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Recommendations for reducing waste and bullwhip effect in Supply Chain Management (SCM) flow at a Bakery Company AA Indah (Gresik, East Java)

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ABSTRACT

Waste and information distortion exist in the supply chain management flow of bread production. Researchers have analyzed waste using value stream mapping tools and calculated the Bullwhip Effect (BE) value using the BE formula, providing improvement recommendations using failure mode effects and analysis. The identified wastes were waiting, excessive transportation, and defects. The tools used were process activity mapping (PAM) and a Supply Chain Response Matrix (SCRM). PAM analysis identified 11 operation activities, 1 transportation activity, 1 inspection activity, 1 storage activity, and 2 delay activities. Meanwhile, the day physical stock is 0.9412, with a lead time of 30 days. Based on the BE value calculation, the bread product in 2024 shows a BE value of 1.0540 for one year. Thus, demand amplification occurred for bread products in 2024. From waste identification using a cause-and-effect diagram and improvements using failure mode effects and analysis, recommendations for improving waiting time include implementing machine maintenance scheduling to prevent delays and evaluating and rearranging workflows to reduce waiting time between processes. For excessive transportation waste, the recommendations are rearranging the machine layout, optimizing goods delivery routes, implementing just-in-time methods to reduce the inventory that needs to be moved, and using technology to manage information flow more efficiently. Defect improvement recommendations include comprehensive operator training, establishment of strict work standards, use of quality checklists, application of quality management tools such as Pareto charts and 5 Why, conducting routine process evaluations, and ensuring continuous monitoring and quality control.

Keywords: bullwhip effect; cause effect diagram; failure mode effect and analysis; supply chain management; VALSAT; waste

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1. INTRODUCTION

In today's era of globalization, competition is becoming increasingly fierce in the industrial and business sectors, whether in the manufacturing or food industries. Customer expectations are also increasing. Offering affordable, high-quality products alone is no longer sufficient to satisfy customers or consumers; product variety is becoming increasingly important for meeting market demands. Industry players are beginning to realize that providing affordable, high-quality products delivered quickly is not enough to drive internal improvements within the food industry. These three aspects require the participation of all parties, from suppliers to manufacturers who transform components and raw materials into finished products. This awareness of the importance of all parties' roles in creating affordable, fast, and high-quality products gave rise to a new concept in the 1990s: SCM. These companies include suppliers, manufacturers, distributors, stores, retailers, and supporting companies such as logistics service providers.

Three types of flows must be managed within the supply chain. First, the flow of goods from upstream to downstream, for example, raw materials are shipped from suppliers to manufacturers, and after production is complete, they are shipped to distributors, retailers, and finally to end users. Second, the flow of money and similar resources moving from downstream to upstream; and third, the flow of information, which can occur from upstream to downstream or vice versa. Supply chain management is an integrated method for managing the flow of products, information, and funds in an integrated manner, involving parties from upstream to downstream, including suppliers, factories, distribution networks, and logistics services (Pujawan & Mahendrawathi, 2017). Supply chain management activities include product development, procurement of materials and components, production planning and inventory control, production, and distribution or transportation (Jacobs & Chase, 2018).

Two major challenges in supply chains are complexity and uncertainty. Complexity arises because of the large number of parties involved. Uncertainty can stem from demand, suppliers, or internal company factors (Davis & Heineke, 2004). During operational processes, this uncertainty leads to waste that can harm the company, as it may result from delivery lead times, raw material prices, quality of delivered materials, imperfect machine performance, machine breakdowns, and many other factors. This bakery company, located in Manyar, Gresik, East Java, requires sound production planning to grow. In the production of white bread, several instances of waste occur during the production process, such as the presence of many unnecessary activities, a production process that requires a considerable amount of time, and excess raw material inventory. In the supply chain flow activities for plain bread production at this company, non-value-adding waste occurs throughout the value streams.

High levels of waste throughout the supply chain affect the time it takes to deliver products to consumers or customers. This is due to the presence of inefficient or non-value-adding activities in various aspects, including raw material procurement from suppliers, material flow from the initial to the final process, the movement of tools and machinery that do not match capacity, waiting times, rework, and other necessary corrections (Hines & Rich, 1997), which constitute forms of waste that must be eliminated to ensure that the value stream flows smoothly (Suyanto & Noya, 2015).

According to Gaspersz and Fontana (2011), lean is a management approach that integrates lean principles and Six Sigma to eliminate waste and continuously improve process quality toward a performance level approaching zero defects. Therefore, the Lean approach is highly relevant in resolving the issues present at the AA Indah Gresik bread production plant. The problem identified by the researchers is how to identify waste and the BE in the supply chain management flow, and efforts are needed to reduce waste and the BE, as explained by Fransoo and Wouter (2000). This indicates an increasing distortion of demand information along the supply chain, necessitating systematic efforts to mitigate its impact on the supply chain. This condition is further reinforced by the findings of Susilo (2008), who stated that information imbalances in the supply chain can amplify demand variability and lead to operational inefficiencies. Based on this, the researcher conducted a study to address these issues with the objectives of determining the extent of waste, identifying the BE within the supply chain management flow, and proposing recommendations for improvements to minimize the occurrence of waste and the BE.

