Decision Support System (DSS) analysis in raw material warehouse using system dynamics model (case study: PT. Modera Furintraco Industri)

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Abstract. PT. Modera Furintraco Industri is a manufacturing company that produces office furniture, such as table, drawer, and office cabinet. Office furniture products manufactured by Modera use the main raw material, namely particle board. Errors in decision making in particle board supplies can affect the production cycle which has an impact on increasing waste, cost, and decreasing profit. Decision-making techniques such as the application of the Decision Support System (DSS) can be used to assist the decision-making process in the particle board inventory process in the warehouse of raw materials. The right decision-making analysis using system dynamics model can help logistics managers in determining the right scenario in order to achieve optimal results. The AME calculation for model validation produces a value of 15.97% (raw material stock ready), 6.34% (customer demand), 13.06% (finished goods), and 3.53% (profit). The system dynamics model simulation results show that scenario 1 is the best decision scenario for companies with an average growth rate for ready stock raw materials variable is 2288 pcs, customer demand is 393 pcs, finished goods is 376 pcs, and profit is Rp 92,140,000, 00-Rp 226,485,000.00.

1. Introduction
In the current era, global industries face difficulties in determining decision or policies that are faced with intense competition between industries. The high level of competition between industries affect the determination of the company’s warehouse inventory (Turban, 2005). Many industries will need optimal results according to the lack of knowledge and data on raw materials that need to be analyzed.

PT. Modera Furintraco Industri is a furniture manufacturing company that uses various raw materials, one of raw material which is Particle Board (PB). Modera produces many variations of products as can be seen in Figure 1 with a number of fluctuating sales. Modera as a creative industry with a changing level of production makes it difficult in the decision-making process related to determine optimal amount of raw materials.
Problem in Modera is the frequent occurrence of errors in decision making related to the process of determine the optimal amount of raw materials. Based on the stock particle board data in Table 1, it can be seen that the stock of PLM 012-200-PB types of particle board in April 2018 and June 2018 can’t require the production needs with stock numbers minus 11 units and 4 units, therefore logistics needs to place an order suddenly.

Table 1 PLM 012-200-PB 12 mm Stock Report (Sept’ 2017-Aug’18)

| Years | Months | Stock | Prod. | Amount |
|-------|--------|-------|-------|--------|
| 2017  | Sept   | 800   | 797   | 3      |
|       | Oct    | 300   | 279   | 18     |
|       | Nov    | 350   | 349   | 17     |
|       | Des    | 650   | 632   | 1      |
|       | Jan    | 800   | 765   | 34     |
|       | Feb    | 150   | 142   | 42     |
|       | Mar    | 100   | 141   | 1      |
|       | Apr    | 150   | 162   | 11     |
|       | May    | 250   | 200   | 39     |
|       | June   | 950   | 993   | 4      |
|       | July   | 450   | 401   | 45     |
|       | Augs   | 900   | 939   | 6      |

Based on data in Table 1, it can be seen that there was an error in determining the amount of raw material stock which was not in accordance with production requirements, thus causing production to be delayed. If this problem recurs, it can cause an increase in costs due to sudden ordering of raw materials, increased waste as a result of improper raw material stocks, and a decrease in profits due to production that is delayed or cannot be fulfilled. Therefore, it is necessary to do a simulation using the dynamics model system to determine the right strategy to determine the optimal decision on raw material inventory in order to answer various problems in the company.

2. Literature Review

2.1. System Dynamics Principles
Modeling can be interpreted as a representation or abstraction of an object or actual situation [1]. Other terms are called artificial real-world models made virtual [2]. The model made must be analyzed further.
Dynamic model are model that can be developed to show changes in over time demand and supply. This model also reflects changes through simulation or based on real time and calculates components constantly by incorporating several alternative actions to come [3]. The modeling process consists of the following steps [2]:

1. Problem formulation and selection of real world boundaries.
2. Dynamic hypothesis formulation by establishing hypotheses based on behavior theory on problems and constructing causal structure maps through description of model with the help of tools, such as causal loop diagram (CLD) and stock flow diagram (SFD).

