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Supply Chain Performance Measurement and Improvement for Indonesia Chemical Industry Using SCOR and DMAIC Method

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Abstract: Indonesia's chemical industry is faced with the challenge of increasing its supply chain competitiveness, while the chemical industry in Indonesia generally still does not have a holistic performance measurement system in its supply chain. The objective of this research is to develop the framework of supply chain performance measurement of the chemical industry using SCOR and DMAIC models. The research stages are the selection of chemical industry supply chain indicators, benchmarking of indicators, development of the framework for supply chain performance measurement for Indonesia's chemical industry, and the improvement of the supply chain performance. The implementation was carried out at the cases in the market leader company which produces textile dyes product in Indonesia. The result of expert consensus recommends 28 indicators of the industrial chemical supply chain. The best in class for each supply chain performance indicator become the performance target on the performance measurement framework which is developed. The results of measuring the performance of the chemical industry supply chain in the textile dyes product showed good performance at flexibility aspect, medium at cost, reliability, and asset management cost aspect, and low at responsiveness aspect. There were three critical to quality (CTQ) for responsiveness aspects; these are demand analysis, raw material issue, and breakdown machine. The recommended improvements are to provide training on demand analysis, to improve communication with the regional party, to provide alternative vendors, raw material scheduling, procurement of buffer stock for raw material critical, and scheduling preventive maintenance.

Keywords: DMAIC, chemical industry, performance measurement, SCOR model, supply chain.

INTRODUCTION

The manufacturing industry is believed to be a leverage of non-oil industry growth in Indonesia. The leading sectors include the chemical, pharmaceutical, and traditional medicine industries; metallic stuff industry and electrical apparatus; food and beverage industry; and machine and apparatus industry. Two industry groups projected to have relatively high growth in the year 2016 are the chemical industry with growth of 8.5 - 8.7 percent and food & beverage industry which increase up to 7.4 - 7.8 percent [1]. The growth of the chemical industry is triggered by the increasing of the chemicals material needs from the various industrial groups such as the plastics industry which was predicted to rise about 8 percent and cement around 10 to 14 percent.

The number of the company which works in the commodity of chemical material and stuff from chemical material keeps on rising started from 889 units in the year of 2008 up to 1,002 units in the year of 2014. But in the first semester in the year of 2015, the chemical sector business grew only as much as 2 percent [2]. There was a contraction compared to the previous year which reached as high as 10 percent (year on year). Although productivity in the chemical sector was weakening in the first semester of 2015, but investment interest did not decline recorded in the third quarter in the year of 2015; basic chemical, chemical and pharmaceutical industries were included in the three fields of business with the largest investment growth. The trend of investment development and the chemical industry performance contrasted to each other since this business was hampered by the reliance on imported raw materials. To anticipate the level of competition in the field of the chemical industry then the company is now not enough to only improve the performance of the company but need to pay attention to the performance of supply chain [3,4].

There are three companies classified as the market leader for textile dyes in Indonesia with a total market share of 87 percent [2]. Generally, the market leader company of textile dye in Indonesia did not have a holistic performance measurement system in its supply chain. Performance measurement conducted so far is still based on departmental performance so it is considered less effective and less efficient. The supply chain measuring system adopted by the company does not currently represent the company's global supply chain performance because it focuses only on internal activities but does not pay attention to the performance of activities related to the company's logistics and supply chain.

The development of supply chain performance measurement system needs to take into account the specific characters of the supply chain that will be measured [5-9]. One approach to performance measurement in the supply chain is the SCOR (Supply Chain Operation Reference) method. SCOR is one of the reference models of supply chain operations capable of mapping the supply chain parts [10]. The supply chain performance aspect which is measured with SCOR method is grouped into five categories. They are reliability, responsiveness, flexibility, cost, and asset [11]. According to Mathieu & Pal [12], SCOR is very good to assess supply chain performance for mass production, not for project work. According to [13], SCOR method is not only able to assess supply chain performance but also can be a tool in determining supply chain risk management.

To make an improvement on performances that is still not optimal in the supply chain, DMAIC (Define, Measure, Analyze, Improve, and Control) might be applied. DMAIC is one of the six sigma methodologies [14]. Six sigma in the organization means the measuring quality to achieve perfection. Six sigma in the organization means the measurement of quality of achieving perfection. DMAIC in a six sigma quality improvement program is a systematic cycle. Starwood mentioned that Lean and Six Sigma combination can produce improvements effectively, but still have weaknesses in the selection of relatively subjective dimensions [4]. Mazolla *et al.* added that SCOR model on problem definition can be improved by the Lean Six Sigma method because the SCOR model is a structured methodology to determine the targeted improvement of the supply chain system [15]. Chakrabarty said that six sigma applications are not only for quality management but also in the development of business strategy [16]. Mishra & Sharma in their research introduced hybrid framework SIPOC+DMAIC to improve supply chain management [17].

The objective of this research is to develop a framework of performance measuring in Indonesia’s chemical industry supply chain. It adopted SCOR approach and provide recommendations will drive improvement of supply chain performance in the Indonesia’s chemical industry.

