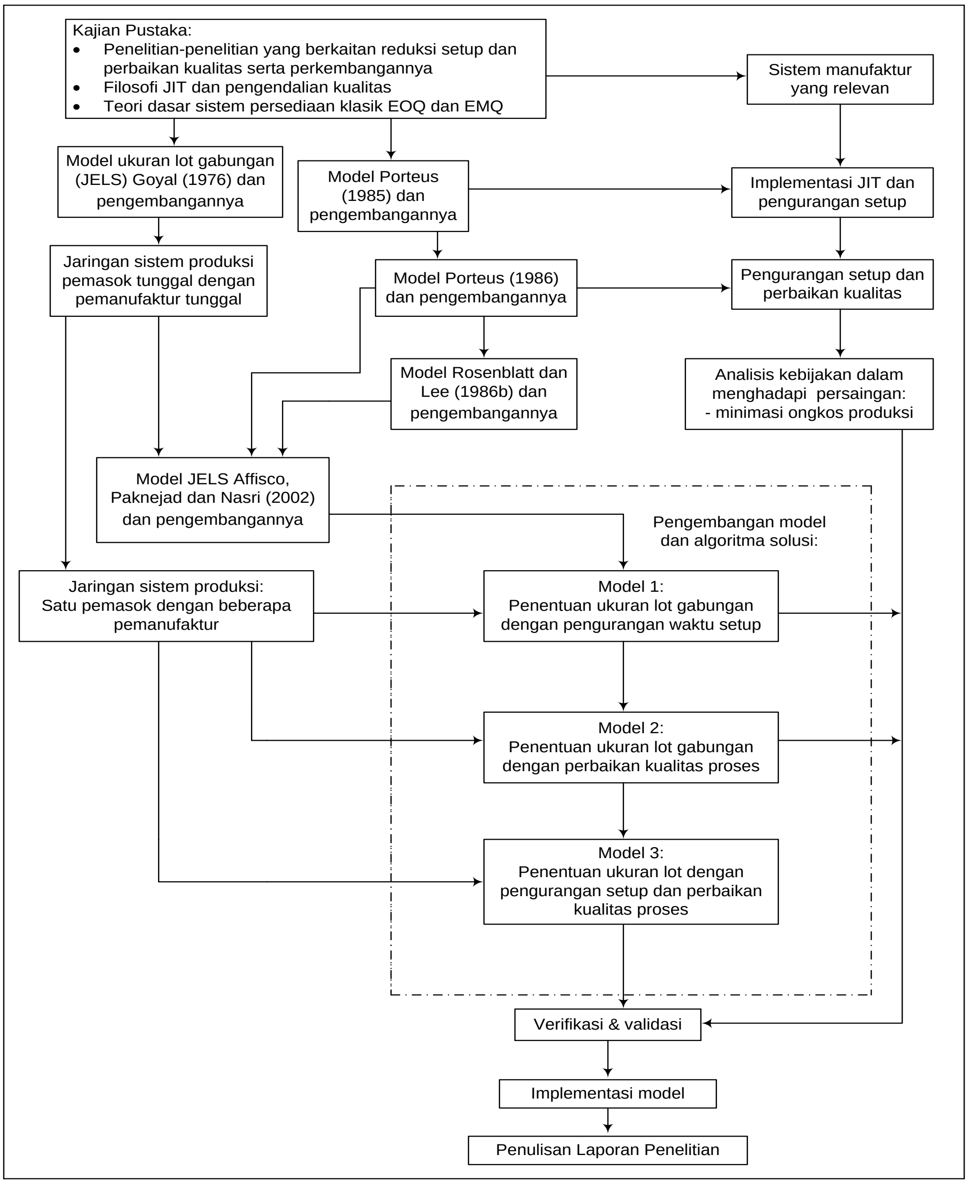

Figure 3.1. Research methodology framework

At each stage of the model, a sensitivity analysis will be carried out to determine the behavior of the model and its solutions to parameter changes.

