CONTROLLING RAW MATERIAL SUPPLIES TO MINIMIZE BULLWHIP EFFECT IN MAKING WATER PUMP HOUSINGS BY DIE CASTING

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ABSTRACT

Industrial development is becoming tighter in terms of competition so that it must have an advantage over other competitors. The most important thing in product management is to be able to manage stock management. PT. XYZ is a manufacturing company engaged in casting pumps. In the production process, it will control the inventory of raw material warehouses with estimates. If a raw material starts to run out, it will place an order again. In fact, it always causes excessive raw materials or shortages.if there is an error in planning, it will be hampered and result in lost opportunities in selling products so that the company does not make a profit. The results of this study are able to identify the problem of bullwhip effect, calculate safety stock, obtain effective planning models, determine steps in overcoming the bullwhip effect and find out the causes of the bullwhip effect.

1. Introduction

The industrial era is now increasingly tight and must have advantages over other competitors, one of which is in product management such as stock management so that the business grows. Factors that cause stock out are fluctuations in demand, inaccurate forecasting and varying lead times. This will also have an impact on advance planning. The bullwhip effect is also one of the problems that occur in companies. Phenomerna that occurs due to changes in demand generally occurs in the supply chain in which there are activities between retailers, producers and suppliers of raw materials. There are many businesses that experience a bullwhip effect due to inefficient consumer buying patterns and in the end many products become dead stock, backordered or resold at a discount to avoid losses.

PT. XYZ is a manufacturing company engaged in casting pumps. In the production process, there is a part in scheduling production, monitoring production and controlling the availability of production raw materials. Along with the times and business competition continues to increase, of course PT. XYZ will improve all efficiency in all fields, one of which is controlling production stock in minimizing the bullwhip effect that occurs at PT. XYZ. In carrying out its production process, PT. XYZ controls raw material warehouse inventory with estimates. If a raw material starts to run out, PT. XYZ will place a reorder. It's just that in reality, PT. XYZ placing orders always causes excessive raw materials or shortages in warehouse stock. The impact of excess raw materials is that there are increased costs for storage and raw material

shortages are that there will be delays in ordering raw materials to suppliers and causing delays in raw materials.

If there is an error in planning, the production process becomes hampered and results in lost opportunities to sell products so that the company does not make a profit. This is an evaluation for PT. XYZ because in the management of raw material control has not run well. The amount of raw material needs is not in accordance with the order, making it difficult to calculate the amount of raw materials when ordered. Therefore the company needs to have planning, management and control of raw materials.

2. Literature Review

Table 1. Literature Review

No	Year	Author	Title	Respondent	Conclusion
1	2017	Lukman Nurhuda, Budi Setiawan, Dwi Retno Andriani [1]	Supply Chain Management Analysis of Potato (Solanum Tuberosum L.) at Ngadas Village, Poncokusumo Sub District, Malang Regency - Journal of Agricultural and Agribusiness Economics (JEPA) Volume I No. 2.	This study aims to analyze supply chain conditions, analyze the marketing efficiency of potato marketing channels at the research site. The data analysis methods used are descriptive analysis *of supply chain management* and marketing efficiency analysis. *Supply chain management* includes activities to obtain raw materials, production planning activities, production activities and potato distribution activities to consumers.	This research shows that *supply chain management* is an indispensable step in the supply chain. Information flow patterns in the supply chain. Determine the effectiveness of the supply chain in the long term, especially. Related to product improvement. Information in the supply chain includes information on the number of requests, per product dose, delivery schedule, product prices at the wholesale and retailer levels and information related to product criteria consumed.
2	2020	FransiskaLefta, Lina Gozali, Iveline Anne Marie [2]	Aggregate and Disaggregate Production Planning, Material Requirement, and Capacity Requirement in PT. XYZ. - IOP Publishing: Materials Science and Engineering	This research shows that the use of *artificial Neural Network* for forecasting for it has the smallest error among forecasting techniques. Use of mixed strategies for aggregate planning and percentage techniques for Disaggregated planning is recommended because it has the lowest cost. A rough chunk of capacity	Forecasting is an art and the science of predicting Future events by taking historical data, and project it into the future Using the model Systematic approach (Heizer, Jay and Barry 2011). Planning Qualitative Inventory is replaced with forecasting and

| | | | Vol. 852. | planning calculations can show what machines are undercapacity for future periods. Lot-sizing. The technique chosen is *the Wagner algorithm* in because it has the smallest cost required. | Error determination smallest. Process forecasting done with *Single Moving Average* (SMA), *Double Moving Average* (DMA), *Average Weighted* Moving(WMA), Single Exponential Smoothing (SES). Smoothing Double Exponential (DES), Linear Regression, Cyclic,Squared , Decomposition, and Artificial neural networks. |

