

# Improving Small Apparel Company's Production Planning using Demand Forecasting and Material Requirement Planning

**Gabriella Regina, Naila Zafira Wilson, Pocut Shafira Putri Aurora, and Rahmat  
Nurchahyo**

Department of Industrial Engineering  
Faculty of Engineering, Universitas Indonesia  
Jakarta, Indonesia

[gabriella.regina@ui.ac.id](mailto:gabriella.regina@ui.ac.id), [naila.zaafira@ui.ac.id](mailto:naila.zaafira@ui.ac.id), [pocut.shafira@ui.ac.id](mailto:pocut.shafira@ui.ac.id), [rahmat@eng.ui.ac.id](mailto:rahmat@eng.ui.ac.id)

## Abstract

Aggregate planning has been widely used by apparel manufacturers to gain maximum profit by finding the optimal solution between maximizing sales and minimizing production cost. Commonly, small apparel companies use chase strategy, where production rates are varied for each time period to meet changes in demand. However, without an appropriate demand forecast and well-calculated production planning, this strategy cannot accommodate the fluctuating demand, causing recurring product stockouts which increases the number of unmet customer demands. To improve the company's production planning, the number of demands is forecasted using Single Moving Average method for each week of the upcoming month. The forecasted demand is then used to plan the production quantity using Material Requirement Planning which helps ensure that all the demands are met while avoiding over-production by taking on-hand inventory into account. Comparison between the former and the improved production planning method shows an increase in the company's sales, increasing profit by 8.98% or equal to Rp616.000. This concludes that the method proposed in this paper can be used as a simple yet effective way to improve the apparel company's production planning, hence increasing the company's profit.

## Keywords

Forecasting, production planning, product stockouts, apparel

## 1. Introduction

Interest and consumption of ready-to-wear apparel keeps growing every year. This phenomenon encourages many people to start their own apparel business, offering more sustainable products at a more affordable price range. To be able to set business in motion and generate profits, each company must establish the most suitable aggregate planning strategy for their business. Maximum profit can be reached by finding the optimal solution between meeting maximum demand and lowering cost. Most small apparel companies use chase strategy, where the production rates are varied each time period to meet changes in demand. This strategy is deemed most suitable for small apparel businesses since this strategy requires lower capital requirement and the resources needed are flexible and inexpensive to change.

Forecasting and planning play a huge role in determining the production rate to balance the customers' order. Good forecasting and planning will lead to on-time delivery, minimum waste, and minimum production cost. To optimize the chosen strategy, the company needs to have a well planned production as well as raw material stock schedule. Delay in the supply of materials and inappropriate storage of materials can result in delays in the completion of a project or even stopping the project, resulting in complaints and customer dissatisfaction that will decrease the competitiveness of the company (Rahmat et al., 2020).

Some studies have revealed the impact of demand forecasting implementation to prevent out-of-stock situations in apparel companies (Rachman, 2018). Demand forecasting has been proven to be an important factor on supply chain improvement, resulting in an increase in the companies' responsiveness to actual customer demand (A. Ross, 2004). Furthermore, Maria et al. (2013) discussed the actual state of the context in the fashion industry compared with the demand forecasting approaches developed over the last few years to understand which forecasting methods are more

effective under the current conditions. Therefore this research attempts to narrow the scope by implementing demand forecasting and material requirement planning for production planning management for small apparel companies.

The object of this paper is Whycotton, a small apparel company which sells plain t-shirts through online platforms. Since it is a small business, the company uses a simple forecasting technique to determine their production for the upcoming week. However, since the forecast was based on a short time period (1 week), this method often causes out-of-stock (OOS) occurrences. Due to the ever-changing and competitive nature of fashion industry, this condition can lead to opportunity loss. If applied in the long run, on-demand strategy can result in stagnancy, or even failure of the business. Thus, this paper attempts to implement demand forecasting and material requirement planning to a small apparel company to prevent product stock outs.

### **1.1 Objectives**

The objective of this study is to improve Whycotton's production planning method by avoiding out-of-stock occurrences using demand forecasting and material requirement planning. These improvements will result in an increase in sales, hence increasing the company's profit.