Furthermore, the research phase will be divided into 3 (three) stages;

Stage I :

understand the completion of an integrated manufacturing system model involving one supplier with several manufacturers. The performance criteria take into account lot size and set-up reduction.

Stage II :

completion of an integrated manufacturing system model involving one supplier and several manufacturers. The performance criteria take into account lot size and quality improvements.

Stage III:

completion of an integrated manufacturing system model involving one supplier with several manufacturers. The performance criteria take into account lot size, reduced set-up costs and deterioration of the production process.

Types of research

This research is a type of case research which is research that is carried out intensively, in detail and in depth on the object of an institutional organism or certain symptoms studied (Arikuanto 1998:115). The case to be discussed concerns the raw material supply policy in ensuring the smooth production process at UD.X.
This research also develops the most economical mathematical model in company inventory management.

Research Steps

The purpose of this research is to plan future production and control the supply of raw materials for production In conducting this research, an approach was carried out with theories including:

a. production management
b. Inventory control (*Inventory control*)
c. The closest forecasting method
d. Statistical science

Identification of Research Variables

As for the research variables that arise in connection with the inventory, among others:

- Requests
- Product structure
- Safety *stock*
- Booking

Data collection

Data collection is done by observing directly to the field and recording data from the company. The data taken is related to inventory control. While the primary data is done by conducting experiments in the company. Especially in the production section.

Data processing

After data processing is carried out, then data processing is carried out in accordance with the theory that has been prepared, including forecasting calculations, production quantities, economic inventory quantities.

Data Analysis and Conclusion

Analysis of the results of the research was carried out in accordance with the developed theories. From the results of the analysis, conclusions can be drawn according to the theory and mathematical model of the costs incurred

3. RESULTS AND DISCUSSIONS

Data Collection

Data collection was carried out by means of field observations, company records and by direct interviews with the company in charge of providing data.
The data collected to solve production planning and control problems at the UD.X.ini company are:
1. Raw material purchase data for 2021-2022
2.Finished product data 2021-2022
3. Data on the use of raw materials for 2021-2022

Data on purchases of past UD.X raw materials starting from 2021 to 2022 can be seen in table.4.1.

Table 1.
Raw material purchasing data 2021-2022

MONTH	Amount of Raw Materials	
	2021 (Tons)	2022 (Tons)
January	91	91
February	91	91
March	83	91
April	83	91
May	83	91
June	83	83
July	83	83
August	83	83
September	101	123
October	101	123
November	101	123
December	101	123
Amount	**1086**	**1197**

Raw materials purchased are entirely used for production because raw materials cannot be stored. If the raw material is stored, it spoils quickly because it contains too much moisture (wet).
UD.X production data. The past from 20 21 to 20 22 can be seen in table 4.2 which is below:

Table 2.
Finished Product Data for 2021-2022

Month	Finished Material Amount	
	2021 (tonnes)	2022 (tonnes)
January	64	64
February	64	64
March	58	64
April	58	64
May	58	64
June	58	58
July	58	58
August	58	58
September	71	86
October	71	86
November	71	86
December	71	86
Amount	**760**	**838**

Inventory Cost Data

The costs that must be incurred by the company in connection with the procurement of raw material supplies consist of ordering costs, storage costs and purchasing costs.

Order Fee

The ordering cost is the cost that includes every purchase in the order and every order fee is borne by the company, the ordering cost consists of manufacturing costs, invoices, unloading costs, trucking costs and telephone costs.

Details of the booking fee are:

C_1 = Cost of making an invoice IDR 10,000 per 1 x message

C_2 = Unloading fee IDR 200,000 per 1 x message

C_3 = Transport fee IDR 450,000, per 1 x message

C_4 = Call fee IDR 10,000 per 1 x message

C_5 = Weighing fee IDR 90,000 per 1 x order

Then the total ordering cost:

$H_{total} = C_1 + C_2 + C_3 + C_4 + C_5$

= IDR 760,000.00 per 1 x message

Storage Fee

Storage costs are costs that include every existing storage within the company, namely the cost of raw materials, semi-finished materials and finished materials and machine costs. Storage costs consist of security guard fees, warehouse maintenance and cleaning costs, warehouse fees and electricity consumption costs.