System dynamics methodology basically uses causal relationships in composing a complex system model, as a basis for recognizing and understanding the system's dynamic behavior. Problems that can be precisely modeled using the system dynamics methodology, namely:

1. Has a dynamic trend (changes over time).
2. The structure of phenomenon contains at least one feedback structure relationships.

2.2. Decision Support System (DSS)

Decision Support System (DSS) is a computer system that processes data into information to make decision from specific semi-structural problems [4]. The objectives of the Decision Support System (DSS) include:

1. Helping managers in making decision to solve semi-structural problems.
2. Supporting manager’s judgement rather than trying to replace it.
3. Increasing the effectiveness of a manager’s decision making.

Model of Decision Support System (DSS) consist of [4]:

1. Mathematical model.
2. Database.
3. Software.

2.3. Inventory Management

Inventory is a deposit of warehouse stock in the form of raw material, work in process (WIP), and finished goods.

Inventory characteristics are as follows, namely:

1. Everything that is stored is then used.
2. Source of unemployed funds owned by the company.
3. Assets owned by a high level of importance that must be owned by the company.

Inventory management is a inventory control concept with the main concept is to manage the optimal of inventory level so that the amount is not too large and not too small. Errors in determining the amount of inventory level will reduce company profits.

3. Research Methodology

Research methodology was carried out beginning with preliminary research in the field, found problems in the warehouse of raw materials at PT. Modera Furintraco Industri, namely there found minimal stocks that do not require production needs in a several times.

Therefore, PT. Modera Furintraco Industri needs an improvement in the decision making process, especially in the process to determine the right amount of raw material in the raw material warehouse area so that the total stock of raw materials can require production needs and not be excessive and become waste. The research objectives to be achieved are as follows:

1. Analyze the factors that affect the decision-making process in raw material inventory in the raw material warehouse area.
2. Knowing the impact that might have an effect as a result of errors in the raw material warehouse area.
3. Providing a variety of alternative decision-making actions in overcoming variation in problems that may arise in the warehouse area of raw materials.
4. Implement and analyze the application of scenario solutions from the system dynamics model. Data collection is done directly with observations in the field and conducting direct interviews with factory manager who know the condition of the field (warehouse and production). If the required data is collected, the next step is to process data to solve problems in the company. The steps of data processing area are:

1. Providing data information of raw materials that will be analyze based on product with a high sales level in years period time.
2. Analyze factors that affect in decision-making process of raw material inventory using causal loop diagram (CLD).
3. Perform data processing and raw material inventory modeling process by considering the causal relationship from causal loop diagrams to obtain a graphical picture of the increase in raw material output to be sought.

After data processing, the results will be validate using two methods: numeric validation and visual validation. Numeric validation is done by calculating Absolute Mean Error (AME) from reference data and simulation result data as decision making variabel. If the model is valid, thus data analyze is done to knowing what result will be found from data processing. Based on data processing that has done, modeling problems using system dynamics obtained scenarios that provide several alternative actions in assisting the decision making process to overcome problems that arise in the raw material warehouse area.

4. Discussion and Result

4.1. Causal Loop Diagram (CLD)
Causal loop diagram is a diagram that describes the relationship between variables in the system [2]. Causal loop diagram for Modera raw material inventory model can be seen in Figure 2.
4.2. Stock Flow Diagram (SFD)
Based on causal loop diagram in Figure 2, stock flow diagram for Modera raw material inventory model using software Powersim Studio 10 can be seen in Figure 3 below.

![Figure 3 Stock Flow Diagram](image)

4.3. Simulation Result
The result of raw material inventory model simulation in 2015-2017 can be seen in Figure 4. The results obtained from the Powersim Studio 10 simulation, include the raw material stock ready level graph – profit – finished goods – customer demand.