## **2. Literature Review**

### **2.1 Plain T-Shirts Manufacturing Process in Small Apparel Company**

The production process consists of several stages. The process starts from the procurement of raw materials by the owner. Raw materials used in this business are modal cotton and rib fabric. These materials are obtained from fabric suppliers. Modal cotton is used as the base fabric of the t-shirt while rib fabric is a type of elastic knit fabric that is used as an accessory or complement to t-shirts on the neck. This stage is followed by the cutting process.

Cutting process aims to cut fabrics into specific cutting designs based on the sample t-shirts, making it to be used as a panel before going to the sewing process. The treatment and cutting technique of each fabric varies depending on the fabric condition. Therefore, the skill and the flexibility of the operator affect the quality of the resulting piece of fabric. The cloth is spread layer by layer on a table and then the fabric will be cut into pieces using a cutting machine which are then separated. This stage is followed by the sewing process.

Sewing is the process of combining fabric components that have been cut into a whole shirt. The first step in the sewing process is sewing the shoulder section. This is done by sewing the front section of the shirt and connecting it to the back section of the shirt. The second step is to sew the arm caps and the last step is to sew the neck section. In the sewing process, the operator needs to check some important details such as checking the t-shirt components as well as trimming to cut threads from the remaining stitches. This step is followed by the finishing process.

Finishing is the final stage of the t-shirt production process and is also called the refinement process. Finishing is done after the sewing stage is complete. At this stage, the production results are checked from all aspects. The activities involved in this process are ironing, labelling, quality control, and packaging. T-shirts that pass the finishing process are t-shirts that have the desired quality.

### **2.2 Aggregate Planning**

Aggregate planning is a process to determine optimal levels of capacity, production, subcontracting, inventory, stock-outs, and pricing within a specific period of time (Chopra and Meindl, 2007) as an attempt to balance capacity and demand with minimum cost. Consequently, its quality has a significant impact towards the profitability of a company, making it one of the most critical areas of planning performed in the design of production systems (Nam & Logendran, 1992). The aggregate planning strategies include pure chase strategy, pure level strategy, and hybrid (mixed) strategy.

#### **2.2.1 Chase Strategy**

Chase strategy refers to a method of aggregate planning in which the company manufacturing capacity is dictated by the demand within the market, meaning the production level is varied and uses almost no inventory (Hamlet: 2013). This strategy is also known as the Demand Matching Strategy. Variable aspects within production are very flexible and are limited to only the necessary.

Chase strategy's most significant advantage lies in its ability to meet the fluctuation of market demand, and this perk is especially useful where market volatility constantly puts companies in positions where they are left with production excess that eventually becomes waste. Another advantage that chase strategy possesses is the ability to reduce inventory to a significant level. As chase strategy focuses on production according to market demand, the number of products has a higher chance to sell out. This means companies do not need to keep their product indefinitely while they wait for a customer to come. However, due to its nature of following market demand, companies must have enough data and other required resources necessary to facilitate accurate forecasting.

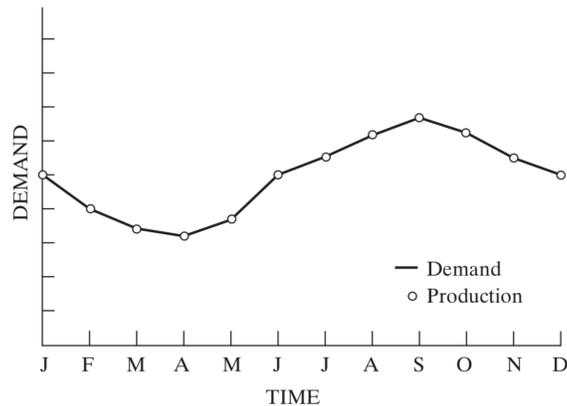


Figure 1. Chase strategy production behavior in relation to market demand

### 2.2.2 Level Strategy

Level strategy is the other spectrum of aggregate planning where chase strategy occupies one extreme and level strategy occupies the other. Unlike chase strategy, level strategy does not follow the trend movement of supply and demand. Regardless of the market demand, companies that adhere to this production model will follow its pre-established production output. This means companies will have an excess number of output during low market demand and shortage of output during high demand.

