Managing internal bullwhip effect to plan product distribution in a garment factory

by Nunung Nurhasanah

Managing Internal Bullwhip Effect to Plan Product Distribution in a Garment Factory

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Abstract - XYZ is a family garment business established in 2004. XYZ produces and sells garments for 6-12 years old boys with brands like Forboys, Wellboy, Nashkid, Yepao, and Kid Dreams. The types of garments are *oblong, setelan* and *wangky*. XYZ has three garment Cut-make-trim (CMT) partners in Rangkas, Serang and Pandeglang. The three CMT partners has been giving XYZ neat and tidy garment products, ready to compete in Tanah Abang wholesale center. Based on the demand forecast calculation XYZ sends its order for production to the CMTs. In return, based on the quantity ordered, the CMTs order the raw materials from XYZ. This study attempts to measure the "internal" bullwhip effect which is observed as the fluctuations of orders sent by the CMTs to XYZ, based on the production orders from XYZ to the CMTs. XYZ experienced high inventories and its mounting costs due to this internal bullwhip effect. Further, the method used in this study investigate the appropriate forecasting method. The best forecasting method is the Double Exponential Smoothing, which also results in the reduction in the bullwhip effect ratio, and improvement of scrap factor (around 10.60%). The reduction of BE ratio is quite significant from 0.344, 0.242 and 0.717 for *oblong*, *setelan* and *wangky* product types respectively.
Keywords: Garment business, Cut-make-trim, Internal bullwhip effect, Scrap factor.

1. INTRODUCTION
XYZ is a family owned small medium garment industry which produces different type of clothing for boys aged 6-12 years. The brands are Forboys, Wellboy, Nashkid, Yepao, and Kid Dreams. XYZ is very committed to quality and always attempts to satisfy the customers with best product quality. XYZ employs a unique production processes. XYZ buys initial textile raw materials from its suppliers which are sent to some cutting partners in Sukabumi area. XYZ is experiencing fluctuative demand from the garment market, while it has to control the order to its CMT partners, who in return will send orders for raw materials from XYZ. Further, XYZ experiences various reject and low quality products which causes product returns. To minimize this matter XYZ applies a scrap factor (SF) when calculating the orders to its CMTs.

Figure 1 shows how XYZ operates its business between allocating production order to the three CMTs, based on its demand forecast. Based on these production orders the CMTs orders textile raw materials from XYZ. XYZ must carefully control the orders such that it does not develop mounting

IOP Conf. Series: Materials Science and Engineering **847** (2020) 012010 doi:10.1088/1757-899X/847/1/012010

number of garment products which should have been sent or sold through its market outlets. The internal bullwhip effect (BWE) emerges when production orders were sent to the three CMTs and other partners, CMTs and other partners send requests for raw materials from XYZ, which may be uncontrollably higher than is necessary. Packaged finished garments were received back at XYZ warehouse in Jakarta from all CMTs and partners.

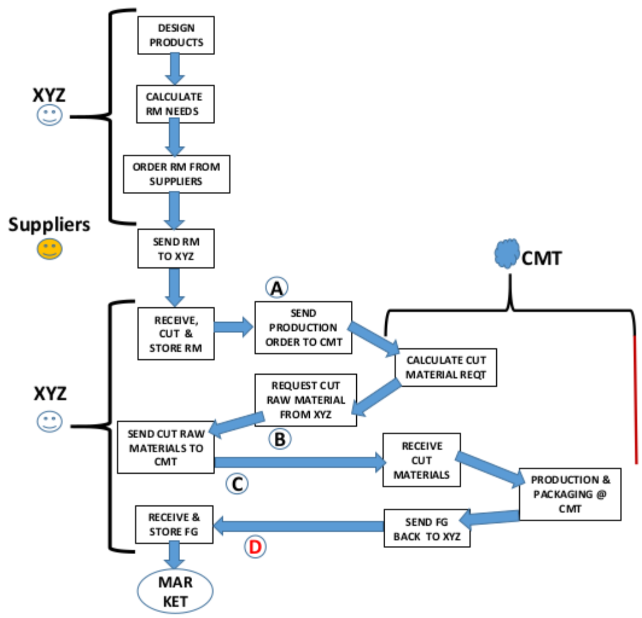

Figure 1. XYZ Business Process Flow

The detail business process at XYZ may be explained as follows:

