Inventory Optimization for A Case Study of the Textile Supply Chain in Indonesia Using Anylogistix

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Abstract. Optimizing inventory involves achieving the ideal supply and demand balance. One way to lower the risk of typical inventory difficulties, such as out-of-stock products and excessive storage costs, is to optimize inventory levels. Popular apparel manufacturers are at the downstream end of a long and complicated textile supply chain facing challenges like fierce competition as the products have many substitutes. Therefore the undisrupted supply of finished products, the clothes, should be maintained to ensure the company's sustainability. It can be attained by administering the integrated inventory from 1st tier suppliers to customers. Considering the variability and dynamic environment of the supply chain, we propose a discrete event simulation using Anylogistix to have the best inventory control. Incorporating 4 scenarios related to a varied set of initial stock, storage policy, and production speed, we found that the 4th scenario gives the best result, yielding the highest profit.

Keywords: textile supply chain, inventory management, discrete event simulation, and anylogistix.

1 Introduction

Now the clothing industry in Indonesia is a sector that is quite large and experiencing the highest production growth. Even as of November 2020 [1], Indonesia is considered one of only 15 countries in exporting textiles as shown in Fig. 1, and garment and apparel in Fig. 2. Comparatively, the demand for international supply chains is critical given that many companies' import/export expenses might make up a big role of their profits [2]. For companies to guarantee timely delivery, cost-effective procedures, and customer satisfaction, these activities of the supply chain management context must be managed effectively. Every

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activity may be run more efficiently with optimal supply chain management [3]. Best practices can help businesses streamline their import and export processes, reduce risks, and increase productivity. In brief, good supply chain management is implemented by controlling demand fulfillment and improving operations performance. This is executed by determining the amount of demand, targeted profit, the capacity of the number of products, raw material requirements, production scheduling, inventory control, and needed resources. All of this certainly requires a clear flow of information between one actor and another therefore fine and well-coordinated supply chain management is mandatory [4].

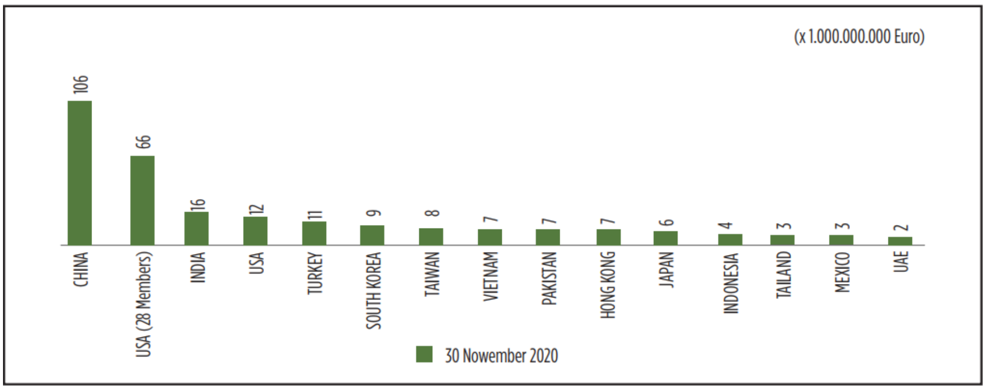

Fig. 1. Best 15 Textile Exporting Countries (Euro) [1].