No	Year	Author	Title	Respodent	Conclusion
3	2015	Lithrone Laricha Salomo, Paula Theresia [3]	Usulan Penerapan Material Requirement Planning (MRP) untuk Pengendalian Persediaan Bahan Baku Produk ANT Ink. - Jurnal Kajian Teknologi Vol 11. No 1.	Research provides proposal to implement MRP for management raw material inventory of ANT Ink products. Product sales data forecasting done with DES, DMA, linear regression, and quadratic methods and choose methods with the smallest error value. Aggregate planning done with a mix *strategy*. The proposed use of *Wagner Within* because it has the best total cost of inventory.	Forecasting is A fusion of art and inner science foresee Situation in the Present Time coming, with How to project Period Data past to the past will come with Using the model mathematics and subjective estimates . Forecasting is the beginning of a process of retrieval of a decision to foresee Request rate What toexpect For a product or several products in a certain period of time in the future.
4	2022	Berdymyrat Ovezmyradov. [4]	Product availability and stockpiling in times of pandemic: causes of supply chain disruptions and	This study analyzes possible reasons for disruptions in supply and demand using mathematical models with *lead times* for analysis of supply, multi-period, *bullwhip effect* and consumer policy models. This research	Lead time variability is assumed to reflect supply-side disruption. But a significant impact comes from rational hoarding and *pannict buying*. Consumers first increased purchases and then readjusted closer to pre-pandemic levels. In response, retailers are raising reorder

No	Year	Author	Title		Results
			preventive measures in retailing.	contributes to business response to *supply chain* disruptions by developing a model where retailers and consumers decide order quantities and reorder points during the pandemic.	points. Higher safety stocks and the bullwhip effect of the pandemic increased costs for consumers and especially retailers. However, inventory levels returned to levels close to pre-pandemic normal after the initial surge phase.
5	2019	Mudjahidin, Lukman Junaedi, Andre Parvian, Yudha Andrian [5]	Influence of Inventory Changes to Bullwhip Effect on Private Industrial Network.	This study presents a mathematical model to calculate the effect of inventory changes on the *bullwhip effect* in the case of private industry consisting of four stages: 6 supplier companies, producer companies, 3 distributor companies and 6 retailers. Every company has an inventory of safety stock products. With a *pull* inventory system for filling and producing products using data set parameters and calculating inventory then comparing the inventory *bullwhip effect* in each company for each stage at a fixed parameter Data set, sensitivity analysis, minimum maximum safety stock value and initial for inventory.	The results showed that by conducting a sensitivity analysis, inventory values can be found so that the *bullwhip effect* that occurs does not cause inventory shortages in each company. In addition, these inventory values can change the average minimum inventory to positive, the maximum inventory decreases, and the availability and number of shortages on the *Private Industrial Network* to non-occur.
6	2020	Gabriela Dias, Pedro Dias, Adriano David [6]	Reverse bullwhip effect: Duality of a dynamic model of supply chain. – Independent journal of management & production	This study aims to investigate *bullwhip effect* control strategies based on linear supply chain dynamic models. Describe inventory dynamics and production rates of productive units by simulating models for conditions of instability and stability determined by mathematical analysis.	Through these results, we verify the classic and inverse bullwhip effects associated with instability and stability conditions, respectively. This model reveals duality after the control strategy proposed by Helbing and Lamer (2005) for the classic bullwhip effect ends up causing the opposite, equally disturbing effect. In the reverse *bullwhip* effect , we

observe amplification of production levels in the network chain from supplier to customer in a way that the upstream chain is unable to meet the needs of the downstream chain. To withstand both effects, we suggest dynamic control of parameters describing networks based on the model of Helbing and Lammer (2005).