LITERATURE REVIEW

Supply chain performance measurement

Performance measurement in the context of a supply chain now becomes extremely important. According to Chan and Qi, performance measurement describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives [18]. It reflects the need for improvement in areas with unsatisfactory performance. Thus efficiency and quality can be improved. Now, organizations start looking at ways to improve their operational performance through a better integration of operations across subsequent echelons and separated functions in the value chain. The ability to measure the performance of operations can be seen as a necessity for improvement, and companies have endeavored to enhance their capabilities of their performance measurement systems over the last years.

Performance measurement system is needed as an approach in order to optimize supply chain and improvement of supply chain competitiveness. Performance measurement aims to support goal design, performance evaluation, and determines future steps at strategic, tactical, and operational levels [19]. There are a number of approaches to supply chain performance measurement (SCPM). Most companies are still in the informal or functional stage where they focus on the performance of their own enterprise and measure their supply chain performance with financially oriented metrics. Instead of immediately aiming for extended enterprise measurement of performance which includes a company’s suppliers and customers, it is a pragmatic approach to first start with measurement of the own enterprise performance in the supply chain. Of all the approaches available, SCOR is the most comprehensive, well-recognized in industry and has been used by many companies to improve their supply chain performance. SCOR is a way that companies can use to communicate a framework that explains the supply chain in detail, defining and categorizing processes that construct the metrics or measurement indicators needed in measuring supply chain performance. Thus obtained an integrated measurement between suppliers, internal companies, and consumers [20]. According to Kocaoğlu *et al.*, the development of a supply chain performance measurement system needs to take into consideration the specific characteristics of the supply chain to be measured [8].

A list of minimum requirements for any SCPM system is described below Gintic Institute of Manufacturing Technology and can easily be compared with SCOR model [21]:

- Metrics that are process based activities: Functional department based metrics can result in each department optimizing its own performance, which seldom results in an optimal enterprise-wide performance. SCOR metrics are based on five distinct processes: Plan, Source, Make, Deliver and Return.

- Metrics defined at executive and operational level: Metrics should ideally be defined both for the company's senior management (or executive level) and for the middle management (or operational level). SCOR is hierarchical with 3 levels. Each level has its own metrics with are linked through cascading.
- Metrics can be aligned to overall business objectives: The supply chain performance as measured by the metrics should be able to be linked to overall business objectives such as profit, return on assets (ROA), market share *etc*. Level 1 SCOR metrics can easily be linked to business objectives such as cost, reliability.
- Metrics cover the performance of all supply chain processes in a company: The minimum covered should therefore be metrics covering the supplier side of a company (related to inbound logistics), the internal operations within the company like purchasing, production, warehousing *etc.* And the customer side of a company (related to outbound logistics). The five process of SCOR cover all major functional areas in a company's supply chain like inbound logistics, sourcing/purchasing, production, order management, outbound logistics/transportation, warehousing etc.
- Metrics can be used cross-enterprise: As more companies implement SCM-initiatives that aim to take some level of control or collaborate with upstream and/or downstream supply chain activities, the need for external measures for processes outside a company's control arises. Most of the SCOR metrics can be used to measure the performance of suppliers and customers, some are more internal focused.

SCOR method

The SCOR model was developed by the supply chain council [22] with the assistance of 70 of the world's leading manufacturing companies. It has been described as the "most promising model for supply chain strategic decision making [23]. The model integrates business concepts of process re-engineering, benchmarking, and measurement into its framework. This framework focuses on five areas of the supply chain: plan, source, make, deliver, and return. These areas repeat again and again along the supply chain. The supply chain council says this process spans from "the supplier's supplier to the customer's customer [24].

The process in SCOR consists of 4 levels. *Level 1* is a top level consisting of 5 key processes namely PLAN, SOURCE, MAKE, DELIVER and RETURN. Level 1 metrics characterize performance based on two perspectives. The first perspective is from the customer side and the second perspective is based on an internal perspective. At this level, a definition of basic competition is to be achieved along with guidance and how to meet the basic competition. The explanation of the five processes at level 1 is as follows:

Plan

It is a process that balances demand and supply to determine the best course of action to meet the needs of procurement, production and delivery. Plan includes the process of estimating the needs of distribution, inventory planning and control, production planning, material planning, capacity planning, and adjusting supply chain plan with financial plan.

Source

That is the procurement process of goods and services to meet the demand. The processes covered include shipping scheduling from suppliers, receiving, checking and authorizing payments for goods shipped by suppliers, selecting suppliers, evaluating supplier performance, and so forth. So the process can be different depending on whether the items purchased include stocked, make-to-order, or engineer-to-order products.

Make

That is the process to transform raw materials/components into products that customers want. Make or production activities can be done on a forecast basis to meet make-to-stock, make-to-order, or engineer-to-order targets. The processes involved here are production scheduling, production activities and quality testing, managing intermediate goods, maintaining production facilities, and so forth.

Deliver

Is a process to meet the demand for goods or services.Usually includes order management, transportation, and distribution. The processes involved include handling orders from customers, choosing shipping companies, handling warehousing of finished products, and sending bills to customers.