Forecasting is a huge aspect within MRP, and where chase strategy would continuously update their MRP, level strategy will in general stick to one MRP that they could continuously use in the far future. Where chase strategy is characterized by instant sellout, level strategy meets market demand by selling its inventory during times when current production output cannot keep up with demand, and store production output for later use when the market demand is low.

Fundamentally, the advantage that comes with level strategy is its ability to decrease production cost because fixed cost is spread over an optimum quantity of products, lowering the overall price of the product in the end. The major disadvantage of level strategy is that it would need companies to assign a significant fund to manage inventory. There is also the matter of producing waste when the inventory expires. Companies with a short span of time between manufacturing and expiration date are at a high risk of loss when adopting this strategy as it renders companies unable to keep up market demand through selling its inventory during high demand periods.

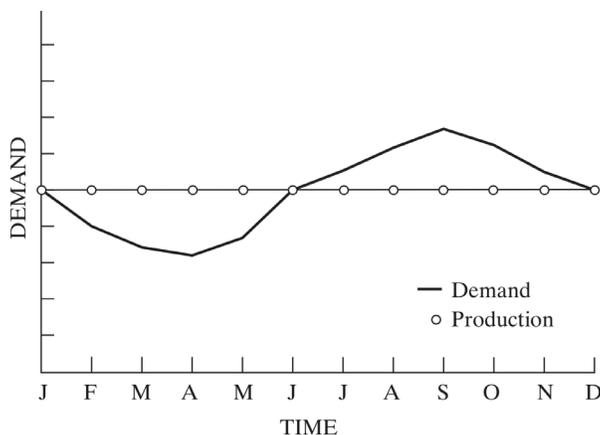


Figure 2. Level strategy production behavior in relation to market demand

### 2.2.3 Hybrid Strategy

Hybrid strategy, as its name suggests, is a hybrid between chase and level strategy. It took the best features that level and chase strategy has and combined them to get the best of both worlds. Hybrid strategy keeps an optimum control over the production capacity, hiring and firing rate, and inventory.

Graphic visualization of a hybrid strategy is similar to approximation of a curve using integration. The production level will remain the same for a certain timespan or period, and change in the next span to follow the change of market demand. Using this strategy, companies are able to adjust product price at a slower interval as the change of fixed cost is limited only between constant production period transitions.

Essentially, hybrid strategy could be thought as level strategy that is revamped every once in a while to follow market demand.

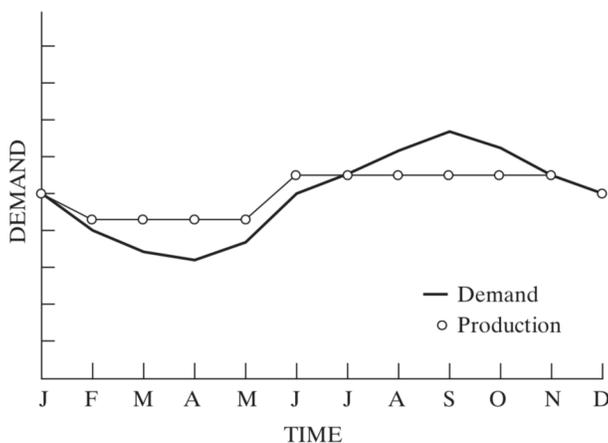


Figure 3. Hybrid strategy production behavior in relation to market demand

### 2.3 Master Production Schedule

In manufacturing industry, the most important element of customer service is product availability (Coyle, Bardi, and Langley, 1992). One of the main tools used to control product availability is Master Production Schedule (MPS). MPS can be defined as a feasible production plan that states the amount and time of production of individual end items (Sheikh, 2002). Whereas production plan deals in families of products, the MPS works with end items. It breaks down the production plan into the requirements for individual end items, in each family, by date and quantity. MPS is limited

by the production plan - therefore, the total of the items in the MPS should not be different from the total shown on the production plan.