Details of storage costs are as follows:

H_1 = Fee for a security guard 1 0person IDR 550,000 per month x 12 = $\frac{Rp6.600.000}{1573,931}$ = 4,193 per tonne per year

H_2 = Warehouse maintenance and cleaning costs for 1 person IDR 550,000 per month x 12 = $\frac{Rp6.600.000}{1573,931}$ = IDR 4,393 per tonne per year

H_3 = Warehouse fee $2m^2$ for 1 ton IDR 5000 per month x 12 = IDR 60,000 per ton per year

H_4 =Electricity cost for 100 watts x 6 pieces x 12 hours x 360 days = 2628 kwh x IDR 600 per kwh = $\frac{Rp1576800}{1573,983}$ = IDR 1000 per tonne per year.

Then the total storage cost:

Htotal = $H_1 + H_2 + H_3 + {}_{4\,-}$

= 4193 + 4193 + 60000 + 1000

= Rp. 69,386 per tonne/year

Data processing

Data processing is done is the calculation of purchases, use of raw materials. Forecasting to plan production control and control raw material inventory.

This production control is intended to be able to respond to demand and determine the amount of production plans to meet consumer needs in the future. While raw material inventory control intends to determine the size of the optimal order size, optimum inventory, reorder point and to determine the total cost of inventory.

Forecast Determination

The forecasting method used is the method:

1. Linear Forecasting Method

2. Quadratic Forecasting Method

The selection of the forecasting function to be used is based on the forecasting method which has the smallest standard error price of each forecasting method, for this reason it is necessary to calculate past sales forecasts. To predict the amount of demand in the future several kinds of calculations are used, namely:

Table.4.3.
Calculation of Demand Forecasting With Linear Method

Month	Year	x	y	xy	X^2	Y'	$(YY')^2$
January	20 21	1	64	64	1	56,993	49,099
February		2	64	128	4	57,827	38.108
March		3	58	174	9	58,661	0.437
April		4	58	232	16	59,495	2,234
May		5	58	290	25	60,329	5,422
June		6	58	348	36	61,162	10,001
July		7	58	406	49	61,996	15,970
August		8	58	464	64	62,830	23,331
September		9	71	639	81	63,664	53,815
October		10	71	710	100	64,498	42,276
November		11	71	781	121	65,332	32,127
December		12	71	852	144	66,166	23,369
January	20 22	13	64	832	169	67,000	8,998
February		14	64	896	196	67,834	14,696
March		15	64	960	225	68,668	21,786
April		16	64	1024	256	69,501	30,265
May		17	64	1088	289	70,335	40.136
June		18	58	1044	324	71,169	173,428
July		19	58	1102	361	72,003	196,087
August		20	58	1160	400	72,837	220,137
September		21	86	1806	441	73,671	152,007
October		22	86	1892	484	74,505	132,140
November		23	86	1978	529	75,339	113,663
December		24	86	2064	576	76,173	96,578
Total		**300**	**1598**	**20934**	**4900**	**1597,986**	**1496.1107**
Average		**12.5**	**66.6**	**872.3**	**204.2**	**66.6**	**62.3**
Standard Error		***8.2465***					

- Linear method (straight line) with the form of the equation:

Y' = a + bX

With the results of the sales calculation above, the prices of constants a and b are calculated, namely:

$$a = \frac{\sum_{t=1}^{n} dt}{n} - \frac{\sum_{t=1}^{n} t}{n} = dt - b.t = 872{,}3 - (0{,}8339)(12{,}5) = 56{,}15942$$

$$bb = \frac{n\sum_{t=1}^{n} t.dt - \sum_{t=1}^{n} dt \sum_{t=1}^{n} t}{\sum_{t=1}^{n} t^2 - (\sum_{t=1}^{n} t)^2} = \frac{24(20934)-(1598)(300)}{24(4900)(300)} = 0,8339$$

