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Measuring Supply Chain Performance of Knitting Industry

Anton Mulyono Azis*

The purpose of this study is to measure the supply chain performance of the knitting industry in Bandung city by investigating the key factors that determine the industrial successes. This research used quantitative research by measuringits drivers' metrics. The result found that the industry is on the poor stage that should be noticed. This research is expected to provide benefits for the development of the knitting industry through improvement in each existing drivers' metrics. Further research can be undertaken in deepening good performance sub-drivers' metrics and research related to increase the value of each indicator.

JEL Codes: L25, L67, and M11

Field of Research: Performance management, Supply chain management

1. Introduction

With the industrial center that existed since 1965 in Bandung CityIndonesia and total production reaching nearly one million units per year and also employing almost 2000 workers (Darusman and Rostiana, 2015), the knitting industry product is not just meet the domestic needs, but also has been exported to various countries, including Singapore, Thailand, Australia, Africa, and other countries.However, like the other labor-intensive industries (Irjayanti and Azis, 2012), the sustainability of this industry began to be disrupted by the presence of a variety of sophisticated textile machinery and facilities, as well asthe depletion of the reliable workforce for producing the goods.Moreover, since the industrial center located in the middle of dense areas, inventories facilities and transportation become another problem that ultimately decreases the supply chain performance of knitting industry (Susanto *et al*., 2016). Furthermore, the most important issues for this industry's supply chain performance is related to the procurement of raw material and the price of various goods.

Hence, for improving the overall supply chain performance, the business owners in this industrial center should not only focus on the provision of goods but also on the efforts to meet consumer demand efficiently and effectively through flows of goods, money, and the right information(Irjayanti *et al.,* 2016).Managingthese three streams leads to customer satisfaction where the goods reach consumers with the right amount, on time, and the best price. Thereforeit is important to understand the current performance position of each individual driver's metrics. So that, it will be easy to make the next working plan by focusing on the lower value driver metricsforthe overall performance improvement.

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*Anton Mulyono Azis, Associate Professor of Performance Management, Ekuitas Business School, Bandung-Indonesia, Email: anton.mulyono@ekuitas.ac.id

Furthermore, this research was conducted because of the gap presented by Charkha and Jaju (2015) whose conducted research on performance management for the textile industry in general and they suggested for doing a research in a specific textile industry. Another research is conducted by Rai and Giri (2015) which focused only on inventory turnover and cash to cash cycle period in measuring supply chain performance in the garment industry. They suggested extending to others metrics which affect the performance, hence this research is done by adding more significant metrics for measuring industrial supply chain performance as mentioned by Chopra and Meindl (2013).Thus the research question is developed from those gaps i.e. what are the determinants factors for measuring supply chain performance and how does the performance value of each metrics compare to Bandung knitting industrial standards.

Based on the research background, the aim of this study is to measure the supply chain performance of the knitting industry in Bandung city by investigating the key factors or drivers metrics that determine the industrial successes in order to make this industry re-grow and develop sustainably.Thus, for the findings of this research, there are six important metrics in the knitting industry in Bandung, namely: facility, inventory, transportation, information, sourcing, and pricing. This is a new finding, considering that it has never been found in similar research, especially in the textile industry.For better understanding, this paper is organized as follows. Section 1 focuses onan introduction. Section 2 deals with a literature review. Section 3 contains methodology.Section 4 provides an analysis of findings. Section 5 deals with the conclusion

2. Literature Review

Whitten *et al*. (2012) and Zhang & Okoroafo (2015) pointed the performance of supply chain will indicate the ability to produce right on time a number of appointed goods with the right standard and maximize the overall value generated (Chopra and Meindl, 2013:15) or minimizing the total supply chain cost (Harland *et al*., 1999). That's why the performance of the supply chain should be measured (Hausman, 2004) and it needs the appropriate indicator (Leonczuk, 2016; Azis and Azis, 2013) for having an excellent performance (Azis *et al.*, 2014) as well as comparing its current position with last year achievement and the competitors. Those researchers deal with knitting industry goals in achieving high supply chain performance.