No	Year	Author	Title	Respondent	Conclusion
7	2017	Maserih, M [7]	Analisis Bullwhip Effect Dan Day Of Inventory (Doi) Serta Implikasinya Terhadap Supply Chain Management	This thesis aims to measure *the Bullwhip Effect* and *Day Of Inventory* (DOI) at PT. XYZ Tbks, as well as to analyze whether the *Bullwhip Effect* and *Day Of Inventory* can have an impact on *Supply Chain Management* at PT. XYZ Tbk. The method used in this study is descriptive analysis with data collection methods through literature study, observation, interview. From the results of writing, it can be seen that by minimizing the *Bullwhip Effect*, it will reduce the *Day Of Inventory number.*	The longer the stock turnover will result in additional costs in storing the stock and this will harm the company if it is not managed properly. Expired goods will be shorter so that this causes rejection of the item in the market, even if it can be sold the company will reduce a special program that will reduce the company's profit. This will give losses to the company if good management is not carried out on the *Day Of Inventory* of each product to be sold.
8	2011	Tapan Panda, Prasanta Mohanty [8]	Supply Chain Management and Bull Whip Effect: A Conceptual Framework for Efficiency Improvement in Supply	This research paper Introducing the concept of the *bullwhip* effect and how it impacts the supply chain . Attempts were made to Crystallizing effect *Bullwhip* through a framework that explains the impact of this effect.	Influence of *bullwhip effect* shows that rate variation stock in the chain Supply tends higher upstream rather than downstream. Thing This is due to factors such as limited/none Information Sharing across the chain supply,market data

Chain - The IUP Journal of Supply Chain Management, Vol. VIII, No. 4

The paper also highlights how these effects can minimized or eliminated from the supply chain cycle by bringing about changes in business operations . The counterstrategies suggested in this article are based on on reference previous research as well as business practices followed by large organizations. This article will help researchers and students to Understand the impact of the *bullwhip effect* and implement strategies counterpoint to improving supply chain efficiency.

unavailable on insufficient, Forecasting methods which is inappropriate, and Other uncertainties that appears. Effect bullwhip refers to on increasing demand variability further upstream in the supply chain, and concludes that the theory Effect measurement *Bullwhip* in The practical setting has received limited attention.

3. Research Methodology

This research methodology describes the stages carried out in a more specific study and sequentially starting from the initial plan to the final plan of the study. The research methodology can be seen in Figure 1. below.
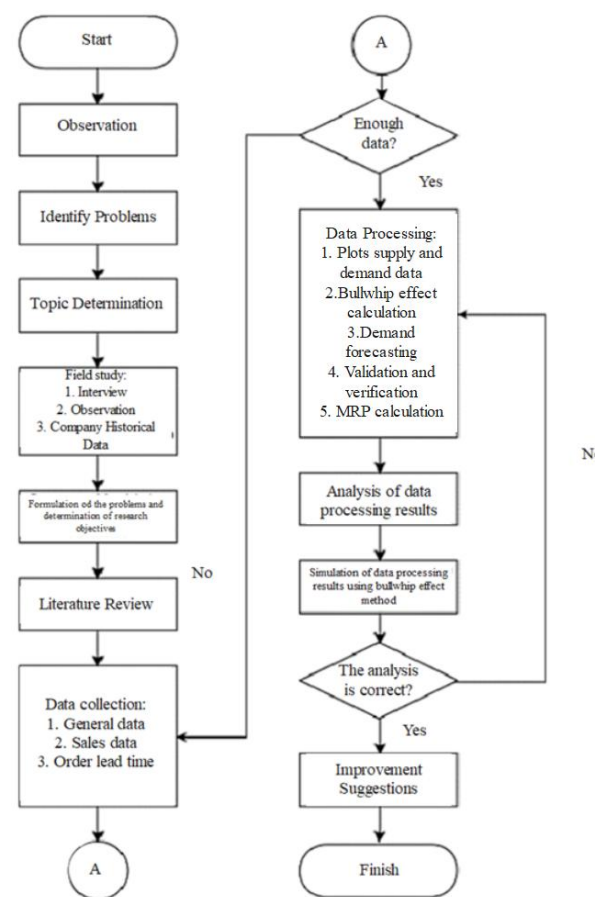
Figure 1. Flowchart Methods

4. Data Collection and Calculation

The following is a data and graph of sales and orders for steel scrap (ton) raw materials in 2022 PT. XYZ in the last 1 year can be seen in Table 2 below.