2. METHODOLOGY

Quantitative research is a process for obtaining truth that must be based on rational thinking, logic, reasoning, empirical evidence, and facts. Quantitative research is based on the fact that research data are statistical data in the form of numbers. This study uses various numerical data, such as data on the time required for each material flow process from raw materials to finished goods, as well as demand and sales data; thus, this research is called quantitative research. Literature Review and Field Study Stage: Literature review stage involves searching for references from international and national journals, books, and previous research. It is used to improve the understanding of the theoretical foundation of the problem being studied, as well as to support and facilitate the formulation of the research problem. The literature reviewed includes the lean approach, value stream analysis tools (VALSAT), the seven wastes, Big Picture Mapping (BPM), and the BE.

Field studies are conducted to understand the actual conditions in the company, especially those related to the object of study. This was conducted by observing the bread production process at the factory and through discussions and interviews with managers and coordinators or supervisors of relevant departments, in this case, the sales department, production department, product planning and inventory control, and quality control to determine the activities included in the production system stream. Problem Formulation and Objective Determination Stage: This stage identifies how to determine the types of waste and BE that occur in the supply chain management flow towards the value stream and how to determine the mapping tools used to analyze and evaluate waste. This stage establishes the research objectives to be explored. This study aims to identify and reduce waste and BE in the supply chain management flow.

2.1. Data Collection and Processing Stages

The data sources for this study are as follows: (1) production process flow time data were obtained from direct research at each production site, from raw material intake to finished product, with guidance from the head of production; (2) order data were obtained from the AA Indah Sembayat Bread Factory; (3) sales data were obtained from the AA Indah Sembayat Bread Factory; (4) company overview was obtained from the AA Indah Sembayat Bread Factory; and (5) literature review was obtained from research journals and books related to the waste BE.

2.2. Data Collection Stage

Data collection was conducted in two ways. First, primary data. These data were obtained through interviews, waste workshops (questionnaires), and direct observation of the company's condition. Second, scondary data. The data required to visualize existing waste within the company include company history, organizational structure, workforce, raw materials production processeded, produc sale data and as data related to the selected BPM and value stream mapping tools.

2.3. Data Processing Stage

The data processing steps in this study included the following: First, a BPM was created. Second, weighting waste (waste identification) occurs along the value stream of the company's production system, obtained from the results of the waste workshop (questionnaire) that significantly impacts the value stream in the production system. Third, a mapping tool was selected based on recommendations from the VALSAT matrix, which is used to weight frequently occurring waste in the company. The formula for the VALSAT score is as follows (see Table 1):

Table 1. The Formula for the VALSAT Score

Waste	**Weight**	***Process Activity Mapping***	***Supply Chain Response Matrix***	***Production Variety Funnel***	***Quality filter Mapping***	***Demand Amplification Mapping***	***Decision Point Analysist***	***Physical Structure Mapping***
over production	*Wo*	*Wo×L*	*Wo×M*		*Wo×L*	*Wo×M*	*Wo×M*	
Waiting	*Ww*	*Ww×H*	*Ww×H*	*Ww×L*		*Ww×M*	*Ww×M*	
Exessive Transportation	*We*	*We×H*						*We×L*
Inappropriate Processing	*Wi*	*Wi×H*		*Wi×M*	*Wi×L*		*Wi×L*	
Unnecessary Inventory	*Wui*	*Wui×M*	*Wui×H*	*Wui×M*		*Wui×H*	*Wui×M*	*Wui×L*
Unnecessary Motion	*Wum*	*Wum×H*	*Wui×L*					
Defect	*Wc*	*Wc×L*			*Wc×H*			
Total	*ΣW*	*Σ*	*Σ*	*Σ*	*Σ*	*Σ*	*Σ*	*Σ*

Source: Hines & Rich (1997)

VALSAT = Skor Waste from the results of the questionnaire x Correlation (H, M, and L)

Description: Hines & Rich (1997)

H = (Hing Correlation) : Multiplier = 9
M = (*medium correlation*) : Multiplier = 3
L = (*Low Correlation*) : Multiplier = 1

Fourth, conducting detailed mapping using secondary data maps into the selected BPM and VALSAT. Fifth, the BE value was calculated from the order and sales data.