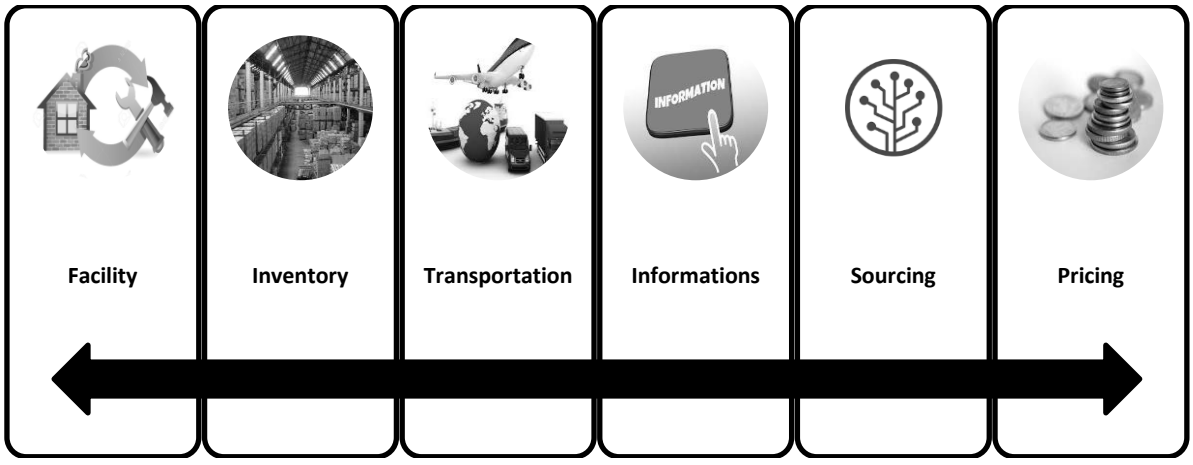
Several studies indicate different numbers of key factors or drivers' metrics intheindustrial supply chain. All of the key factors provide by those studies lead this research for using the appropriate metrics for the knitting industry in Bandung City as indicated in the research questions. Chopra and Meindl (2013:56) mentioned six drivers in supply chain decision making framework that grouped into two categories i.e. logistical drivers and cross-functional drivers, while others such as Jayaraman and Pirkul (2001) mentioned 3 drivers, Gopal (2009): 5 dimensions, or Anand and Grover (2015) with 4 drivers. The summaries of each drivermetricsfrom various researchers are shown in Table 1.

Table 1: Supply Chain Key Factors or Drivers' Metrics

Author (Year)	# Metrics	Key Factors or Drivers' Metrics
Anand and Grover (2015)	4	Transportation, inventory, information technology, resource
Chopra and Meindl (2013)	6	Facility, inventory, transportation, information, sourcing, and pricing.
Hugos (2011)	5	Capacity, workload, quality, maintenance,andfacilities.
Gopal (2009)	4	Customer, distribution, internal operation, and supply
Haq and Kannan(2006)	3	Inventory, production, and transportation
Hill and Omar (2006)	3	Production, shipping, and holding
Hwang *et. al* (2005)	3	Stock level, backlog, total cost
Yao and Chiou (2004)	3	Ordering, holding, and purchasing
Huiskonen and Pirttila (2002)	6	Delivery, order status, information accuracy, transportation, warehousing, inventory
Jayaraman and Pirkul (2001)	3	Purchasing, production, and distribution
Beamon (1999)	3	Resources, Output, Flexibility
Stank *et al.* (1999)	5	Inventory, transportation, warehousing, ordercycle and cost, deliveries

Considering key factors or drivers' metrics from those twelve authors which mentioned various metrics that may not all be suitable for the specific industry, especially for knitting industry, this study uses the drivers' metrics from Copra and Meindl (2013) for measuringthesupply chain performanceof knitting industry. These six key factors can be shown in figure 1, that consist of facility, inventory, transportation, information, sourcing, and pricing.

Figure 1:The Drivers' Metrics of Supply Chain in Knitting Industry



Adapted from Copra and Meindl (2013)

Based on the work of Copra and Meindl (2013), the measurement of the knitting industry supply chain performance uses several appropriate measures for each key factors. In total for this industry there are 47 metrics, consisting 9 metrics for facility, inventory: 8 metrics, transportation: 7 metrics, information; 7 metrics, sourcing: 8 metrics, and pricing; 8 metrics. For more details, those metrics are (1) Facility: utilization, processing time, capacity, quality losses, cycle time, time efficiency, product variety, batch size, and production level. (2) Inventory: average stock, safety stock, obsolete inventory, cash to cash cycle time, inventory turns over, fill rate, high-level inventory, and seasonal inventory. (3) Transportation; average inbound transportation, inbound transportation cost,averageincoming shipment size, incoming shipment cost, average outbound transportation, outbound transportation cost, and mode of transportation. (4) Information: punctuality of forecasting, updating frequency, seasonal factors, variance, errors, demand variability, and order variability. (5) Sourcing: payable days, purchase price, the range of price, quantity purchase, supplier quality, lead time, on-time deliveries, and supplier reliability. (6) Pricing: payment days, profit margin, fixed cost per unit, variable cost per unit, selling price, order size, the range of selling price, and range of selling time.