Then the equation of the linear method becomes:

Y'=dt' = 56.15942 + 0.8339.t

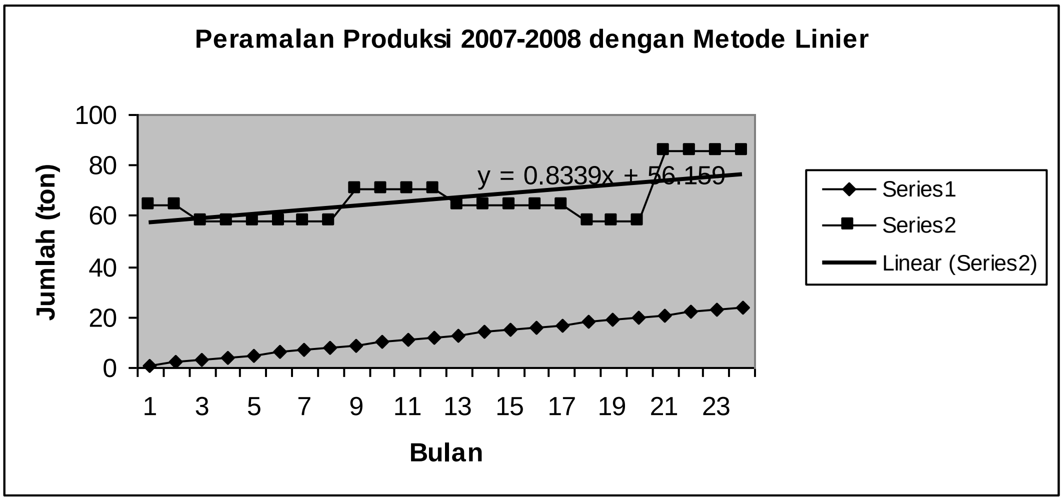

Fig.1
Demand Forecasting Results for 2021-2022 using the linear method

Calculation of forecast raw materials with this quadratic method can be seen in table 4.5 below:

Table.4.
Calculation of Production Forecasting With the Quadratic Method

Year	X	Y	XY	X^2	YX^2	X^4	Y'	$(YY')^2$
20 21	-12	64	-768	144	9216	20736	65,226	1,504
	-11	64	-672	121	7744	14641	64,877	0.768
	-10	58	-551	100	5800	10000	64,669	44,482
	-9	58	-493	81	4698	6561	64,605	43,628
	-8	58	-435	64	3712	4096	64,684	44,670
	-7	58	-377	49	2842	2401	64,905	47,675
	-6	58	-319	36	2088	1296	65,269	52,831
	-5	58	-261	25	1450	625	65,775	60,452
	-4	71	-248.5	16	1136	256	66,424	20,936
	-3	71	-177.5	9	639	81	67,216	14,316
	-2	71	-106.5	4	284	16	68,151	8.116
	-1	71	-35.5	1	71	1	69,229	3.138
20 22	1	64	96	1	64	1	71,812	61,022
	2	64	160	4	256	16	73,317	86,811
	3	64	224	9	576	81	74,966	120,245
	4	64	288	16	1024	256	76,757	162,733
	5	64	352	25	1600	625	78,690	215,810
	6	58	377	36	2088	1296	80,767	518,335

	7	58	435	49	2842	2401	82,986	624,311
	8	58	493	64	3712	4096	85,348	747,923
	9	86	817	81	6966	6561	87,853	3,433
	10	86	903	100	8600	10000	90,500	20,252
	11	86	989	121	10406	14641	93,290	53,150
	12	86	989	144	12384	20736	96,223	104515
Total	***0***	***1598***	***1679***	***1300***	***90198***	***121420***	***1783540***	***3061055***
Average	***0***	***66.58333***	***69.95833***	***54.16667***	***3758.25***	***5059,167***	***74.31415***	***127,544***
Standard Error		***11.7957***						