2.4. Data Analysis Stage

This stage involves the analysis of the results of the previously obtained data processing will be analyzed. From this stage, BPM analysis, VALSAT analysis, analysis of the factors causing seven wastes with a cause-effect diagram (fishbone diagram), recommendations for improvement using Failure Mode Effect Analysis (FMEA), and analysis of the BE based on order data and sales data are carried out. This stage aims to improve the process and eliminate the causes of defects. In this refinement stage, Potential Impact and Failure Mode Analysis (FMEA) is used. FMEA is a systematic activity used to identify and evaluate the potential failure rate of a system, product, or process, especially the fundamental functions of the product or process in terms of the factors that influence it. The purpose of FMEA is to develop, improve, and control the possibility of failure detected from the source (input) and reduce the impact caused by the occurrence (error) (Meykasari et al., 2022) (see Table 2, Table 3, and Table 4).

Table 2. Severity Rating Scale

Rate	**Criteria**	**Description**
1	None Severity	No adverse effects
2	Negliblw Severity	Negligible adverse effects
3	Mild Severity	Mild or slight adverse effects
4	Mild Severity	Mild or slight adverse effects
5	Moderat Severity	Moderate adverse effects (within tolerable limits)
6	Moderat Severity	Moderate adverse effects (within tolerable limits)
7	Moderat Severity	Moderate adverse effects (within tolerable limits)

8	High Severity	High adverse effects (beyond tolerable limits)
9	High Severity	High adverse effects (beyond tolerable limits)
10	Potential Safety Problem	Very dangerous consequences (related to potential safety or security)

Source: Automotive Industry Action Group (2019)

Table 3. Occurrence Rating Scale

Rate	Failure Rate	Description
1	1 in 1.000.000	It is unlikely that this is the cause
2	1 in 20.000	causing failure mode
3	1 in 4.000	Failure will be rare
4	1 in 1.000	Failure will be rare
5	1 in 400	Failure is rather possible
6	1 in 80	Failure is rather possible
7	1 in 40	Failure is very possible
8	1 in 20	Failure is very possible
9	1 in 8	It is almost certain that a failure will occur.
10	1 in 2	It is almost certain that failure will occur.

Source: Automotive Industry Action Group (2019)

Table 4. Detection Rating Scale

1	Detection and prevention methods are highly effective.	< 0,01 per 1000 fetch
2	There is virtually no chance of failure.	0,1 per 1000 fetch
3	The probability of the cause occurring is very low.	0,5 per 1000 fetch
4	The probability of the cause occurring is moderate.	1 per 1000 fetch
5	Prevention methods sometimes allow the cause to occur.	2 per 1000 fetch
6	The probability of the cause occurring is still high.	5 per 1000 fetch
7	Prevention methods are less effective.	10 per 1000 fetch
8	The cause still recurs.	20 per 1000 fetch
9	The probability of the cause occurring is still very high.	50 per 1000 fetch
10	Detection and prevention methods are highly ineffective, and the cause still recurs.	100 per 1000 fetch >

Source: Automotive Industry Action Group (2019)

FEMEA proposal. The Risk Priority Number (RPN) is the multiplication of severity (S), Occurrence Rating (O), and detectability (D); based on this definition, the RPN formula is obtained as follows: RPN = S × O x D. The number from the RPN result is used as a guide to determine the most serious problems, with the identification of the highest number that requires serious handling.

3. RESULTS AND DISCUSSION

3.1. Waste Identification and Weighting

The first step in processing this data is to distribute a waste workshop to relevant leaders, specifically in the production department. The waste workshop aims to identify waste within the company. The workshop discussed the relationship between the seven types of waste and the activities performed. The results of the waste workshop are then weighted to determine the dominant types of waste within the company.

For the weighting, I used three values: 1, 3, and 9, with the following explanation: 1 = Insignificant waste. 3 is significant waste and 9 is very significant waste. After identifying the highest levels of waste within the company, tools were selected to reduce waste. Waste Scoring: Based on the scoring of the 16 activities throughout the volume stream, the types of waste that significantly impact the company can be identified. The following is the weighting calculation for each waste type.

3.1.1. Over Production

For more details, see Equation 1.

$$\text{Weight} = \frac{26}{26+60+36+24+22+28+32} X100\% = 11{,}40\%$$

3.1.2. Waiting

For more details, see Equation 2.

$$\text{Weight} = \frac{60}{26+60+36+24+22+28+32} X100\% = 26{,}32\%$$

3.1.3. Exessive Transportation

For more details, see Equation 3.

$$\text{Weight} = \frac{36}{26+60+36+24+22+28+32} X100\% = 15{,}79\%$$

3.1.4. Inappropriate Processing

For more details, see Equation 4.

$$\text{Weight} = \frac{24}{26+60+36+24+22+28+32} X100\% = 10{,}53\%$$

3.1.5. Unnecessary Inventory

For more details, see Equation 5.

$$\text{Weight} = \frac{22}{26+60+36+24+22+28+32} X100\% = 9{,}65\%$$

3.1.6. Unnecessary Motion

For more details, see Equation 6.

$$\text{Weight} = \frac{24}{26+60+36+24+22+28+32} X100\% = 12{,}28\%$$

3.1.7. Defect

For more details, see Equation 7.

$$\text{Weight} = \frac{32}{26+60+36+24+22+28+32} X100\% = 14{,}03\%$$

From the calculation of the weight of each waste, we can see that the biggest waste that occurs in the company (see Table 5).