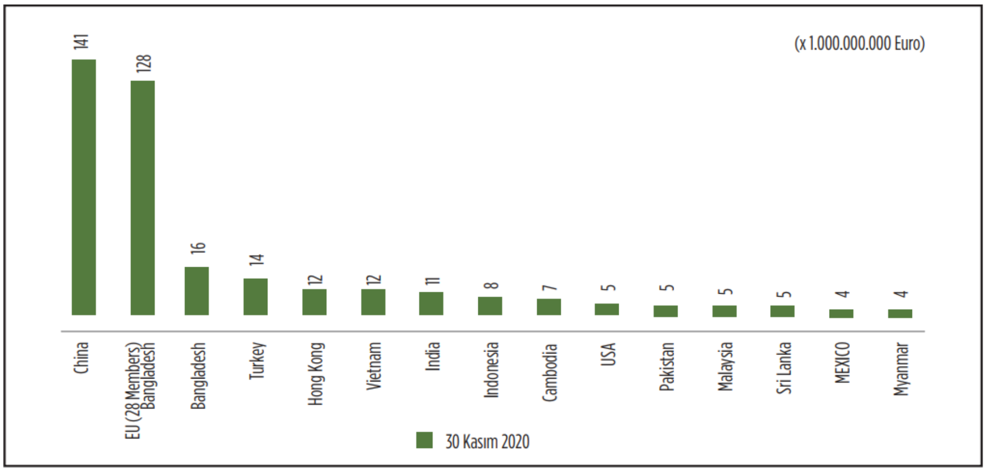

Fig. 2. Best 15 Garment and Apparel Exporting Countries (Euro) [1].

Sabi is a convection business located in the Bintaro area, Jakarta, Indonesia which provides screen printing, border, and sewing services for t-shirts, shirts, masks, towels, hats, jerseys, and tote bags. They carry out their activities starting from selecting suppliers to manufacturing the finished product and delivering it to end customers. The increasingly widespread use of the internet and e-commerce due to the Covid-19 pandemic has also had an impact on Sabi's business. Sabi also participates in marketing its products not only through direct sales channels but also online through various platforms such as Instagram, Shopee, and others. Sabi provides services where customers are allowed to be able to order products according to their specifications. Sabi accommodates a wide variety of clothing product designs including the choice of materials. To be able to meet the wide variety of products and materials, a reliable supplier is needed. In quality control, Sabi searches for its raw material suppliers to maintain quality and commitment to its customers. On the one hand, the existence of choices for customers has a good impact on retaining purchase intention and realization but on the other hand, it adds complexity to the overall supply chain network.

Another important aspect of a supply chain is the one related to inventory management. This aspect cannot be separated due to the monitoring of goods from producers to warehouses and from other logistics facilities up to a point of sale is a crucial part of the supply chain [5]. As discovered that the performance of the supply chain can be considerably influenced by the inventory policy employed by the retailers other than information sharing, and early order commitment [6]. A flexible and effective supply chain depends on decisions regarding the timing and size of inventories [7]. Aligned with the one objective of inventory management to ensure raw materials or product availability for production and sales, Sabi is required to forecast the optimal amount of stock that should be placed, the time of order by considering the required lead time, and other things. Therefore inventory policy is needed to manage existing operations to generate profit for the company.

The majority of previous research discussed inventory policy in a supply chain focused on the manufacturing sector which aligns with this study. Here we focus on safety stock as one of the inventory policies. The selection of safety stock policy settings in the observed company is based on previous literature but the calculation process or the framework used is modified. A study conducted by [8] using the Anylogic software helped create a simulation comparing three inventory policy methods as an extension of traditional Material Requirement Planning (MRP) to typical MRP itself. The three methods are designed to relax the safety stock as MRP ignores capacity constraints [9]. As a result, the three methods gave a greater improvement in overall costs than MRP. There are five parameters considered in the comparative scenarios, namely minimum overall costs, relative improvement, fixed order period, planned lead time, and minimum safety stock. Subsequent research was conducted to regulate existing inventory policies due to variability [10]. This variability is often referred to as the Bullwhip effect, which greatly affects the supply chain and also company operations, which often corresponds to the term stochastic on demand. There are two aspects reviewed in their study, they are the dispersion of historical demand data from the mean which is denoted as the standard deviation, and the difference between actual demand and forecast data which is denoted as the standard deviation of the forecast error. The results proved the relationship between existing variability and inventory needs. Other research talks about managing inventory policies of vehicle tires encountered at South African Airways (SAA)'s Operational Procurement and Fleet Department [11]. The research captured the variability of demand and price to build an inventory policy based on the Economic Order Quantity (EOQ) model with backorders, predetermined fixed order quantity, and time. Another study [12] tried to reduce ordering costs and increase service levels by making optimal inventory policies so that variable costs can be minimized.