The focus of optimization in production scheduling is to determine an effective scheduling production based on demand (Rahmat et al., 2020). MPS helps determine the amount of production needed per period to meet anticipated customer demand using data of the beginning inventory and the demand forecast for a particular end item. There are five inputs needed to construct MPS: total demand data from sales and order forecasts, inventory status, production plans, planning data such as lot-sizing, safety stock, lead time, etc, and rough cut capacity planning information.

Data from the MPS is then used to determine the raw materials requirement to meet the planned production schedule. MPS therefore drives operations in terms of what is assembled, manufactured, and bought (Vieira and Favaretto, 2006). MPS additionally provides information for sales regarding what can be promised to customers and when deliveries can be made, which makes the method a vital link between customer order management and production (Zhao et al., 2001). These characteristics mean that MPS is the basis for meeting delivery promises without inducing high inventory levels, as well as for resolving trade-offs between sales and manufacturing (Jacobs et al., 2011).

## 2.4 Material Requirements Planning

End items are made or assembled from components that must be available in the right quantities and at the right time to meet the MPS requirements. If any component is missing, the product cannot be built and shipped on time. Raw material is a major factor that determines the smoothness of a production process. Error in determining the amount of raw material can cause delay in production, inhibiting the manufacturer from producing the product on time. Thus, raw material has a direct effect on company profits. To help plan the order of raw materials, Material Requirement Planning (MRP) is used. MRP is a time-phased priority planning technique that calculates raw material requirement and schedules supply to meet demand of a product (Moustakis, 2000). It establishes a schedule (priority plan) showing the components required at each level of the assembly and, based on lead times, calculates the time when these components will be needed.

One of MRP's main objectives is to keep the due date equal to the need date, eliminating material shortages and excess stocks. MRP breaks a component into parts and subassemblies, and plans for those parts to come into stock when needed. Material requirement planning system help manufacturers determine precisely when and how much material to purchase and process based on a time-phased analysis of sales orders, production orders, current inventory, and forecasts. It ensures the company will always have sufficient inventory to meet production demands, but not more than necessary at any given time. The application of this popular tool in materials management has greatly reduced inventory levels and improved productivity (Wee and Shum, 1999).

In its simplest form, an MRP system consists of three basic components: a master production schedule (MPS); bill-of-material (BOM) files of the end items; and inventory status files of various materials, components, parts, subassemblies and final products (Hoey, Kilmarting, and Leonard, 1986). The MPS drives the MRP, and MRP drives, or is input to, production activity control (PAC), and purchasing.

## 3. Methods

To forecast the demand and the production capacity, Simple Moving Average (SMA) is used to find out means of past production capacity as well as means of past sales and use it as the forecast value of Whycotton's projected demand and production capacity in May 2021. SMA is one of the technical indicators which is widely used to predict future data in time series analysis. It is appropriate when there is no noticeable trend or seasonality. Since the object of this paper is a small apparel company which sells plain t-shirts, their demand and production pattern is not considered as seasonal.

Formula that is applied in the SMA method is:

$$SMA = \frac{X_{t-1} + X_{t-2} + \dots + X_{t-n}}{n}$$

With

$X_{t-1}$  = Actual occurrence in the past period for up to  $n$  periods  
 $n$  = Numbers of period to be averaged

In this paper, the number of periods chosen is three consecutive weeks in order to get more solid forecast results while using limited company's data. The historical data which was used are from Week 1 until Week 4 of April 2021. By comparing the demand forecast with the production capacity forecast, the company's ability in satisfying the upcoming demand can be deduced.

#### 4. Data Collection

The t-shirt produced was made out of 4 main components: 2 pieces of t-shirt's sleeves, one piece of the collar, one piece of front t-shirt body and one piece of back t-shirt body. Bill of material for t-shirt production has three levels which are level 0, level 1, and level 2 as seen on the figure below (see Figure 1). The details of how much fabric is required in each level is shown on the Bill of Material and the quantity summary is attached on a table form as well (see Table 1).