Table 5. Waste Weight and Ranking

Ranking	Waste	Weight
1	Waiting	24,32 %
2	Excessive Transportation	20,54 %
3	unnecessary motion	14,60%
4	unnecessary inventory	12,97%

5	Defect	10,27%
6	Inappropriate Processing	9,73%
7	over production	7,57%
Total	**100,00%**	

After identifying the existing waste within the company, a tool was selected to eliminate it. This selection was made using a simplified version of the VALSAT. The first part of this process is to identify the value stream specifications for review. Second, interviews with managers within the value stream are crucial, as it is crucial to identify the various wastes within the value stream that managers believe can be reduced. Mapping tools were selected using the VALSAT approach, as shown in the following Table 6:

Table 6. Calculations Using VALSAT

Waste	***Weight***	***PAM***	***SCRM***	***Production Variety Funnel***	***Quality filter Mapping***	***Demand Amplification Mapping***	***Decision Point Analysist***	***Physical Structure Mapping***
Over production	11,4	11,40 ×1 = 11,40	11,40 × 3 = 34,2		11,40 ×1 = 11,40	11,40 × 3 = 34,2	11,40 × 3 = 34,2	
Waiting	26,32	26,32 × 9 = 236,88	26,32 × 9 = 236,88	26,32 × 1 = 26,32		26,32 × 3 = 78,96	26,32 × 3 = 78,96	
Exessive Transportation	15,79	15,79 × 9 = 142,11						15,79 × 1 = 15,79
Inappropriate Processing	10,53	10,53 × 9 = 94,77		10,53 × 3 = 31,59	10,53 × 1 = 10,53		10,53 × 1 = 10,53	
Unnecessary Inventory	9,65	9,65 × 3 = 28,95	9,65 × 9 = 86,85	9,65 × 3 = 28,95		9,65 × 9 = 86,85	9,65 × 3 = 28,95	9,65 × 1 = 9,65
Unnecessary Motion	12,28	12,28 × 9 = 110,52	12,28 × 1 = 12,28					
Defect	14,03	14,03 × 1 = 14,03			14,03 × 9 = 126,27			
Total	100	638,66	370,21	86,86	148,2	200,01	152,64	25,44

From the Table 6, a ranking of the VALSAT scores is compiled based on the tools with the highest to lowest scores. The ranking results were as follows:

Table 7. Weighted Ranking Results

No.	**Tools**	Weight	**Ranking**
1	PAM	638,66	1
2	SCRM	370,21	2
3	Production Variety Funnel	86,86	6
4	Quality filter Mapping	148,2	5
5	Demand Amplification Mapping	200,01	3
6	Decision Point Analysist	152,64	4
7	Physical Structure Mapping	25,44	7

Based on the Table 7, it can be seen that the selected tools to evaluate existing waste are PAM and SCRM. The two mapping tools mentioned above, namely, PAM and SCRM, were selected based on the highest or dominant total weight compared to the total weight of the other mapping tools.

3.2. PAM

PAM describes all activities within a company in detail. A table is then created containing activity types, areas, distances, times, and various activity types, including operation, transportation, inspection, delays, and storage. Once the table is complete, a graph is created for the activity types, and a comparison chart between activity types in the form of tables and diagrams. The goal of this approach is to eliminate unnecessary activities and simplify, combine, and modify sequences to reduce waste.

3.3. PAM Analysis

The PAM results revealed conditions related to the value stream of the production system.

Table 8. Activity Mapping

Number of Activity Types Along the Value Stream						
	Operation	Transportation	Inspection	Storage	Delay	Amount
Number of Activities	11	1	1	1	2	16
Percentage	68,75%	6,25%	6,25%	6,25%	12,5%	100%
Total time of Activity Types Along the Value Stream						
	Operation	Transportation	Inpection	Storage	Delay	Amount
Time (minute)	65	10	25	2	45	147
Percentage	44,22%	6,80%	17%	1,36%	30,61%	100%

Table 8 identifies several aspects that occur during the production process. First, operations. The production process involves 11 operational activities, which is approximately 68.75% of all activity types. The time required to complete each activity was 65 min, or approximately 44.22% of all activity types. Second, transportation is required. There was one transportation activity, totaling 10 min, or approximately 6.80% of all activity types. Third, inspection. One inspection is conducted, totaling 25 min, or approximately 17% of all activity types. Fourth, storage. One inspection was conducted. Inaccurate sales forecasting and production planning result in overproduction. Fifth, delay. There were two delays, totaling 45 min, or approximately 30.61% of all activity types.