All of these reviewed research used the same tools to solve their problem which is the AnyLogic software. One tool that can be utilized to make a simulation of inventory management easier is AnyLogistix which is known to be suitable for generating the best solutions based on supply chain components [13]. Conceptually, these two tools of Anylogic and Anylogistix have something in common in that AnyLogistix is a further development of the AnyLogic hence we are determined to use it. AnyLogistix is designed to facilitate analysis in the supply chain, especially in designing, optimizing, and analyzing based on input data. AnyLogistix combines analytical optimization with dynamic simulation. The data can be fed in the form of a Bill of Material (BOM), customer details, number of DCs and factories, demand and product quantity, supplier information, and others.

The scope of this research is limited by several assumptions, including:

- The research focuses on convection products of clothes consisting of screen printing shirts, oversized clothes, embroidered clothes, and raglan clothes.
- Production costs are composed of activity components such as screen printing, cutting, electricity usage, and sewing.
- Only one type of vehicle is used: a pick-up car with a load capacity of 1,000 pieces per trip.
- Three types of raw materials used in the manufacturing process simulation cover polyester yarn, cotton yarn, and cotton combat.
- The simulation period is carried out for one year starting in January 2022 and ending in December 2022.

2 Research methodology

This type of research is quantitative using simulation equipped with descriptive. A field study or direct observation is carried out at the Sabi location to obtain real data. The data collection is also carried out by conducting interviews with the workers at Sabi. In addition, desk documentation is also conducted to get suitable data. This technique is used to obtain data or information to support research in the form of archives, documents, and reports that can corroborate facts and support research. After comprehending the case study, a conceptual model was developed for use in the simulation process. Fig. 3 depicts the logic of the conceptual model for the order processing to goods delivery at Sabi.

Before the simulation is run, an analysis of Sabi product inventory policies is executed using the min-max policy to determine the minimum and maximum inventory for each product. The Min-max policy used is as the following equation [14]:

$$Minimum\ inventory = (Average\ demand\ per\ year \times Lead\ time) + Safety\ stock \quad (1)$$

$$Maximum\ inventory = 2\ \times (Average\ demand\ per\ year \times Lead\ time) \quad (2)$$

$$Reorder\ Point\ (ROP) = Max - Min \quad (3)$$

This study aims to determine the most appropriate inventory policy which will be suggested to be implemented by Sabi as studied [15] to determine replenishment quantity. By carrying out dynamic simulations using AnyLogistix taking into account the supply chain configuration (number of suppliers, factories, and customers) then the number of requests per order, storage policies, production time and costs, and transportation policies with costs. The simulation results will show how Sabi can meet customer demands, cover storage and transportation costs, fulfill demand backlog, evaluate production performance, and gain profits.

Here Sabi produces 4 products, namely screen printing, embroidered, raglan, and oversized clothes as shown in Table 1. To meet its material needs for production, Sabi works with 2 suppliers, said as “Tanah Abang” which provides polyester and cotton yarns, and “Focus” which provides cotton combat 25 and 30s, and rib fabric. The data details can be seen in Table 2.