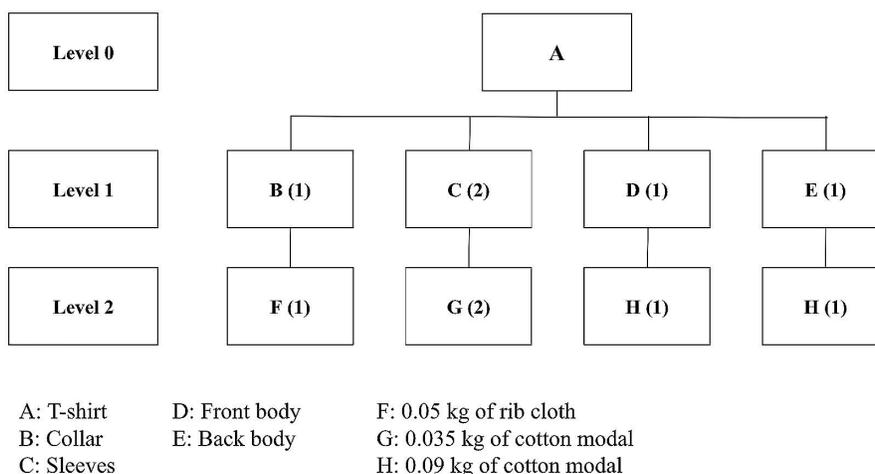


Figure 4. Bill of Materials (BOM) of T-Shirt

Table 1. Raw Materials Requirement for One T-Shirt

Material	Part	Quantity (kg)
Cotton modal	Sleeves	0.07
	Front body	0.09
	Back body	0.09
Rib cloth	Collar	0.05

To anticipate customer demands for the following week, the company has always referred to the sales data from the previous week and added 40 - 50% more pieces from last week's sales. However, from the data of number of sales and volume of production in April 2021, it can be seen that the demand still exceeded the production capacity (see Table 2 and Table 3). This proves that the company's strategy in planning and deciding the production quantity is still inadequate, causing a recurring out-of-stock situation.

Table 2. Data of T-Shirt Sales in April 2021

Time Period	Sales (pcs)
Week 1	77
Week 2	30
Week 3	98
Week 4	58

Table 3. Data of T-Shirt Production in April 2021

Time Period	Production Capacity (pcs)
Week 1	31
Week 2	49
Week 3	38
Week 4	83

## 5. Results and Discussion

### 5.1 Numerical Results

To know whether the production capacity can satisfy the demand needs in May 2021, the simple moving average method is used to forecast the demand and production capacity (see Table 4 and Table 5). Week 1 – Week 4 refers to weeks in April 2021 and Week 5 – Week 8 refers to weeks in May 2021. The forecast is done in weeks-period because the company produces t-shirts every one week. Furthermore, the forecast is only based on the data in April 2021 due to lack of data availability from the company.

Table 4. T-Shirt Demand Forecast in May 2021

Week	Sales (pcs)	Demand Forecast (pcs)
1	77	-
2	30	-
3	98	-
4	58	-
5	-	62
6	-	73
7	-	65
8	-	67

Table 5. T-Shirt Production Volume Forecast in May 2021

Week	Sales (pcs)	Demand Forecast (pcs)
1	31	-
2	49	-
3	38	-
4	83	-
5	-	57
6	-	60
7	-	67
8	-	61

### 5.2 Graphical Results

By comparing the forecasted number of demand and quantity of production, it can be seen that the number of demand still exceeds the number of production in three out of four weeks in May 2021 (see Figure 2). This imbalance means that a significant amount of customer demands went unfulfilled, implying an inadequateness in satisfying customer demand. This means that the current production planning and inventory management adopted by the company is ineffective, urging an adoption of a better planning system.