1. XYZ designed the garment to be produced. The owner of XYZ evaluated the design prototype before order for production is released. Required materials to produce the garment are calculated and then ordered from the suppliers. Received raw materials at XYZ Jakarta warehouse are cut following the design pattern, then are stocked in XYZ Jakarta warehouse.
2. XYZ calculates the demand as the basis for assigning production order to the CMTs (point A). CMTs orders the required cut materials from XYZ (point B). This is the point where internal BWE emerges.
3. Cut raw materials are sent to CMTs in Rangkas, Serang and Pandeglang, as well as to other partners for further sewing processes (point C). Finished garments at all the CMTs are packed and sent back to XYZ in Jakarta (point D). This is where the number of finished garments are accumulated from all partners.
4. XYZ made the final finishing touch on the garments before being sent to market/sales outlets at Tanah Abang. XYZ has to control the flow and inventory of its various raw materials and finished products in its Jakarta warehouse.

2. METHODS

Due to the informal and intuitive forecasting using previous historical sales data, XYZ does not develop proper and accurate raw material orders from its suppliers, does not develop proper production assignments to its CMT partners, and does not send appropriate amount of cut raw materials to the CMT partners. The result is that XYZ receives "uncontrolled" and "inaccurate" number of finished garments from the CMT partners. All these garments as well as the initial raw materials, and cut raw materials are piling up in XYZ Jakarta warehouse. The Jakarta warehouse is in fact a mansion which was turned to be a garment processing facilities without proper design and layout. The phenomenon of highly uncontrollable fluctuation of raw material and finished garments at XYZ warehouse is what we describe as "internal bullwhip effect". We describe it as such because it is happening inside a company material logistics.

XYZ experienced high number of rejects finished garments from CMTs. From this experience XYZ employed a certain "scrap factor" when calculating number of production assignments to the CMTs. This numbers were determined roughly from past 12 months (returned) sales on each class of product and each CMTs. This practice of applying scrap factor helped reduced the huge level of inventories at XYZ. The handling costs incurred with this huge inventories has significantly eroded its profitability and negatively affect the morale of its Jakarta staff and workers due to the high piles of materials everywhere.

XYZ needs to measure the level of its "internal bullwhip effect" and then find more ways to get rid of the mounting level of its inventories. The idea to help XYZ is by improving the forecasting method with more "scientific" models.

2.1 Distribution Requirement Planning (DRP)

Distribution requirement planning is a system that determine demand for supplies to the center of the distribution of, combining historical demand, and as its input in order to the system of production and material [1]. Another expert stated that DRP is a forecasting based system that plans and determines the right inventory level to ensure satisfactory flow of products distribution. DRP gives future demand visibility pertaining to the need to shipping from source stocking points to destinations selling points. This will help the firm to take corrective measures before undesirable occurrence develops into a crisis [2].

2.2 Scrap Factor

To reduce the effect of unwanted order quantity accumulation, the formula to calculate DRP is merged with the scrap factor. The formula is applied to planned order release, rather than on gross requirement, for scrap estimate lost during the distribution of products. The scrap factor is the percentage that is used in the calculation of the DRP to anticipate the loss in the distribution process [3]. The planned order release quantity which include scrap factor is calculated as follows:

$$PO\ Release\ Quantity = \frac{PO\ Receipt\ Quantity}{(1-\%Scrap)} \tag{1}$$

2.3 Forecasting

Management is continuously faced with a fast-paced flow of business planning and decision-making situations. Forecasting is an engineering analysis done by a quantitative and qualitative approach to estimate the future using past reference data. A sound forecasting system is a necessity in the expanding supply change management world, allowing firms to cope with the ever-changing shifts in demands for their products and resources. The common goal is to have the least amount of inventory to satisfy the customers' demands for its products, and at the same time minimize the cost of buying and holding the inventory [5]. In this study three models of forecasting method are used. (1) Double Moving Average (DMA), (2) Exponential Smoothing Method (DES), and (3) Triple Exponential Smoothing (TES), following the approach by Siregar [5] to analyse the best method in Palm Oil production.