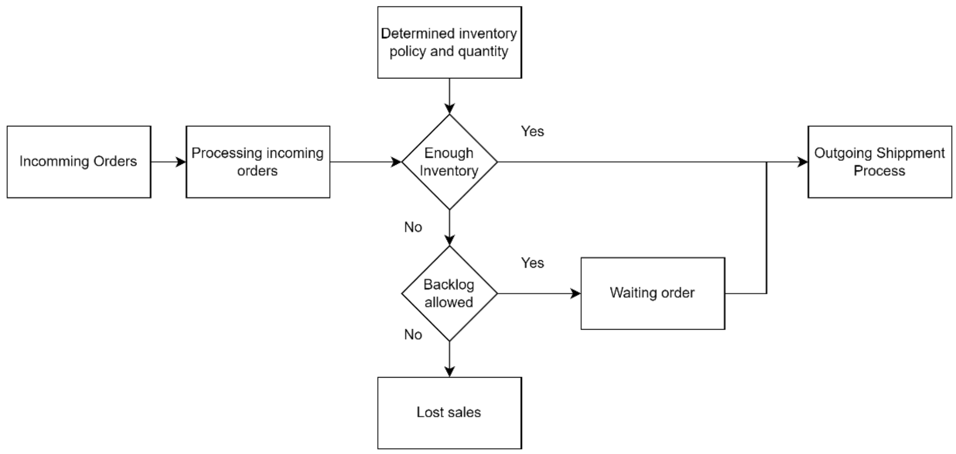

Fig. 3. Conceptual model.

Table 1. Product details.

Customer	Product	Quantity	Revenue (USD)	Lead Time (Day)
Kemayoran	Embroidered clothes	100	15	7
Bobos Design	Screen printing shirt	188	15	5
Universitas Indonesia	Oversized clothes	500	15	7
Universitas Multimedia Nusantara	Screen printing shirt	100	15	5
Probationary Civil Servant	Raglan dress	100	15	7

Table 2. Raw materials price.

Item	Price	Unit
Cotton combat 25s	IDR112,000	Kg
Cotton combat 30s	IDR117,000	Kg
Rib fabric	IDR122,000	Kg
Polyester yarn	IDR7,000	pcs
Cotton yarn	IDR17,000	pcs

The production costs and selling price for each product can be seen in Table 3.

Table 3. Production cost and price.

Item	Selling Price	Production Cost
Embroidered clothes	IDR52,000	IDR4,000
Screen printing shirt	IDR52,000	IDR5,000
Oversized clothes	IDR72,000	IDR4,000
Raglan dress	IDR55,000	IDR4,000

Utilizing equations (1), (2), and (3), we have data in Table 4.

Table 4. Min-max inventory calculation.

Item	SS	Demand	Lead time	Min	Max	Reorder Point
Screen printing shirt	0	288	0.17	48	96	48
Embroidered clothes	0	100	0.23	24	47	23
Raglan dress	0	100	0.23	24	47	23
Oversized clothes	0	500	0.23	117	234	117

3 Results and discussion

Sabi's supply chain simulation model was created with the AnyLogistix software, which simulates the supply chain from the supplier to the customer. Sabi has a market share spread across the Greater Jakarta area, with another customer in South Sumatra Province. This study considers these supply chain actors: the supplier, Sabi as the manufacturer, and customers in which the simulations performed are included in the one-staged supply chain. There are at least two raw material suppliers who will then supply materials to the Sabi production line.

Aside from the research participants, the simulation model takes into account supply chain decisions regarding distribution and inventory. The Min-Max Policy is the inventory policy used in scenario 1 (baseline) conditions. Sabi's distribution can be assumed to use a fleet of pick-up trucks with a maximum capacity of 1,000 units of finished product per trip, and a 60 Km/hour speed. Fig. 4 depicts the availability of products in units over a specific time.

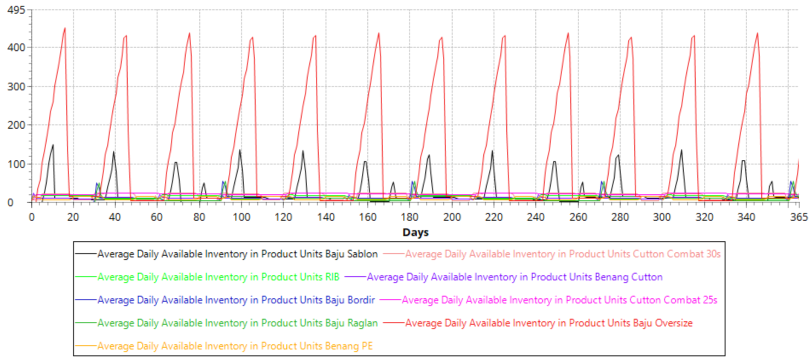

Fig. 4. Availability of inventory.