3.4. SCRM

The SCRM is used to evaluate inventory and lead times in the distribution channel. With this tool, management will be able to identify increases or decreases in inventory levels and distribution times in each area of the supply chain. The purpose of mapping using this tool is to improve inventory levels and minimize lead times, thereby improving service in each distribution channel at a lower cost. The SCRM for bakery products occurs in the production area, so the monthly average is 6,666.67 books.

Customer demand per month is 7,083.33 books and the product storage lead time is 30 days; thus, the value of days physical stock can be calculated as follows:

For more details, see Equation 8.

$$\text{Value } \textit{days physical stock} = \frac{6.666,67}{7.083,33} = 0,9412$$

SCRM Analysis: After obtaining the SCRM data, the following explanation was obtained: the raw material warehouse receives raw materials from suppliers with an average lead time of 10 days, an average daily arrival of 30 quintals, and an average raw material usage of 25 quintals. Therefore, the physical stock days were 1.08. In the production area, each month produces an average of 222 books/day, and the average raw material usage is 25 quintals/day. Therefore, the physical stock days are 8.88 days, with an average lead time of 5 days.

In the finished product storage area, the packed products are stored in the finished goods warehouse. The average daily packed product is 222 packs. After the packing process, the products are stored in a warehouse awaiting shipment. If 215 books are shipped daily, the physical stock days are 0.96 days, with an average lead time of 5 days (see Table 9 and Figure 1).

Table 9. SCR Calculation

No.	Item	Days Phisycal Stok	Lead Time	Cumulative Days Phisycal Stok	Cumulative Lead Time
1	Product raw material storage area	1,08	10	1,08	10
2	Production process area	8,88	5	9,96	15
3	Finished goods storage area	0,96	5	10,92	20
Total				**30,92**	

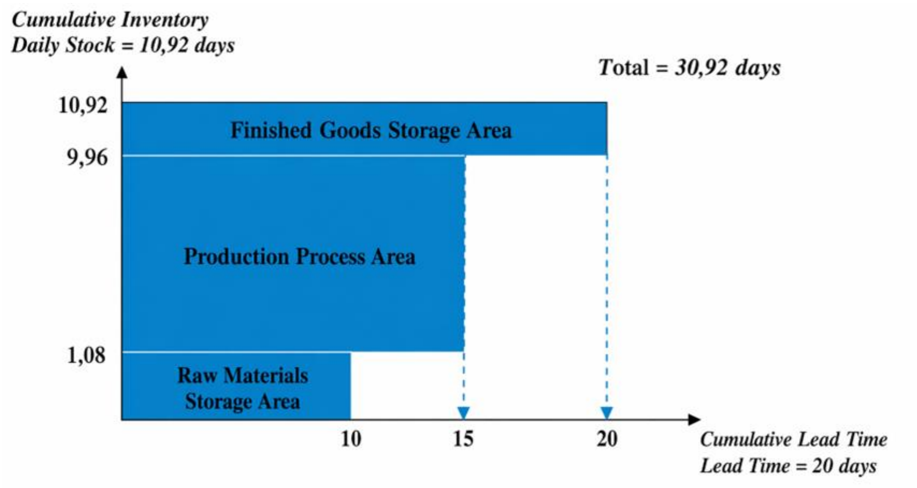

Figure 1. SCRM Graphic

3.5. BPM Analysis

From the BPM data, it can be seen that the demand for bread products comes from customers placing orders by phone or email to the Head of Marketing. The Head of Marketing then passes the order information to the Sales Staff. The Sales Staff then issues a work order to the Production Department. The Production Department then carries out the production process. After production is complete, the goods are stored in a warehouse. The warehouse department then informs the Distribution Department that the production process is complete and ready for shipment. The distribution section sends orders for organic fertilizer products to customers (see Figure 2).