Table 2. Supply and Demand *Steel Scrap* 2022

Month	Supply (ton)	Demand (ton)
January	60.080	68.342
February	77.734	77.454
March	83.973	95.053
April	83.464	75.833
May	73.644	64.348
June	76.846	87.500
July	66.346	72.848
August	90.367	79.346
September	75.009	70.859
October	67.231	72.424
November	80.359	85.938
December	75.940	72.872

The following is a graph of steel scrap sales and orders in tons in 2022 as follows.
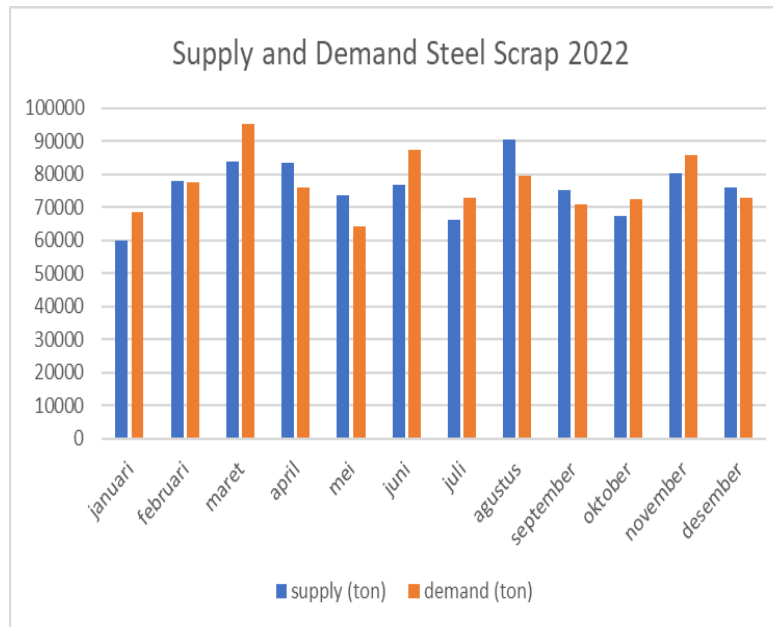

Figure 2. Supply and Demand Data 2022

The graph shows in the supply and demand of raw materials carried out at PT. XYZ is still not suitable. As in March there was an excess stock of 11,080 tons and in August there was a stock shortage of 11,021 tons so that it could not meet consumer needs. This problem means that the company does not always experience an increase but also experiences a decrease in raw material inventory, making fluctuations in *the company's* inventory.

In the development of the pump industry in Indonesia experienced many innovations to improve pump efficiency and performance. The innovation made is already using digital technology so that the development of pumps that are more energy efficient. In addition, there is also the development of materials and pump designs that are more durable and can reduce maintenance costs. This causes market competition to be tighter so that companies must continue to innovate to survive and win the market. PT. XYZ must have these innovations so that it causes increasingly fluctuating demand patterns for upstream supply chains so that it experiences inefficient economic conditions called the bullwhip effect. Therefore, precise calculations are needed in *safety stock* in order to minimize the occurrence of *bullwhip effects* due to erratic order demand.

Based on the data above, forecasting pump casting demand for the next 1 year, namely in 2022 using the DES, SES, Multiplicative Decomposition, Linear, and SMA methods [9][10]. The following are the results of error calculations using the DES and SES methods (α = 0.1; 0.3; 0.5; 0.7; 0.9) and Multiplicative Decomposition, Linear, and SMA methods. The error calculation can be seen in the attachment. The error calculation results can be seen in Table 3, Table 4 and Table 5.