B. Quandratic function with general form of equation

Y' = a + bX + C X^2

By using this formula, it is obtained:

$$b = \frac{\sum_{t=1}^{n} t.dt}{\sum_{t=1}^{n} t^2} = \frac{1679}{1300} = 1{,}2915$$

$$c = \frac{\sum_{t=1}^{n} dt \sum_{t=1}^{n} t^2 - n\sum_{t=1}^{n} t^2.dt}{\sum_{t=1}^{n} (t^2)^2 - n\sum_{t=1}^{n} t^4} = \frac{(1598) - 24x90198)}{(1300)^2 - (24x121420)} = 0{,}0785$$

$$a = \frac{\sum_{t=1}^{n} dt - c\sum_{t=1}^{n} t^2}{n} = \frac{(1598) - (0{,}0785x1300)}{24} 64{,}669$$

Then the equation of the cadratic method is: dt = 64.669 + 1.1289 - 0.0785.t

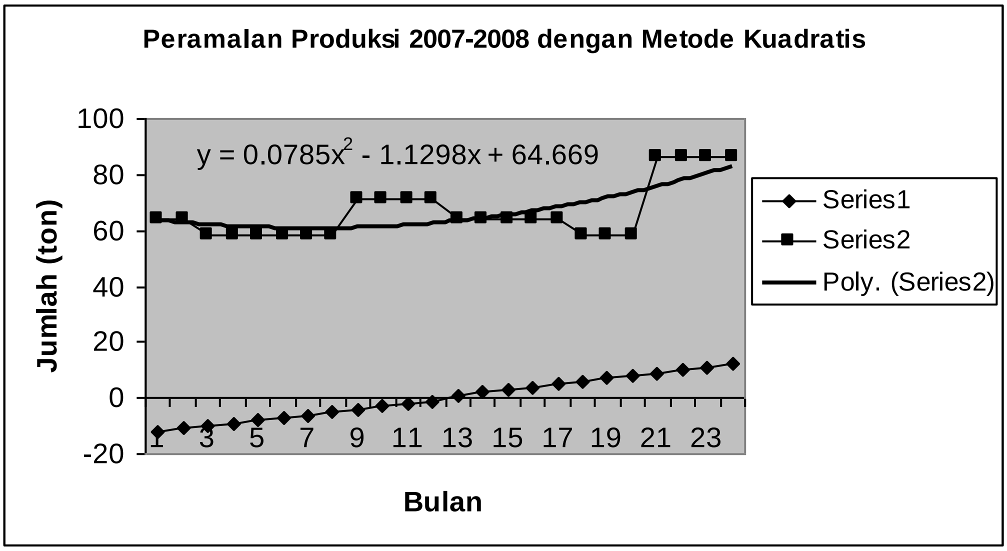

Fig. 2
Production Forecasting Results for 2021-2022 using the Quadratic Method

Table. 5
Production Forecasting 2023-2024 with Selected Functions (Linear)

Month	**Year (tonnes)**			
	X	Y'	X	Y'
January	25	77,132	37	87.1987
February	26	77,971	38	88038
March	27	78.81	39	88,877
April	28	79,649	40	89,715
May	29	80,488	41	90,554
June	30	81,326	42	91,393
July	31	82165	43	92,232
August	32	83,004	44	93,071
September	33	83,843	45	93.91
October	34	84,682	46	94,749
November	35	85521	47	95,588
December	36	86.36	48	96,427
Total		**980.95**		**1101752**