3. Research Methodology

This research is conducted in 2017 and used quantitative research method by measuring the drivers' metrics of the supply chain in knitting industry and involving 127 business owners as a sample size from nearly 300 home industrieswithin this industry center in the first semester ofthe year 2017, this means the response rate of this primary data nearly 43%. This study uses the Drivers' Metrics Model from Copra and Meindl (2013) as the suitable model for answering the research question in measuring supply chain performance of the knitting industry. The data gathered by performing several observations in the jobshops, interviewing the owners using the semi-structured questioners as well as employees, suppliers, and customers, and conducting three focus group discussions among the business communities. Each variable justified by conforming to the experts before implementing it in the interview processes.

Furthermore, to ensure the research quality results, in term of validity and reliability (Yin, 2014), this study excerpts selected primary documents and approved secondary documents as well as doing discussion sessionsregarding the findings with a keyperson in the industry for increasing internal validity. For the external validity, researcher has done a kind of deep explanations according to the definition of each metrics to the interviewee and other related parties, so it will make a very clear understanding for every single statement that is used in this research, and to improve the research reliability in order to avoid bias and to improve objectivity, researcher carefully reviewed all the data gathered and analyzed all decisions by multiple processes.Furthermore, as part of the benchmarking process (Azis, *et al*., 2013)the result then be compared with the baseline data for allofsix drivers' metricsand they are displayed using spider-diagram for easiness of comparison.

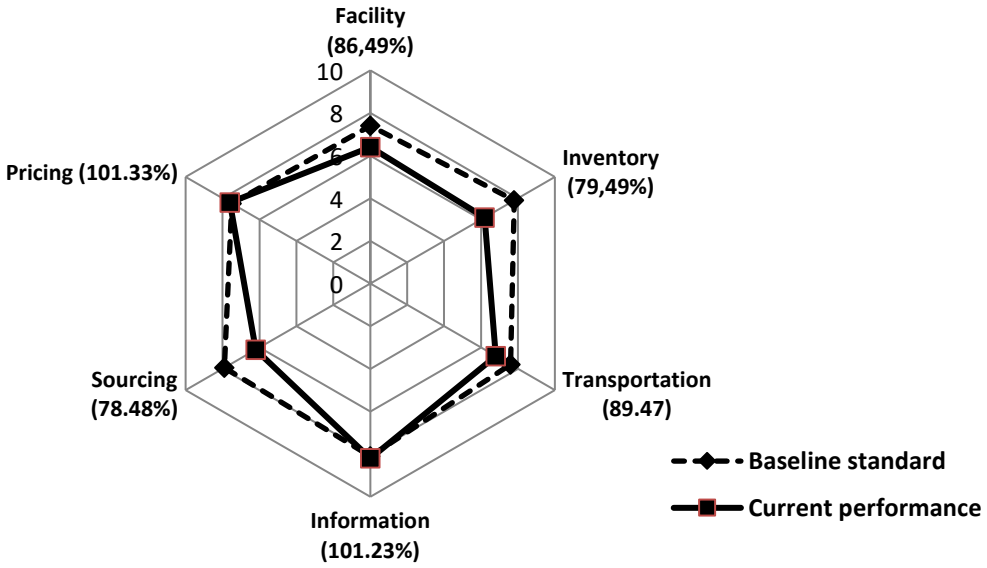
4. Results and Analysis

Based on interviews and feedback answer from owners and other parties, supply chain performance will lead to the efficiency or response time of an industry. There are several benefitscould be gained from paying attention to the six existing driver

metrics in this industry. Those benefits are: (a) more efficient production cost that will increase the competitiveness of the product from the selling price aspect. This is possible due to supply chain management increase confidence level in the availability of raw materials and other materials needed in the production process, so large inventories no longer needed. (b)Faster the goods could arrive at costumers' hand. This is of course beneficiary to the company in improving its reliability to fulfill the promise on-timedelivery to consumer demand. It will also increase consumer loyalty through repeat order as quick and easy products arrived at their hands. (c) Increase the accuracy of demand forecasting, so the number of production goods willmore or less is exactly with the number of demand. This could be happened because of the good network as the impact of the smooth flow of the communication. (d) Facilitate the arrangement of the warehousing process and the distribution of goods, due to the parties involved along the supply chain will support in the process of distributing goods to consumers. (e) Increased responsiveness to business changescondition, it is possible because the information from various parties flows well and smoothly so that feedback can be immediately given without delaying or waiting too long.