Figure 4 portrays an inventory inefficiency that occurs under current conditions or in the scenario 1 (baseline). For information, Sabi's current storage policy is order-on-demand. This means that Sabi lacks in storage planning because they will always store products when it is needed or when they run out. Oversized clothing products have the highest availability value, while raglan clothing products have the lowest. The relatively high inventory costs in scenario 1 (baseline) demonstrate this. Inventory spending refers to the costs associated with acquiring inventory, such as product purchase costs. The high inventory in this monthly cycle during one study period resulted in quite high inventory costs of USD26,864,359. This could happen due to the monthly demand characteristics that are frequent and high in volume. This fee alone does not cover Sabi's revenue. The costs incurred in scenario 1 (baseline) are shown in detail in Table 5.

Table 5. Result from scenario 1 (baseline).

Cost	USD
Inventory Spend	26,864.359
Production Cost	3,609.9
Transportation Cost	31,262.703
Total Cost	61,736.962
Revenue	25,648.32
Profit	–36,088.642

In the case of scenario 2, changes were made to the Sabi storage policy. The relatively high storage costs could be reduced. The action of the simulation model that we want to create is on-storage with the Min-Max Policy and the calculations described in Table 6.

Table 6. Input inventory policy of scenario 2.

Product	Min (unit)	Max (unit)
Screen printing shirt	48	96
Embroidered clothes	24	47
Raglan dress	24	47
Oversized clothes	117	234

Table 7 expresses the cost in scenario 2 and explains it in detail. When compared to scenario 1 (baseline), the second scenario has higher costs. The Min-Max policy is derived from the calculations depicted in equations (x), (y), and (z). Based on these findings, it is possible to conclude that the Min-Max policy has a negative impact on the company.

Table 7. Output of scenario 2.

Cost	USD
Inventory Spend	27,732,631
Production Cost	3,762.8
Transportation Cost	31,590,966
Profit	-37,402,078

Because inventory costs were still relatively high and product stocks tended to fluctuate in the previous scenario, adjustments were made again in scenario 3 by changing the Sabi storage policy. The Min-Max Policy for each product is still in effect. Table 8 shows the minimum and maximum policy changes for each product in scenario 3.

Table 8. Input inventory policy of scenario 3.

Product	Inventory Policy	Initial Stock
Embroidered clothes	Min 25, Max 100	15
Screen printing shirt	Min 25, Max 100	15
Raglan dress	Min 25, Max 50	15
Oversized clothes	Min 25, Max 70	15

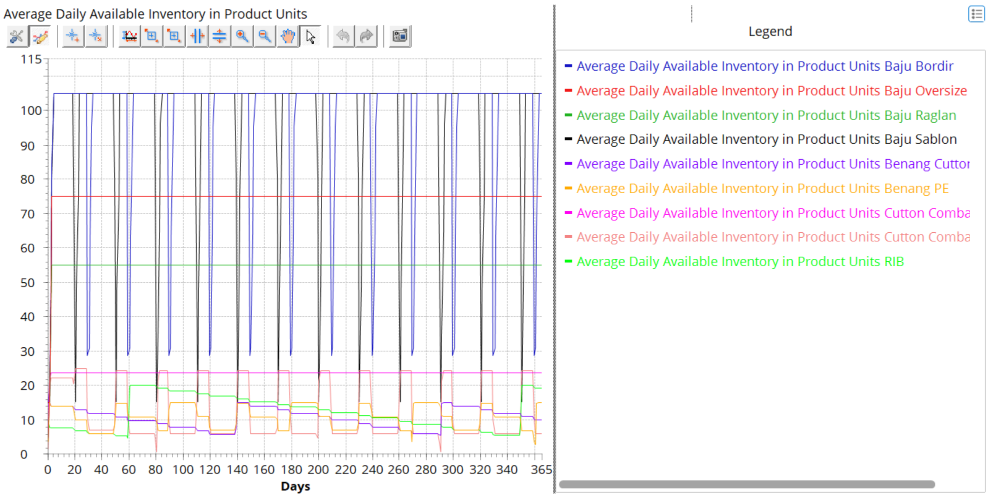

Fig. 5. Availability of inventory of scenario 3.