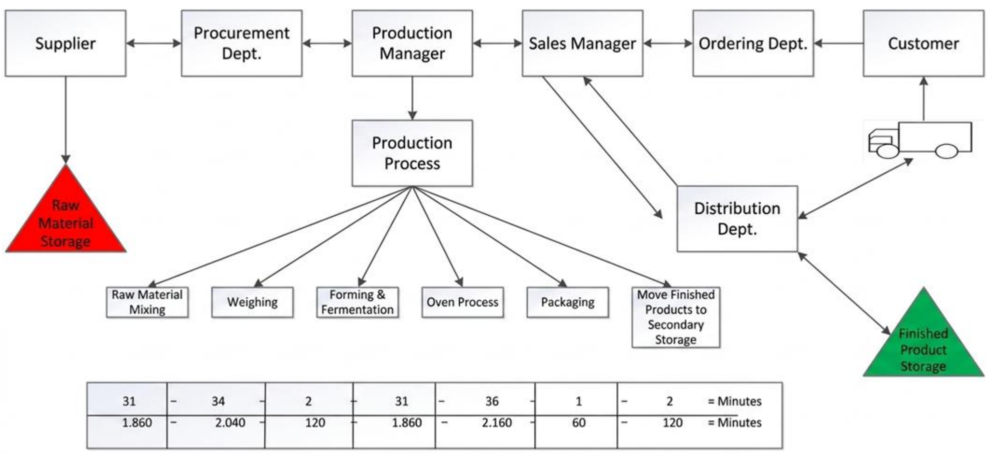

Figure 2. BPM

3.6. Calculating the BE

The BE can be calculated from the data in the Demand and Sales tables. In this case, the author calculated the value using Microsoft Office Excel as follows (see Table 10).

Table 10. Calculation of BE Value

Month		Mu	S	CV	BE
1-12	Order	7.083,33	2.443,2	0,3449	1,0540
	Sale	6.456,25	2.112,5	0,3272	

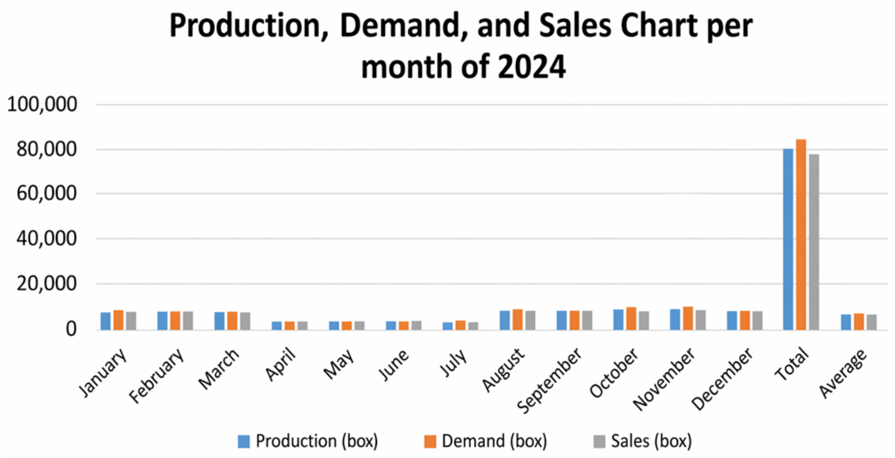

Figure 3. Comparison of the Number of Orders and Sales in 2024

Figure 3 shows an imbalance between the number of orders and sales, where the number of orders shows a relatively greater level of fluctuation compared to that of sales.

3.6. BE Analysis

Based on the BE calculation, a value is obtained that indicates the level of demand variability (demand amplification) across the two supply chain actors. The BE value is obtained by dividing the order variance coefficient by the sales variance coefficient. If the BE value is >1, demand amplification occurs for the product. Conversely, if the BE value is <1, demand remains stable, or there is a smoothing of the demand pattern. Bread products in 2024 show a BE value of 1.0540 for one year. Therefore, demand amplification for bread products will occur in 2024.

The graph shows an imbalance between the number of orders and sales in 2024, with the number of orders showing a relatively greater level of fluctuation than sales. This situation is caused by several factors, one of which is inaccurate demand forecasting.

3.7. Identifying the Causes of the BE

Based on the data above, the causes of the BE are as follows. First, Demand Forecast. Inaccurate demand forecasting results in significant demand variability. Second, Demand Exceeds Inventory. The number of orders and sales of bakery products in 2024 were not the same. Orders in 2025 were 85,000 boxes, and sales in 2024 were 77,475 boxes. This indicates that demand exceeds inventory, resulting in the BE. Third, there is an Inappropriate Process. Lack of skill and rushing during product packaging can result in defects. Poorly maintained machine settings can result in damage. Fourth, Unnecessary Motion. Inaccurate work methods on the production floor result in worker fatigue, resulting in decreased performance. Operators' lack of concentration and rushing result in defective products. Fifth, Unnecessary Inventory. Poor production planning results in the overstocking of finished goods in warehouses. Excessive finished goods stock in the warehouse increases the finished product maintenance costs. Sixth, Defect. Operators' lack of attention and rushing during production processes can result in fatigue.