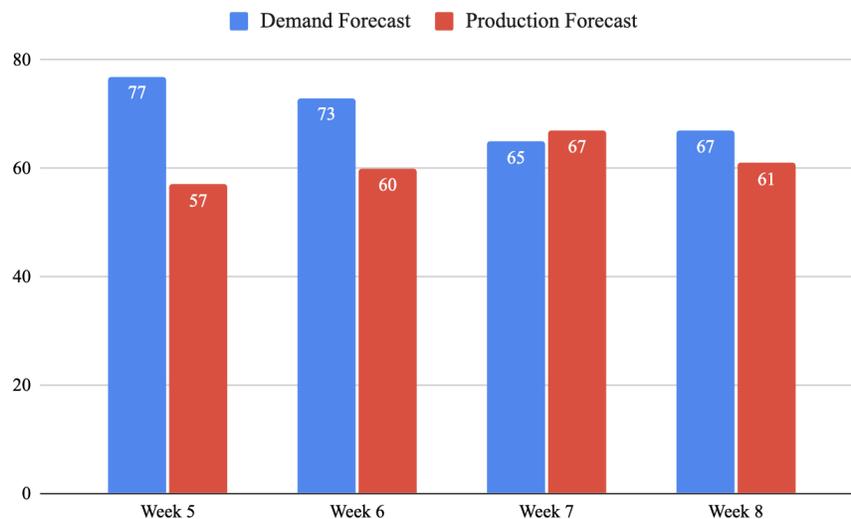


Figure 5. Histogram of Demand Forecast vs. Production Capacity Forecast

### 5.3 Proposed Improvements

The Table 6 below shows the material requirement planning of cotton modal to satisfy the demand in May 2021. This material is needed to make the sleeves, the front body, and the back body of the t-shirt produced. The quantity needed to produce one T-shirt is 0.25 kg of cotton modal (0.09 for the front body, 0.09 kg for the back body, and 0.07 kg for the collar).

Table 6. Material Requirement Planning (MRP) of Cotton Modal in May 2021

Cotton Modal		Week			
		5	6	7	8
Gross Requirement (pcs)		62	73	65	67
Project On Hand Inventory (pcs)	8	2	1	0	1
Net Requirement (pcs)		54	71	64	67
Planned Order Receipt (pcs)		56	72	64	68
Planned Order Receipt (kg)		14	24	16	17
Planned Order Release* (kg)	14	24	16	17	

\*1 piece of t-shirt = 0.25 kg of cotton modal

The authors also calculate the material requirement planning of rib clothing to satisfy the upcoming demand in May 2021 (see Table 7). Rib clothing is needed to make the collar of the t-shirt produced, in which every t-shirt has one collar. To produce one t-shirt, 0.05 kg of rib cloth is required.

Table 7. Material Requirement Planning (MRP) of Rib Cloth in May 2021

Rib Cloth		Week			
		5	6	7	8
Gross Requirement (pcs)		62	73	65	67
Project On Hand Inventory (pcs)	8	2	1	0	1
Net Requirement (pcs)		54	71	64	67
Planned Order Receipt (pcs)		56	72	64	68
Planned Order Receipt (kg)		2.8	3.6	3.2	3.4
Planned Order Release (kg)*	2.8	3.6	3.2	3.4	

\*1 piece of t-shirt = 0.05 kg of rib cloth

The adoption of Material Requirement Planning (MRP) in determining the production quantity and inventory level is a form of improvement strategy to prevent the out-of-stock situation in May 2021. The company can better determine the production quantity because the production quantity is based on the forecasted demand while taking on-hand inventory and net requirement into account. Using empirical calculation, the company can prevent the occurrences in which the quantity of materials exceeds or unfulfill the amount needed. The acknowledgement of raw materials' lead time will also help in ensuring that the materials needed are always available on time, which will decrease the chance

of product stock outs. Decrease in the number of unmet demands will increase the amount of goods sold, which will result in an increase in the company's overall profit.

#### 5.4 Validation

Based on comparison below (see Table 8, Table 9, and Table 10), it is found that cost calculation using MRP can increase the company's profit in May 2021 to Rp 7.476.000,- or equal to adding 8,98% more profit than its original value which is Rp 6.860.000,-. This validates the hypothesis mentioned in the objective of this paper which stated that by applying inventory planning, profit of the company will increase.