Table 6. Raw Material Requirement Forecasting Results

Month	2023 (tonnes)		2024 (tonnes)	
	Y'	*Conversion*	Y'	*Conversion*
January	77,132	110,188	87.1987	124,570
February	77,971	111,387	88.0376	125,768
March	78,810	112585	88.8765	126,966
April	79,649	113,784	89.7154	128.165
May	80,488	114,982	90.5543	129,363
June	81,326	116,181	91.3932	130,562
July	82165	117,379	92.2321	131,760
August	83,004	118,577	93,071	132,959
September	83,843	119,776	93.9099	134,157
October	84,682	120,974	94.7488	135,355
November	85521	122,173	95.5877	136,554
December	86,360	123,371	96.4266	137,752
Total		**1401.357**		**1573,931**

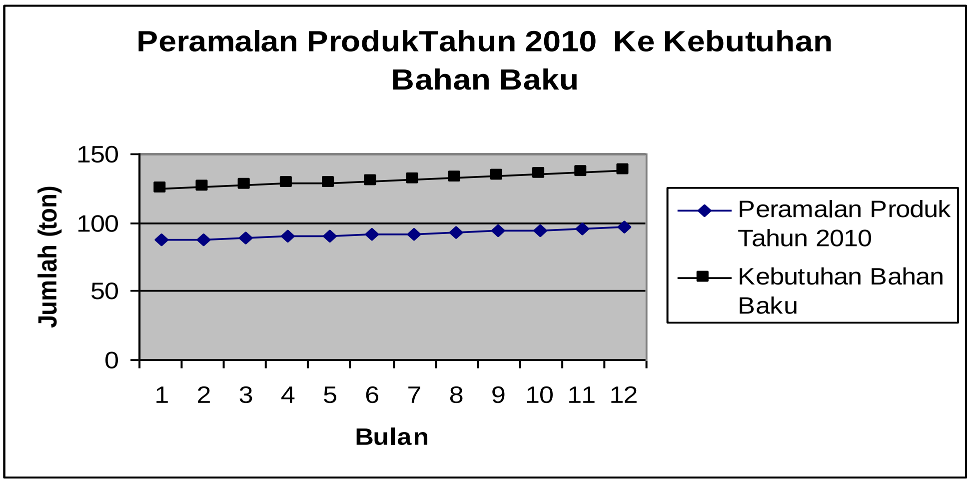

Figure 3.
Conversion of Production Forecasting Results to Raw Materials

Calculation of Economic Order Quantity (EOQ)

To determine an economical purchase, it can be calculated using the EOQ calculation so that the optimal purchase quantity can be determined each time a message is ordered. The assumptions for calculating the EOQ are that demand is known with certainty, demand is constant at all times, lead time for receiving orders is known and constant, orders are received all at once. Below is the EOQ of raw coffee beans:

EOQ =Q*= $\sqrt{\frac{2RC}{H}}$

$$EOQ = \sqrt{\frac{2x1574x760.000}{69386}} = 185 ton$$ = 185.685

Order frequency (f) is:

$$f = \frac{R}{Q} \frac{1574}{185} = 8{,}6 \approx 9 \text{ and or } 8$$

Reorder points (ROP) are:

$$ROP = \frac{RL}{50} = \frac{1574}{50} = 31{,}48 = 31.478 \text{ tons}$$

Between order times = Week of work / frequency

$$= \frac{50}{8}$$

= 6.25 == 6 weeks
Assuming lead time (L) = 1 week and 50 week working days in one year
The total cost for procuring raw materials at the economic order quantity (EOQ) is:

$$TC = RP + \frac{CR}{Q} + \frac{HQ}{2}$$

$$= (1574)(\text{Rp.}10{,}000{,}000) + \frac{(760000)(1574)}{185} + \frac{(69386)(185)}{2}\ ]$$

= Rp.(15,740,000,000 + 6,466,162 + 6,418,215)
Total cost = IDR 15,725,864,367

Table 7.
Economic Purchase Order(EOQ Calculation)