3.8. Identifying Causes of Waste with a Cause-Effect Diagram

Several instances of waste occur in a bakery's value stream. The causes and consequences of waste will be identified. This will facilitate improvements in the bakery value stream. The cause-effect diagram is shown below (see Figure 4):

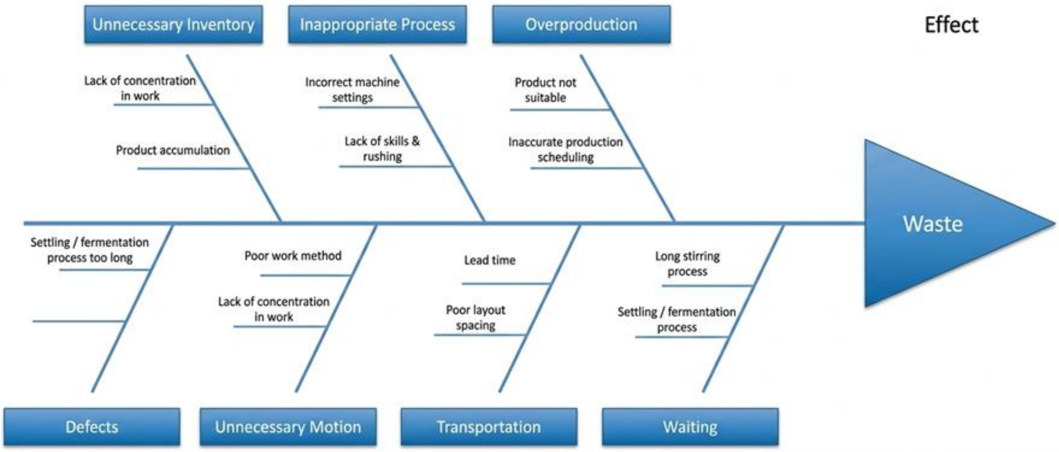

Figure 4. Cause Effect Diagram

The cause-and-effect diagram of waste in the bread product flow is as follows: (1) waiting: the mixing and stirring of ingredients takes a long time. The aging/fermentation process takes a long time, increasing production lead time; (2) overproduction: inaccurate production scheduling results in many products that do not meet customer demand and creates excess inventory in the finished goods warehouse. Lack of coordination and carelessness in product production between the production and marketing departments results in excess production in the finished goods warehouse and rework; (3) transportation: a shortage of labor leads to fatigue, which disrupts production performance. An unfavorable factory layout results in long transitions between processes (increased lead time); (4) inappropriate process: lack of skill and rushing during the product packaging process results in defects. Poorly maintained machine settings result in damage; (5) unnecessary motion: inadequate work methods on the production floor can lead to worker fatigue, which can lead to decreased performance. Operators' lack of concentration and excessive rushing can lead to defective products; (6) unnecessary inventory: poor production planning can lead to the overstocking of finished goods. Excessive finished goods inventory can lead to increased maintenance costs; and (7) defects: operators' lack of attention and excessive rushing during production can lead to fatigue and defects.

3.9. Recommendations for Improvement Using Failure Mode Effect Analysis (FMEA)

Based on the cause-effect diagram identification data above, a remedial analysis using failure mode effect analysis (FMEA) was conducted. It is hoped that by continuously implementing the proposed corrective actions, waste can be reduced in the future. To conduct an analysis using FMEA, the RPN is determined by multiplying the severity, occurrence, and detection ratings, with the result expressed as a number. The FMEA assessment table is presented in Table 11, Table 12, and Table 13:

Table 11. Severity Rating Scale

Rate	Criteria	Description
1	None Severity	No adverse effects
2	Negliblw Severity	Negligible adverse effects
3	Mild Severity	Mild or slight adverse effects
4	Mild Severity	Mild or slight adverse effects
5	Moderat Severity	Moderate adverse effects (within tolerable limits)
6	Moderat Severity	Moderate adverse effects (within tolerable limits)
7	Moderat Severity	Moderate adverse effects (within tolerable limits)

8	High Severity	High adverse effects (beyond tolerable limits)
9	High Severity	High adverse effects (beyond tolerable limits)
10	Potential Safety Problem	Very dangerous consequences (related to potential safety or security)

Source: Automotive Industry Action Group (2019)

Table 12. Occurance Rating Scale

Rate	Failure Rate	Description
1	1 in 1.000.000	It is unlikely that this is the cause
2	1 in 20.000	causing failure mode
3	1 in 4.000	Failure will be rare
4	1 in 1.000	Failure will be rare
5	1 in 400	Failure is rather possible
6	1 in 80	Failure is rather possible
7	1 in 40	Failure is very possible
8	1 in 20	Failure is very possible
9	1 in 8	It is almost certain that failure will occur
10	1 in 2	It is almost certain that failure will occur

Source: Automotive Industry Action Group (2019)