Table 9 shows that, despite the change in inventory policy, Sabi is still able to meet its customers' demands. The production batch was also changed to 0.03 days per unit.

Figure 5 shows that inventory in scenario 3 is stable and there is no backlog for each inventory. With a small and stable number of products or raw materials stored, storage costs occur in Scenario 3, which is USD4517.30. Scenario 3 recalculates transportation costs in addition to making policy adjustments to the inventory policy. Sabi is advised to look for a 3PL (third-party logistics, a freight forwarder) delivery of cargo goods with a lower shipping price to reduce transportation costs to USD1,312,922.

Table 9. Output of scenario 3.

Cost	USD
Inventory Spend	4517.304
Transportation Cost	1312.922
Production Cost	840.699
Profit	-2194.92

Table 10. Input inventory policy of scenario 4.

Product	Inventory Policy	Initial Stock
Embroidered clothes	Min 5, Max 30	15
Screen printing shirt	Min 5, Max 250	200
Raglan dress	Min 5, Max 25	15
Oversized clothes	Min 100, Max 150	500

In scenario 4, an experiment was conducted by modifying each product's Min-Max policy in the inventory policy. Table 10 shows the minimum and maximum policy changes for each product.

Fig. 6. Availability of inventory of scenario 4.

The most popular Sabi products are oversized clothing items with an average inventory of 150 pieces. This is depicted in Fig. 6. By advising Sabi to continue using the same 3PL as in scenario 3, the shipping cost in scenario 4 is known to be USD27,085. A profit of USD960,629 was obtained by changing the storage policy and speeding up the clothing production process to 0.005 days per unit. Table 11 is dedicated to the cost in scenario 4.

Table 11. The output of scenario 4.

Cost	USD
Inventory Spend	530.845
Transportation Cost	9.108
Production Cost	27.085
Profit	960.629

After adjusting the two parameters, namely the inventory policy and the production speed. Finally, scenario 4 produced the highest profit value. This demonstrates that experiments on these two parameters using the best guess approach can provide good economic performance for the company. The most significant impact of this parameter improvement is the change in the value of inventory costs and production costs. In this study, we use the revenue parameter as the primary reference for conducting long-term experiments. This method is viable because it allows us to test policy changes in isolated situations without incurring direct costs. Improvements can be made to improve the results, but the goal of determining whether this simulation approach has succeeded in producing good results based on the profit parameter ensures that this research is sufficient. Table 12 compares the outcomes of all scenarios.

Table 12. Output comparison of all scenarios.

Scenario	Inventory Spend (USD)	Profit (USD)
Scenario 1 (Baseline): the current scenario.	26,864.359	–36,088.64
Scenario 2: Using the Min-Max Policy to override the retention policy.	27,732,631	-37,402,07
Scenario 3: Each finished product has an initial stock, and the inventory policy has changed. Shipping costs have been reduced.	4,517.304	-2,194.92
Scenario 4: Increasing initial stock, establishing an inventory policy, reducing batch production time to 0.05 days, and lowering shipping costs.	530.845	960.629

4 Conclusion

Based on the experiments using 4 scenarios, it was found that the fourth scenario gives the highest profit value of USD960,629 and the highest average inventory is known for oversized clothing products with an average inventory of 150 pcs. These results were obtained by changing the inventory policy along with the initial stock and accelerating the batch production process to 0.005 days per unit. However, production utilization at Sabi is still very low because the value is below 0.1 therefore in the future, Sabi may increase their production rate first before adjusting their inventory. To achieve this scheme, Sabi is required to increase their initial stock to some point that they may need further calculation on whether to add space in their storage or optimize the existing layout to store those products. Other than that, Sabi is also required to reduce their production time or to expedite production. One way to do that without increasing cost is by increasing order frequency and communicating effectively with the suppliers to minimize the risk of delivery delay and fulfillment.

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