F	Q*(tons)	Average Supply(Q/2)	B. Deposit (Rp)	B. Orders (Rp)	Total Cost (Rp)
1	1574	787	54,303,000	760,000	55,063,000
2	787	393.5	27,151,500	1,520,000	28,671,500
3	524	262	18,078,000	2,280,000	20,358,000
4	393	196.5	13,558,500	3,040,000	16,598,500
5	315	157.5	10,867,500	3,800,000	14,667,500
6	626	313	21,597,000	4,560,000	26,157,000
7	224	112	7,728,000	5,320,000	13,048,000
8	197	98.5	6,796,500	6,080,000	12,876,500
9	175	87.5	6,037,500	6,840,000	12,877,500
10	157	78.5	5,416,500	7,600,000	13,016,500

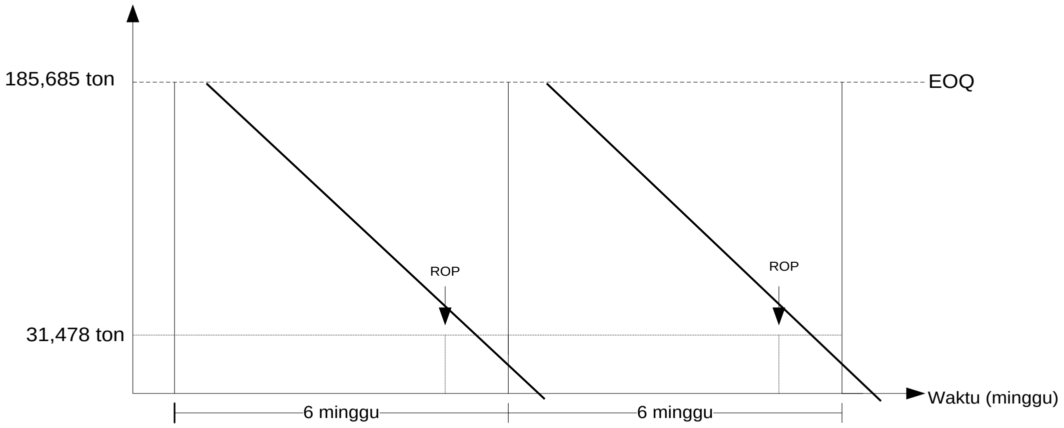

Fig.4.
Calculation of EOQ in 20 23

Calculation example:

$$f = 1 \qquad Q = 1574$$

$$Persediaan\ rata - rata = \frac{Q}{2} = \frac{1574}{2} = 787\ ton$$

$$Biaya\ penyimpanan = persediaan\ rata - rata\ x\ biaya\ simpan$$

$$= Rp.(787\ ton\ x\ 69386)$$

$$= Rp.54.606.172\ per\ ton / tahun$$

$$Biaya\ pesan = biaya\ telepon + biaya\ listrik + biaya\ faktur + biaya\ truk$$

$$= Rp.760.000\ per\ 1\ x\ pesan$$

From the table above the EOQ calculation can be determined, it can be seen that an economical order is 8 orders with a raw material procurement cost of IDR 12,876,500
Whereas ;

a. The constant transport cost is IDR 450,000/ 6 tons, so the transportation cost for 1574 tons is 1574 tons x $\frac{450.000}{6\ ton}$ = IDR 118,050,000

b. Purchase costs are constant at a price of IDR 10,000/kg, so the cost of purchasing raw materials = quantity of raw materials x price
= Rp.(1574 x 1000 x 10000)
= IDR 15,740,000,000

Because :
The cost components a and b above are the same for each order. So it doesn't need to be taken into account in comparing the lowest message costs.

4. CONCLUSION

. From data analysis UD. X, it can be concluded as follows:

1. The forecasting method chosen is the linear trend forecasting method with the smallest *standard error of estimate* , namely 8.24.
2. The total raw material requirement for 2023 is 1574 tons.
3. The number of economic orders (EOQ) is 1197 tons with a procurement cost of IDR 12,876,500 per order excluding transportation costs and purchasing costs.
4. Order frequency is 8 times a year and orders are made every 6 weeks with a reorder point (ROP) of 32 tons.
5. *EOQ* method can minimize costs company, so that it can be allocated to other fields

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