Table 13. Detection Rating Scale

Rate	Criteria	Description
1	Very High	100% of control tools are capable of detecting errors and functioning well
2	High	85-90% of all errors can be detected by control tools and functioning well
3	High	80-90% of control tools are capable of detecting errors and functioning well
4	*Moderately High*	70-80% of control tools are relatively reliable for detecting errors and mostly functioning well
5	Moderate	65-70% of control tools are capable of detecting errors and mostly functioning well
6	Moderate	50-65% of control tools are sufficiently capable of detecting errors and mostly functioning well
7	Low	30-50% reliability of control tools for detecting errors is low and only a few are functioning well
8	Very Low	20-30% reliability of control tools for detecting errors is very low and only a few are functioning well
9	Almost Impossible	0-20% of control tools cannot be relied upon to detect errors and almost none are functioning
10	Impossible	No control tools are available or can be used to detect errors

Source: Automotive Industry Action Group (2019)

The next step was to calculate the RPN by multiplying severity (S), occurrence (O), and detection (D). An example of the calculation is as follows:

Waste Type:

Waiting = S x O x D = 8 x 7 x 5 = 280
Transportation = S x O x D = 7 x 6 x 6 = 252
Overproduction = S x O x D = 8 x 7 x 4 = 224

Based on these calculations, priority improvement recommendations were made from the largest to the smallest. More details are explained below (see Table 14).

Table 14. Recommendations for Waste Improvement

Waste Type	RPN	Improvement Recommendations
Waiting	280	Implement machine maintenance scheduling to prevent delays, evaluate and redesign workflows to reduce waiting times between processes, and improve overall production efficiency and speed. Enhancing coordination between employees and adjusting production based on demand is essential.
Excessive Transportation	252	Machine layouts can be rearranged, delivery routes optimized, just-in-time methods implemented to reduce inventory movement, and technology used for more efficient information flow management. Automate transportation on the production floor.
Defect	224	Comprehensive operator training, establishing strict work standards, using quality checklists, and implementing quality management tools, such as Pareto charts and 5 Whys. Routine process evaluations should be conducted, and regular equipment maintenance should be ensured.

Source: Automotive Industry Action Group (2019)

4. CONCLUSION

Based on the analysis and discussion conducted in the previous section, the following conclusions can be drawn. First, identifying waste types based on the waste workshop weighting or scoring results shows that the types of waste that significantly impact the supply chain management flow are waiting, with a weighting of 26.32%, and excessive transportation, with a weighting of 15.79%. Based on VALSAT, the selected tools were PAM and the SCRM. PAM analysis revealed 11 operational activities, 1 transportation activity, 1 inspection activity, 1 storage activity, and 2 delay activities. The SCRM analysis revealed a relatively long waiting period in the Super Dolomite Fertilizer finished product warehouse, as evidenced by the high physical stock of 0.9412 days with a lead time of 30 days.

Second, based on the BE calculation, the 2024 bakery product demonstrated a one-year BE value of 1.0540. Consequently, the demand for bakery products will increase in 2024. Third, recommendations for improvements in waiting, excessive transportation, and defects can be made by rearranging machine layouts, optimizing delivery routes, implementing just-in-time methods to reduce inventory movement, and using technology to manage the information flow more efficiently. Automate transportation on the production floor. Comprehensive operator training should be conducted.

Ethical Approval

This study did not require ethical approval, as it used operational company data and employee interviews with internal permission from AA Bakery. All participants were fully informed of the research objectives aimed at reducing waste and the BE. Informed consent was obtained from all individuals prior to the interviews and data collection. Participation was voluntary, and all shared information was kept confidential and used strictly for academic research and operational improvement at the bakery.

Informed Consent Statement

All participants were informed about the research objectives, and informed consent was obtained prior to the interviews and data collection.

Authors' Contributions

I contributed to the conceptualization, methodology, formal analysis, and writing of the original draft. INAK contributed to the conceptualization, data collection, formal analysis, and review and editing of the manuscript. Both authors approved the final manuscript.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request and with permission from the Manyar Gresik-based Bread Company, AA Indah.

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Notes on Contributors

Iksan
Iksan is a faculty member specializing in Industrial Engineering. His expertise includes supply chain management, strategic operations, and manufacturing efficiency. As the primary researcher and supervisor for this study, he provided the core methodology, academic framework, and final validation of the strategic recommendations for optimizing the bakery's supply chain.

Ibnu Nafis Al Khawarizmi
Ibnu Nafis Al Khawarizmi is an Industrial Engineering graduate from Universitas Qomaruddin. His research interests include supply chain management, operational performance measurement and logistics efficiency. In this project, he served as a research assistant responsible for field data collection at the bakery, conducting interviews, and performing the initial analysis of waste and the BE. Additionally, he was responsible for manuscript preparation, ensuring the technical alignment of the draft with academic publication standards and the journal's specific template.

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