2.4 Bullwhip Effect and Bullwhip Effect Measurement

A phenomenon that is now well known as the BWE is the variability of orders increases as they move up the supply chain from retailers to wholesalers to manufacturers to suppliers. Other researchers describe BWE as the large discrepancy between inventory and demand, or the jump from small order in the downstream to high request in the upstream [4]. Existing approaches that aim at quantifying the BWE neglect the network structure of supply chains. Some major factors said to cause or contribute to BWE are [6, 7, 8]:

- The causes are often interconnected and tracking down the sources of the disruption is difficult. Other than identifying the causes for the BWE, it is difficult to quantify the degree to which each cause affects the supply chain. For this reason, many of the studies in this area either base their empirical results on a narrow range of causes, or study simple supply chains using simulations.
- Rationing and shortage gaming – buyers' strategic ordering behaviour as a possible cause of the bullwhip effect. In an environment where there is supply shortage, buyers tend to overorder to secure resources for themselves, and suppliers tend to correct this over ordering by rationing back to smaller quantities. These two patterns of behaviour are interrelated and mutually reinforce one another.
- Past demands are not used in forecasting future customer demand. up-to-S policy where S is a constant. Other conditions by which these causes were derived include: (a), No fixed order cost, (b) Re-supply comes from an infinite source with a constant fixed lead time (c) Purchase cost for the product is stationary.
- Lack of communication between each link in the supply chain makes it difficult for processes to run smoothly. Managers can perceive a product demand quite differently within different links of the supply chain and therefore order different quantities.
- Demand information – relying on past demand information to estimate current demand information of a product does not take into account any fluctuations that may occur in demand over a period of time.
- When the retail and manufacturing industries do not smooth their production relative to their demand, i.e., they impose more volatility on their suppliers than they face the demand from their customers.

In this study, we attempt to consider the confusion of a manufacturer in managing the flow of its order of raw materials from its suppliers, the production order to its external CMT partners who must use the cut raw materials from the manufacturer, and getting the finished garment back from the CMTs as a problem of internal bullwhip effect.

Bullwhip Effect Measurement

BWE needs to be measured and controlled to achieve a better company inventory and cost position. The formula for measuring bullwhip effect ratio (= BE) is shown below [4]:

$$\text{BE} = \frac{CV\ (Order)}{CV\ (Demand)} \tag{2}$$

$$\text{CV Order} = \frac{\sigma\ (Order)}{\mu\ (Order)} \tag{3}$$

$$\text{CV Demand} = \frac{\sigma (Demand)}{\mu\ (Demand)} \tag{4}$$

Where:

BE	=	Bullwhip effect ratio
$CV_{(Order)}$	=	Coefficient of Variable for sales (= order)
$CV_{(Demand)}$	=	Coefficient of Variable for demand
$\sigma_{(Order)}$	=	Standard Deviation for sales (= order)
$\mu_{(Order)}$	=	Average Sales (= order)
σ (Demand)	=	Standard Deviation for demand
μ (Demand)	=	Demand average

This paper attempts to measure the internal BWE in the garment business of XYZ and the appropriate solution to reduce the BWE. The reason for reducing the effect is obviously to reduce the high cost of garment inventory mounting up due to the error in the demand forecast. Figure 2 shows the methodology applied in this study. Data collection are obtained directly from the management and staff of XYZ. When the data is considered sufficient they are processed using three forecasting methods and analyzed. BWE is then calculated before and after the forecast.