Table 3. SES Error Calculation

Metode Error	SES				
	0,1	0,3	0,5	0,7	0,9
ME	5,492	2,437	1,441	0,942	0,576

MAD	7,951	8,758	9,87	10,888	11,981
MSE	117,838	115,546	130,2	150,978	177,045
SDE	12,001	11,884	12,615	13,584	14,71
MAPE	9,575%	10,945%	12,486%	13,822%	15,232%

Table 4. DES Error Calculation

Metode Error	DES				
	0,1	0,3	0,5	0,7	0,9
ME	5,22	1,733	0,641	-0,055	-0,789
MAD	7,995	9,302	11,185	13,781	16,823
MSE	116,453	121,451	159,84	238,205	395,266
SDE	11,93	12,184	13,977	17,063	21,98
MAPE	9,66%	11,729%	14,249%	17,596%	21,491%

Table 5. SMA, Linear, and Multiplicative Decomposition Error Calculation

Metode Error	SMA			Linear	Multiplicative Decomposition
	4 month	8 month	12 month		
ME	-1,46	-1,704	-4,396	0	0,025
MAD	7,863	6,035	4,396	6,758	4,989
MSE	75,435	40,26	19,322	70,81	33,712
SDE	10,029	8,973	0	9,218	8,211
MAPE	10,52%	7,91%	6,03%	8,69%	6,35%

Based on the results of the error calculation above, the smallest error is obtained at most in the DES 0.1 method compared to other methods so that forecasting for the next 5 years will use the DES 0.1 method. The following is a detailed control tracking signal from the DES 0.1 method can be seen in Figure 3 below.

	Demand(y)	Forecast	Error	Cum error	Cum abs error	Cum Abs	MAD	Track Signal
January	68,342							
February	77,454	68,342	9,112	9,112	9,112	9,112	9,112	1
March	95,053	69,344	25,709	34,821	25,709	34,821	17,41	2
April	75,833	72,173	3,66	38,48	3,66	38,48	12,827	3
May	64,348	72,579	-8,231	30,249	8,231	46,712	11,678	2,59
June	87,5	71,677	15,823	46,072	15,823	62,534	12,507	3,684
July	72,848	73,42	-,572	45,5	,572	63,106	10,518	4,326
August	79,346	73,361	5,985	51,485	5,985	69,092	9,87	5,216
September	70,859	74,022	-3,163	48,322	3,163	72,255	9,032	5,35
October	72,424	73,678	-1,254	47,068	1,254	73,509	8,168	5,763
November	85,938	73,543	12,395	59,463	12,395	85,904	8,59	6,922
December	72,872	74,909	-2,037	57,425	2,037	87,941	7,995	7,183

Figure 3. Control Tracking Signal

Safety Stock

Safety stock relates to the preparation of inventory of goods prepared by the company to prevent inventory shortages when demand market conditions are unstable. Companies ordering goods until the goods arrive require a period of time called the order waiting time (Delivery Lead Time). Safety stock aims to control the stock available in the raw material warehouse. The Safety Stock method was chosen because it can know the safe inventory that must exist.

$$SS = n \times \mu$$

Information:
SS   = Safety Stock
n = Safety Level Factor
μ   = Standar Deviation

Safety factor PT. XYZ has a percentage of 90%. This means that 90% of needs are met and 10% are not met. Supplier goods come on time according to the lead time, so the value of 1.28 is obtained from the cumulative Z table with a α value of 90%. Lead time for making in the company is on average 4 days per week.

Raw Material	SF (90%)	Lead Time (day)	Lead Time (week)	Average Demand (ton)	Standar Deviation Demand	Safety Stock
Steel Scrap	1.28	4	0,571	76901,41	8421,049	21557,88

5. Conclusion

From the results of the study, several conclusions can be drawn, namely PT. XYZ, which only estimates raw material warehouse inventory control, experiences a bullwhip effect due to inefficient consumer purchasing patterns and in the end many products become dead stock, backorders or resold at a discount to avoid losses. It can be known that the influence factor occurs because problems in the calculation of inappropriate lead time cause a buildup of the number of inventory items and experience losses. Too many offers of discounts and promotions also cause problems with forecasting production figures and demand forecasting that is wrong causing a shortage of stock so that it is stuck in the production warehouse. To be able to overcome the bullwhip effect that occurs is PT. XYZ simplifies the amount of supply of goods not too much and not too little. Limiting promotions and sales can stabilize purchase demand figures and set minimum order quantities to meet customer needs.

6. References

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