Table 8. Profit obtained without applying MRP

T-shirt sold (pcs)	Revenue	Production cost*	Profit
57	Rp3.819.000	Rp2.223.000	Rp1.596.000
60	Rp4.020.000	Rp2.340.000	Rp1.680.000
67	Rp4.489.000	Rp2.613.000	Rp1.876.000
61	Rp4.087.000	Rp2.379.000	Rp1.708.000
Total profit			Rp6.860.000

\*0.25 kg of cotton modal and 0.05 kg of rib cloth (1 t-shirt) = Rp34.000

Cutting and sewing cost (1 t-shirt) = Rp5.000

Total cost for 1 t-shirt = Rp39.000

Table 9. Profit obtained with applying MRP

T-shirt sold (pcs)	Revenue	Production cost*	Profit
62	Rp4.154.000	Rp2.418.000	Rp1.736.000
73	Rp4.891.000	Rp2.847.000	Rp2.044.000
65	Rp4.355.000	Rp2.535.000	Rp1.820.000
67	Rp4.489.000	Rp2.613.000	Rp1.876.000
Total profit			Rp7.476.000

\*0.25 kg of cotton modal and 0.05 kg of rib cloth (1 t-shirt) = Rp34.000

Cutting and sewing cost = Rp5.000

Total cost for 1 t-shirt = Rp39.000

Table 10. Total profit comparison of MRP implementation

Profit with applying MRP	Profit without applying MRP	Incremental profit	
		In Price	In Percentage
Rp7.476.000	Rp6.860.000	Rp616.000	8.98%

#### 6. Conclusion

Whycotton is a small apparel company which applies chase strategy as their production plan method. This company often faces out-of-stock conditions (OOS) because they do not have a well-planned production scheduling and

inventory control. This problem results in opportunity loss. In the long run, this problem can lead to stagnancy or even failure of the business.

By using the simple moving average (SMA) as the forecasting method, it is found that in the upcoming month, May 2021, the company's production capacity cannot satisfy customer demand due to limited stocks. To answer this problem, an implementation of Material Requirement Planning (MRP) is performed as the proposed improvement method. This method was chosen because it provides a schedule showing the components required at each level of the assembly and calculates the time when these components will be needed based on lead times.

In comparison data, it can be seen that in May 2021 demand, Whycotton can increase their profit by 8.98% if the company has applied the MRP on their production planning. Results generated from calculation of the incremental profit obtained are relatively small in percentage. However, in its capacity as a small company, the application of MRP method in the purchasing planning of raw materials resulted in the company to gain a significant amount of profit. Judging from the size of this small company, this increase has a considerably big impact.

In addition to the terms of increase in profit, the application of this method also resulted in companies being able to fulfill the customer demand schedule on time. Other than that, this method implementation helps the company in minimizing the possibility of the production capacity not meeting the customer demand, and an ease in analyzing how much raw materials to be purchased to meet demand.

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## Biographies

**Gabriella Regina** is an Industrial Engineering undergraduate student from Universitas Indonesia. She is currently a research assistant in the Management Information System and Decision Support Laboratory. Her research interests are Business Process Reengineering, Information System, Enterprise Resource Planning, Project Management, Industrial Feasibility Analysis, Customer Relationship Management, Database Management System, and Decision Support System.

**Naila Zaafira** is an Industrial Engineering undergraduate student from Universitas Indonesia. Her research interest includes mostly visual ergonomics and communication, and minoring in Animation and Game Design. At the moment she is working on an animated TV series pre-production as well as serving as a teaching assistant in an online graphic design mentorship program.

**Pocut Shafira Putri Aurora** is an Industrial Engineering undergraduate student from Universitas Indonesia. She is currently a research assistant in the Statistics and Quality Engineering Laboratory. Her research and teaching interests are mostly related to Statistical Learning & Optimization and Social Finance & Market Analytics. She has been involved in some Quality Engineering training programs by providing materials for the Certified Quality Engineer Exam participants.

**Rahmat Nurcahyo** is currently active as academic staff in Industrial Engineering Department, Universitas Indonesia. Mr. Rahmat was born in Jakarta, June 2nd 1969. He started his higher education in Mechanical Engineering, Universitas Indonesia and graduated in 1993. Then, he continued his study in University of New South Wales and obtained his master degree (M.Eng.Sc.) in 1995. Now, he is a candidate of doctoral degree in Faculty of Economics, Universitas Indonesia. Mr. Rahmat has taught several courses in Industrial Engineering UI, including Industrial Psychology, Industrial Economy, and Total Quality Management. Mr. Rahmat is International Register of Certificated Auditors and a member of Ikatan Sarjana Teknik Industri dan Manajemen Industri Indonesia (ISTMI).