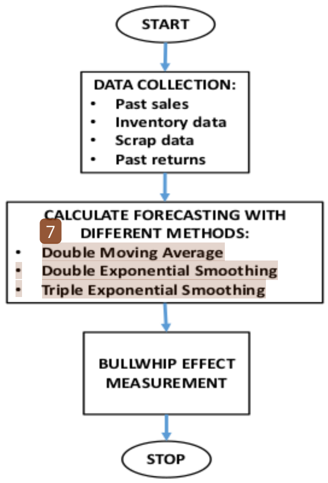

Figure 2. Research Flowchart

3. RESULTS AND DISCUSSION

3.1 Data Collection

3.1.1 Allocation Order Production Between XYZ and CMT

Figure 3 describes how the internal BWE occurred in the order of XYZ to CMT concerned and the return to XYZ. This is a horizontal redrawing of Figure 1.

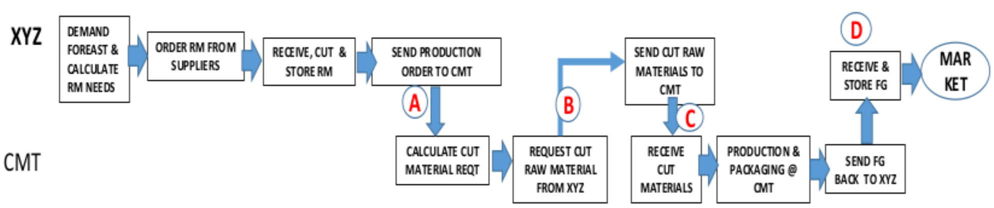

Figure 3. Mapping of XYZ Bullwhip effect

The three CMTS in Serang regency are CMT Tarji, CMT Basri and CMT Toro, following the names of the CMT facility owners. Fig. 4 explains the internal distribution network of XYZ which consists of 3 levels of distribution.

- At level 0 is XYZ who assigns production order to CMTs (outsourcing).
- At level 1 is the three CMTs as outsource garment producing; CMT will order cut material or other material required to XYZ as material for making the garment. The three CMTs include the scrap factor in this “support factor” in anticipation of damaged product by the market.
- At level 2 is XYZ who will store the product received (after finishing steps)
- At level 3 is the Marketing Centre that deals directly with customers.

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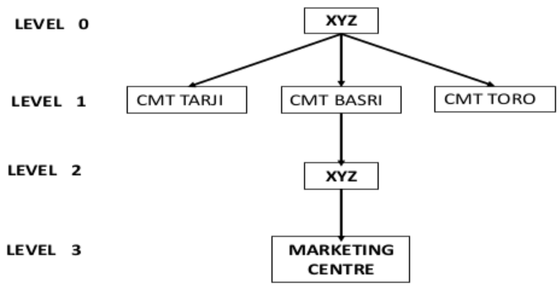

Figure 4. Internal Distribution Levels of XYZ

3.1.2 Returns Data

Some defective product or products are returned back to XYZ for several factors, namely: (1) The neck is unsymmetrical, (2) Moist, and (3) Untidy stitches. Table 1 shows the product return data for the three CMTs.

Table 1. Returns Data of XYZ

No	Month	Returned product (unit)			Total	% of total product
		CMT Tarji	CMT Basri	CMT Toro		
1	January	699	306	677	1,682	3.52
2	February	688	730	661	2,079	5.08
3	March	526	161	678	1,365	2.92
4	April	459	610	467	1,536	2.74
5	May	454	833	675	1,962	4.93
6	June	661	864	345	1,870	4.61
7	July	678	699	654	2,031	4.58
8	August	700	1,028	786	2,514	5.32
9	September	651	526	675	1,852	4.39
10	October	972	972	456	2,400	5.30
11	November	455	809	432	1,696	4.71
12	December	467	809	745	2,021	5.10
	Total	7,410	8,347	7,251	23,008	4.43

3.2 Forecasting

After the data from the three CMTs are collected and plotted, they are ready for forecast. Forecasting methods used are the Double Moving Average (DMA), Double Exponential Smoothing (DES) by Brown and Triple Exponential Smoothing (TES) by Brown.

Table 2 shows the result of all three forecasting calculations. The figure for the third product (*Wangky*) shows the smallest value of MAPE (mean absolute percentage). For all CMTs (Tarji, Basri and Toro) the smallest MAPE values is achieved using DES method.