![Figure 4 Model Simulation Results](image)

Based on the simulation results in Figure 4, the trend of profit data graph has decreased in 2015 to 2017 due to errors in determining raw material inventories. However, trend of customer demand data graph increased in 2015 until 2017. The finished good simulation graph has decreased in 2015 to 2017 that was unable to require the number of customer demands, therefore during this time period,
the company often had production delay and sudden production. The level of raw material stock ready in 2015-2017 has increased which is not all used for production and become waste.

4.4. Model Validation

The results of raw material inventory model validation in Modera using Absolute Means Error (AME) can be seen in Table 2. The results of model validation based on AME calculation are 15.97% for raw material stock ready material, 6.34% for customer demand variable, 13.06% for finished good variable, and 3.53% for profit variable.

| Year | Raw Material Stock Ready (pcs) | Customer Demand (pcs) | Finished Goods (pcs) | Profit (Rupiah) |
|------|--------------------------------|-----------------------|----------------------|-----------------|
|      | Actual | Model | Actual | Model | Actual | Model | Actual | Model |
| 2015 | 2100   | 2100  | 2200   | 2200  | 2045   | 2057  | 318,880,000.00 | 318,880,000.00 |
| 2016 | 2612   | 2713  | 2342   | 2486  | 1668   | 1971  | 313,257,400.00 | 317,367,419.33 |
| 2017 | 3156   | 3474  | 2789   | 2800  | 1523   | 1436  | 310,144,600.00 | 317,136,931.11 |
| Ave. | 2622   | 2762  | 2443   | 2495  | 1745   | 1821  | 314,094,000,000 | 317,794,783,485 |
| AME  | 15.97% | 6.34% | 13.06% | 3.53% |
| Ket. | Valid  | Valid | Valid   | Valid   |

4.5. Business As Usual Simulation (BAU)

Business As Usual Simulation (BAU) conducted for 2018-2020 based on company expectations. The BAU model scenario is done by calculating the growth fraction for all based variables with reference data from the company. Raw material inventory model simulates several variables to look for growth trends per year. Model variables simulated in the BAU scenario can be seen in Table 3.

| No. | Variabel          | Nilai       |
|-----|-------------------|-------------|
| 1   | RM Stock Ready    | 2100 pcs    |
| 2   | Customer Demand   | 2200 pcs    |
| 3   | Finished Goods    | 2057 pcs    |
| 4   | Profit            | Rp 318,880,000.00 |

(Source: PT. Modera Furintraco Industri and Badan Pusat Statistik (Recorded by Researcher))
BAU simulation of raw material inventory model for 2018-2020 can be seen in Figure 5 below.

Based on the BAU simulation results in Figure 5, it can be seen that in 2018 to 2020 there is an increase in profit as a result of the fulfillment of finished goods production which continue to increase along with the fulfill customer demand data trends.

4.6. Future Scenario Simulation
Intervention is carried out to achieve several objectives, namely increasing profit and minimizing costs by optimizing raw material inventories.
In the raw material inventory model, the intervention produces 3 scenarios, such as the following:
1. Scenario 1: Increase the profit level of company by optimizing the amount of raw material stock ready through the intervention of raw material return variable, raw material check, raw material purchase, warehouse stock, waste warehouse, target production, WIP, and sales.
   a. Cope with raw material returns or returning defect items to supplier by increasing raw material checking by 10% from the initial conditions. This simulation is the desire of company.
   b. Cope with warehouse waste by increasing raw material checking and reducing raw material return by 5% from the initial condition. Reducing the WIP level by 1% affects the warehouse waste level as a result of the reduction of WIP level.
   c. Increase the company’s production target by 1% which results in increasing the company’s sales percentage by 20% as a result of determining the optimal amount of raw material stock ready for production.
2. Scenario 2: Increase the profit level of company by optimizing the amount of raw stock ready material through target production variable intervention of 10%, WIP by 0%, and sales percentage of 10%.
3. Scenario 3: Combine with scenario 1 the addition of labor variable intervention of 100 people out of 50 people. Increasing the number of labor is believed by the company can affects the amount of production which has an impact on increasing profit.