Furthermore, as the answers for the research question for knowing the determinants factors in measuring supply chain performance, there are six suitable drivers' metricsin the knitting industry of Bandung city and the performance value of each metrics compare to industrial standards showed astounding results. The six drivers' metrics are at the limit of performance baseline standard or less which actually indicates the industry is in a collapsed position. Those results could be seen in figure 2 of the industrial spider-diagram performance.

Figure 2: Knitting Industry Supply Chain Performance



In total, the performance of this industrial supply chain is in poor performance, with only 89.61% achievementin entire indicators or metrics. The poor performances come from four below-standarddriver metrics, while only two drivers haveperformancevaluesslightlybigger than 100%. Those two drivers' metrics are information and pricing. For more detailed from nine metrics in the facility's drivers or key factors, the value of four metrics is below the baseline, although the overall performance of the facility's drivers is 86.49%, i.e. 6.4 out of 7.4 as a baseline standard. Those four metrics are utilization, capacity, batch size,and production

level, while the rest are in a good performance, namely:processing time, quality losses, cycle time, time efficiency, and product variety. Moreover, from eight metrics in the inventory's drivers or key factors, only one metrics is above the baseline standard, i.e. obsolete inventory, while the rest are in a poor condition. In total the performance of this drivers are 79.49% i.e. 6.2out of 7.8 as a baseline standard. The rest metrics, i.e. average stock, safety stock, cash to cash cycle time, inventory turns over, fill rate, high-level inventory, and seasonal inventory are below the baseline standard. While, from seven metrics in the transportation's drivers or key factors, the value of three metrics is below the baseline, although the overall performance of the facility's drivers is 89.47%, i.e. 6.8out of 7.6 as a baseline standard. Those three metrics are average inbound transportation, inbound transportation cost, and mode of transportation, while the rest, namely average incoming shipment size, incoming shipment cost, average outbound transportation, and outbound transportation cost are in a good performance.

Furthermore, the fourth driver metric is one of two drivers that has performed above the baseline. With the overall performance of the information's drivers is 101.23%, i.e. 8.2out of 8.1 as a baseline standard. From seven metrics in this drivers, entire metrics, except seasonal factors are in a good performance. Those are punctuality of forecasting, updating frequency, variance, errors, demand variability, and order variability. Whereas from eight metrics in the sourcing's drivers or key factors, the value of five metrics is below the baseline, although the overall performance of the facility's drivers is 78.48%, i.e. 6.2out of 7.9 as a baseline standard. Those five metrics are payable days, the range of price, quantity purchase, lead time, and supplier reliability, while the rest metrics, i.e. purchase price, supplier quality, and on-time deliveries are in good performances.Finally, the last driver metrics is also another one of two drivers that haveperformed above the baseline. With the overall performance of the pricing's drivers is 101.33%, i.e. 7.5out of 7.6 as a baseline standard. All of metrics in this drivers are in a good performance, those are: payment days, profit margin, fixed cost per unit, variable cost per unit, selling price, order size, the range of selling price, and range of selling time.

Following paragraphs are focusing on the effort to performance improvement of each metrics that is under the baseline standard and emphasized on the lowest value metrics among the existing metrics. The discussion begins with the first driver metric of the facility, i.e. capacity, which relates to how the facility will able to meet consumer demand and to long-term flexibility. In general, the existing capacity of this industry center as a home industry business is verylimited; therefore it is necessary to recalculate the existing capacity as an elementary requirement to meet the demand (Cachon and Lariviere,1999; Hugos, 2011)The second low-value metric is batch size, which is caused by the Companys inability to meet customer’s demand with consistent quantities, making it somewhat difficult to set the right batch size standard. This can be enhanced by coordinating (Arshinder*et al*., 2008; Herwig and Monroy, 2008; Yao and Chiou, 2004;Barratt,2004;Li *et al*. 2002)between craftsmen along the supply chain, so that when there is an increase in the number of orders, it can be fulfilled by the groups not only by the business alone (Power,2005; Hoyt and Huq, 2000; Lambert, *et al*., 1999).