Table 2. MAPE Result of CMTs

No	Method	CMT Tarji			CMT Basri			CMT Toro		
1	Double Moving Average	0.38	0.57	0.29	0.26	0.38	0.23	0.22	0.30	0.26
2	Double Exponential Smoothing	0.25	0.32	0.25	0.27	0.22	0.15	0.18	0.23	0.23
3	Triple Exponential Smoothing by Brown	0.28	0.37	0.25	0.27	0.22	0.16	0.22	0.26	0.26

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3.2.1 Scrap Factor Calculation

The next stage is to calculate manually to determine the percentage scrap factor. Table 3 shows the result. Obviously the calculation for the third product (*oblong*) gives the lowest value of the scrap factor. This data are obtained by dividing the numbers returned products from Table 1 by the total production of each CMT.

Table 3. Calculation Result Scrap Factor of Three CMTs

No	CMT	Oblong	Setelan	Wangky
1	Tarji	10.69%	11.88%	11.41%
2	Basri	14.05%	15.76%	17.33%
3	Toro	12.45%	13.22%	12.87%

3.2.2 Bullwhip Effect Measurement

Table 4 shows the result of BE measurement for the next 3 months. The table shows that the measured BE ratio are better (or lower) after the orders and flows are based on better forecasting method, namely Double Exponential Smoothing (DES). For *oblong* products at CMT Tarji the reduction is 0.49/1.41 = 0.347; for *setelan* product 0.20/0.83 = 0.241 while for *Wangky* product, the ratio is reduced 0.71/0.99 = 0.717.The figures for the other two CMTs are shown in the table.

Table 4. Calculation of Bullwhip Effect Product all CMTs

Garment type	Parameter	Sales Value Before and After Forecasting: CMT Tarji			CMT Basri			CMT Toro		
		Before	After	Improve	Before	After	Improve	Before	After	Improve
Oblong	Average	6,621	3,797		4,550	5,013		4,578	4,749	
	Std Dev	1,104	218		289	3		991	29	
	Coef Var	0.17	0.06		0.06	0.00		0.22	0.01	
	BE Ratio	1.41	0.49	0.344	1.28	0.01	0.010	1.80	0.05	0.028
Setelan	Average	6,151	3,519		4,310	5181		4,221	4,718	
	Std Dev	1,389	192		764	80		374	18	
	Coef Var	0.23	0.05		0.18	0.02		0.09	0.00	
	BE Ratio	0.83	0.20	0.242	0.80	0.07	0.087	1.65	0.07	0.043
Wangky	Average	6,198	3,480		4,378	3,707		4,165	4,877	
	Std Dev	540	217		245	38		626	23	
	Coef Var	0.09	0.06		0.06	0.01		0.15	0.00	
	BE Ratio	0.99	0.71	0.717	0.78	0.14	0.186	0.87	0.03	0.031

4. CONCLUSION

Based on the results of data processing that has been carried out, some conclusions can be drawn as follows:

1. The best forecasting method is the double exponential smoothing (DES) which has the smallest value of MAPE (Mean Absolute Percentage). For *oblong* product from CMT Tarji = 0.25%. For *wangky* Produk from CMT Basri = 0.15%. For *oblong* product from CMT Toro = 0.18%.
2. The reduction of BE ratio is quite significant from 0.344, 0.242 and 0.717 for *oblong*, *setelan,* and *wangky* product types respectively. For the CMT Tarji, the reduction are from 0.241 to 0.717 for CMT Tarji products. The reduction of BE ratio for CMT Basri are 0.009, 0.087, and 0.186; and for CMT Toro are from 0.344, 0.242 and 0.717 for *oblong*, *setelan* and *wangky* product types respectively. In general the BE ratio becomes less when the the right forecasting method is used.

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3. The BW value has been decreasing with the use of appropriate forecasting method DES. The smaller the value of BW the better sales level would be achieved because there would be less sales returns.

The recommended future research area is performing the calculations for the rest of the products. The idea of Internal BWE may sound strange or alien. But in Indonesia the practice of production outsourcing is everywhere. Not only in the garment, but also in other kinds of products like food, even for bicycles or automobiles. Definitely the concept and definition need to be smoothen or improved to be acceptable by the research community.

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