Comparison of variable fractions for raw material inventory model between BAU scenario, intervention scenario 1 to 3 can be seen in Table 4.
Table 4 Scenario Fractions Comparison

| Variable       | BAU  | Scenario 1 | Scenario 2 | Scenario 3 |
|----------------|------|------------|------------|------------|
| RM Stock       | 0,2% | 0,2%       | 0,2%       | 0,2%       |
| RM Return      | 10%  | 5%         | 10%        | 5%         |
| RM Check       | 80%  | 90%        | 80%        | 90%        |
| RM Purchase    | 60%  | 65%        | 60%        | 65%        |
| Safety Stock   | 20%  | 35%        | 20%        | 35%        |
| Target         | 3%   | 4%         | 10%        | 4%         |
| Production     |      |            |            |            |
| Warehouse Stock| 60%  | 65%        | 60%        | 65%        |
| Warehouse Waste| 1%   | -15%       | 1%         | -15%       |
| Production Waste| 0,5% | 0,5%       | 0,5%       | 0,5%       |
| Production WIP | 2%   | 2%         | 2%         | 2%         |
| Custom Production| 16% | 16%        | 16%        | 16%        |
| Sales          | 70%  | 90%        | 80%        | 90%        |
| Persen PPH     | 5%   | 5%         | 5%         | 5%         |
| Company        |      |            |            |            |
| Operational Tax| 0,2% | 0,2%       | 0,2%       | 0,2%       |
| Labor          | 50 orang | 50 orang | 50 orang | 100 orang |
| Salary Labor Cost | Rp. 3.555.834,67,00 | Rp. 3.555.834,67,00 | Rp. 3.555.834,67,00 | Rp. 3.555.834,67,00 |

Table 4 Scenario Fractions Comparison (Continued)

| Variable       | BAU  | Scenario 1 | Scenario 2 | Scenario 3 |
|----------------|------|------------|------------|------------|
| Warehouse Stock| 60%  | 65%        | 60%        | 65%        |
| Warehouse Waste| 1%   | -15%       | 1%         | -15%       |
| Production Waste| 0,5% | 0,5%       | 0,5%       | 0,5%       |
| Production WIP | 2%   | 2%         | 2%         | 2%         |
| Custom Production| 16% | 16%        | 16%        | 16%        |
| Sales          | 70%  | 90%        | 80%        | 90%        |
| Persen PPH     | 5%   | 5%         | 5%         | 5%         |
| Company        |      |            |            |            |
| Operational Tax| 0,2% | 0,2%       | 0,2%       | 0,2%       |
| Labor          | 50 orang | 50 orang | 50 orang | 100 orang |
| Salary Labor Cost | Rp. 3.555.834,67,00 | Rp. 3.555.834,67,00 | Rp. 3.555.834,67,00 | Rp. 3.555.834,67,00 |

(Source: PT. Modera Furantraco Industri and Badan Pusat Statistik (Recorded by Researcher))

**Scenario 1**
Result of scenario 1 intervention simulation can be seen in Table 5 and Figure 6.

Table 5 Scenario 1 Intervention Result

| Years | A    | B    | C    | D    |
|-------|------|------|------|------|
| 2018  | 5314 | 3087 | 3165 | 317,884,078 |
| 2019  | 7084 | 3443 | 3368 | 318,110,563 |
| 2020  | 9372 | 3836 | 3947 | 318,202,703 |
| A     | RM Stock Ready (pcs) |
| B     | Customer Demand (pcs) |
| C     | Finished Goods (pcs) |
| D     | Profit (billion rupiah) |
Based on the result of scenario 1 intervention simulation, it can be seen that the production of finished goods continue to increase from 2018 to 2020 which follows the trend of increasing customer demand. This means that customer demand that continues to increase is fulfill with the number of stable production increasing until 2020. Satisfied customer demand affects the level of sales of company which has an impact on increasing company profits. Likewise with the number of finished goods, this variable increases as the impact of the optimal number of raw material stock ready which is starting from 2018-2020.