The second driver metric is inventory with a value of this driver metric is below 80%. The two main poor position indicators are seasonal inventory and safety stock performance. Seasonal inventory can be understood as the worst indicator on this

driver since not easy to forecast seasonally for fashion products such as knitted products. For thisreason, it is necessary to have the best process forecasting mechanism (Albarune and Habib, 2015; Barlas and Gunduz, 2011; Reiner and Fichtinger, 2009), so that it will improve the performance of this first metrics. In addition, this problem can also be solved by using the appropriate and relevant information (Huang *et al.,* 2003; Azisand Azis, 2013) relating to seasonal-dependent demand. Furthermore, another bad indicator of this driver is safety stock. This bad performance due to the inconsistent amount of inventory compliance makes fluctuation in safety stock to zero levels, causing the company's inability to fulfill orders. In addition, it was also experienced where the safety stock is stored too long, resulting out of date goods. For this situation, the company must be able to manage inventory by using various approaches of inventory management (Hill and Omar, 2006; Anand and Grover, 2015), so the performance value of this indicator will increase.

The third underbaselinestandard driver metric is transportation. The lowest performance value for this driver occurs in the average inbound transportation associated with inbound transportation cost. These two indicators are in poor performanceasmost companies use manual tools to move the partfrom one place to another in the production processes, so the moving cost becomes swollen. For thisreason, itis necessary to manage the inbound transportation (Huiskonen and Pirttila, 2002; Stank *et al.*, 1999) byutilizingsimple inbound tools or vehicle, considering the small production placesand the narrow alleysamongproduction rooms. This can be done by utilizing good inbound transportation tools that have been used in other home industries such as the t-shirt or denim pants factories, which could be functioned perfectly. The next lowest value indicator is the transportation mode. This indicator relates to the medium-capacity vehicle that is used by the most companies in this industry center. The current delivery system using that vehicle requires simultaneous shipment, and this leadstotime inefficiency when the goods sent are not directly dispatched, due to waiting for the fully loaded vehicle. The solution for improving this indicator performance is utilizing several smaller capacity vehicleowned by the group for more effective shipment and as well as decreasing the transportation cost (Anand and Grover, 2015; Haq and Kannan, 2006).

The lastpoordrivers' metric for this industry center is sourcing. There are fivepoor value indicators, and the worst of the five is lead time and payable days. For the lead time indicator,the poor performance occurs because the suppliers are unable to guarantee that raw materials be delivered on time.Moreover, this also happens because the company often asked for a delivery postponement, so raw materials that had been ready to be sent should be canceled and eventually it was sent to other buyers. For this indicator, the best solution isundertaking a good coordination and having the contract among involvingparties (Taylor and Plambeck, 2007; Sun *et al*., 2010; Cachon and Lariviere, 1999) that would give a mutual benefit in medium and long-term agreement. While the second indicator namely payable days associated with the necessity of period and in-cash payment system, which incriminatedknitting business owners, although the not in-cash payment is still possible, however, the period given by suppliers isfor one month only. Similar to the first solution, the second indicator also requires agreement among parties that can give thebest solution for both parties, hence it can be expected it will increase this indicator performance.

From the findings mentioned above, this research suggested business owners of the knitting industry in Bandung city to immediately improve each indicator for dealing with globalcompetitions. Severalpoor indicators should be considered carefully; so that the value of performance can be improved in the future. Moreover, the measurement results have illustrated the real situation of the industry, which requires all stakeholders to improve their performance. Finally, estimation ofnexttargets should be adjusted and be achieved with improvements to relevant indicators.

5. Conclusions

The research found the different result from the previous researchers (see Anand and Grover, 2015 and Hugos, 2009) by discussing six drivers' metrics, i.e. facility, inventory, transportation, information, sourcing, and pricing. Anand and Grover (2015) mentioned only four metrics, i.e. transportation, inventory, information technology, resource; while Hugos (2011) mentioned five metrics, i.e. capacity, workload, quality, maintenance, and facilities. The finding also showed that currently,theknitting industry is encountering the poor supply chain performance in those drivers'metrics. This result adding the body of knowledge in performance research area by indicating four of the six drivers' metrics measured are below the average value and target achievement, or in short, they are in poor performances, while the other two are slightly above the performance baseline standards. This position meansthe industry is on the poor stage that should be noticed by entire stakeholders. This finding has implication to the seriousness of industry stakeholders to pay attention to any poor performance metrics indicators.

The limitation of the research is the utilization oflimited data for only one semester. It will be much better if further research could use a longerperiod, so it can be compared comprehensively the achievement for the year of 2017 and before or after 2017.The other limitation is on research variables that are still as broad variables, whereas the drivers' metrics described, can still be made more specific, so the paper also recommends for the future research to undertake for deepening performance sub-drivers' metrics or indicators and research that relate to increasing the value of each indicator. In addition, this research is expected to provide benefits for the development of knitting industry through improvement in each and every poor existing drivers' metrics by performing the necessary activities as described in the finding and discussion section.

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