**Skenario 2**

Result of scenario 2 intervention simulation can be seen in Table 6 and Figure 7.

| Years | A    | B    | C    | D          |
|-------|------|------|------|------------|
| 2018  | 5131 | 3722 | 3798 | 317,937,260|
| 2019  | 6742 | 4334 | 4470 | 318,381,070|
| 2020  | 8770 | 5008 | 5288 | 318,753,595|

**Table 6 Scenario 2 Intervention Simulation**

- **A**: RM Stock Ready (pcs)
- **B**: Customer Demand (pcs)
- **C**: Finished Goods (pcs)
- **D**: Profit (billion rupiah)
Based on the result of scenario 2 intervention simulation, it can be seen that in 2018-2020, the level of finished goods production has increased which is able to meet customer demand. The increase experienced is seen in the simulation results in Table 6, namely the level of customer demand in 2018 amounting to 3722 pcs M-Class tables fulfilled with the number of finished goods amounting to 5008 pcs. Likewise with the level of corporate profits, profits have increased by hundreds of millions to one billion rupiah per year. This is as a result of the increasing number of sales due to the optimal amount of raw material stock.

**Scenario 3**

Result of scenario 3 intervention simulation can be seen in Table 7 and Figure 8.

| Years | A      | B      | C      | D      |
|-------|--------|--------|--------|--------|
| 2018  | 5331   | 3245   | 3312   | 317,605,416 |
| 2019  | 7122   | 3666   | 3945   | 317,741,715 |
| 2020  | 9444   | 4129   | 4625   | 317,744,776 |

A: RM Stock Ready (pcs)
B: Customer Demand (pcs)
C: Finished Goods (pcs)
D: Profit (billion rupiah)

Based on the result of scenario 3 intervention simulation, it can be seen that profit have increased very significantly from 2016 to 2020. Profit increases as in Table 7, which amounted to Rp. 317,605,416,318.00 in 2018 and Rp. 317,744,776,887.00 in 2019. what happened was Rp. 139,360,569.00. The company’s profit increased as a result of increased sales because it was able to
require customer demand with a stable number of finished goods production increasing from 3312 pcs in 2018 to 4625 pcs in 2020.

5. Conclusion
Based on optimal raw material inventory modeling in the raw material warehouse area and production of PT. Modera Furintraco Industri, the conclusions are as follows:

The BAU condition of the optimal raw material inventory projection model in the raw material warehouse and Modera production shows that in 2015-2017, Modera experienced a decline in the level of finished goods making it difficult to meet customer demand of 2057 pcs to 1436 pcs. Then, in 2018 to 2020, finished goods production will increase (3402 pcs-4606 pcs (2018-2020)) as an impact of the optimal supply of raw materials (4415 pcs-6998 pcs (2018-2020)).

Modera company profit increases are influenced by the number of optimal raw ready stock materials that are able to meet the needs of finished goods production to meet customer demands. The minimization of the waste warehouse, the level of raw material returns, and the amount of WIP can reduce the cost of the warehouse and production parts.

Alternative strategies to overcome crisis problems will determine the optimal raw material inventory to the level of finished goods production in fulfilling customer demand at PT. Modera Furintraco Industri is by intervening in raw material return variables, raw material checks, raw material purchases, warehouse stock, waste warehouses, target production, WIP, and sales.

The decision scenario chosen by the company is scenario 1, with the level of raw material stock ready increasing steadily starting from 5314 pcs in 2018 to 9372 pcs in 2020, the level of finished goods increasing by 3165 pcs in 2018 to 3947 pcs in 2020 able to meet customer demand of 3087 pcs in 2018 to 3836 pcs in 2020, and the level of profit that increases as a result of the right decision making with optimal results, namely Rp 317,884,078,000.00 in 2018 to Rp 318,202,703,000.00 in 2020.

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