Return

That is the process of returning or receiving a product return for various reasons. The activities involved include the identification of product conditions, requests for disability refund authorization, rescheduling scheduling, and returns. Post-delivery-customer support is also part of the return process.

The SCOR process can go into many levels of process detail to help a company analyze its supply chain. It gives companies an idea of how advanced its supply chain is. The process helps companies understand how the 5 steps repeat over and over again between suppliers, the company, and customers. Each step is a link in the supply chain that is critical in getting a product successfully along each level. The SCOR model has proven to benefit companies that use it to identify supply chain problems. The model enables full leverage of capital investment, creation of a supply chain road map, alignment of business functions, and an average of two to six times return on investment [25].

Level 2 is a configuration level and closely related to process categorization. At level 2 it is defining the categories of each process at level 1. At this level, the process is structured in line with the supply chain strategy. The goal to be achieved at level 2 is to simplify the supply chain and improve the flexibility of the whole supply chain. At level 2, the market constraints, product constraints and constraints companies to arrange inter and intra-company process.

Level 3 is the level of the process element and is the lowest level in the scope of the SCOR model. At the implementation level, i.e. the level below level 3, the process elements are broken down into tasks and advanced activities. This level of implementation does not cover within the scope of the SCOR model. Level 3 allows companies to define in detail the identified processes as well as performance measures as well as best practice on each activity. Performance levels and practices are defined for the processes of these elements. At this level, benchmarking and required attributes are also required for enabling software. At level 3 also included input output and basic logic flow of process elements.

Level 4, implementation of the supply chain takes the role. At this level are described in detail the tasks within each activity required at level 3 to implement and manage a daily-based supply chain. There are three types of processes in the SCOR model, namely planning, execution and enable. The planning process plans the entire supply chain in line with the specific type planning of the execution process. The execution process includes all process categories consisting of source, make, deliver and return except the enable process category. Enable process of a particular process element.

By using the four SCOR-level models, a business can quickly and precisely describe its supply chain. A supply chain defined using this approach can also be modified and rearranged rapidly in accordance with changes in business and market demand. SCOR model has a strong role in the implementation of the supply chain. SCOR models level 1 and 2 keep management to stay focused. While level 3 supports the diagnosis.

Although SCOR models provide a variety of performance measures to evaluate supply chains, SCOR does not indicate whether they are suitable for all industry types. Therefore customization or customization chains to SCOR models are sometimes required. The selection of suitable performance measures here is done for each process element including for the performance of the process. The calculation of a metric may depend not only on the item data process but also the detailed calculations at the lower level.

The latest version of SCOR model includes 9 performances on level 1 metrics. Each metric of the SCOR model is appropriately associated with one of the performance attributes:

- Supply Chain Reliability is related to reliability.
- Supply Chain Responsiveness is related to the speed of response time of each change.
- Supply Chain Flexibility deals with flexibility in the face of any change.
- Supply Chain Cost deals with costs within the supply chain.
- Efficiency in asset management is related to the value of a good.

Six sigma's DMAIC method

Six Sigma is a comprehensive and flexible system for achieving, maintaining, and maximizing business success. Its use is increasingly widespread in many industries, including both service and manufacturing companies, with many proponents of the approach claiming that it has developed beyond a quality control approach into a broader process improvement concept. While the basic concept has its origins in industry, its popularity has led to an increasing level of interest from the academic community, with a substantial rise in the number of academic papers published in recent years [26,27]. The DMAIC (Define-Measure-Analyze-Improve-Control) method in Six Sigma is often described as an approach for problem solving. The DMAIC model refers to five interconnected stages that systematically help organizations to solve problems and improve their processes.

DMAIC resembles the Deming's continuous learning and process improvement model PDCA (plan, do, check, act). Within the Six Sigma's approach, the DMAIC model indicates, step by step, how problems should be addressed, grouping quality tools, while establishing a standardized routine to solve problems [28]. Thus, DMAIC assures the correct and effective process execution by providing a structured method for solving business problems [29]. This rigorous and disciplined structure, according to Harry *et al.* [30], is what many authors recognize as the main characteristic which makes this approach very effective. Pyzdek considers DMAIC as a learning model that although focused on "doing" (i.e. executing improvement activities), also emphasizes the collection and analysis of data, previously to the execution of any improvement initiative [31]. This provides the DMAIC's users with a platform to take decisions and courses of action based on real and scientific facts rather than on experience and knowledge, as it is the case in many organizations, especially small and medium side enterprises (SMEs) [32].

Dale *et al.* briefly defines the DMAIC phases as Define, Measure, Analyze, Improve, and Control [33]. *Define* stage within the DMAIC process involves defining the team's role; project scope and boundary; customer requirements and expectations; and the goals of selected projects. *Measure* stage includes selecting the measurement factors to be improved and providing a structure to evaluate current performance as well as assessing, comparing and monitoring subsequent improvements and their capability. *Analyze* stage magnitudes in determining the root cause of problems (defects), understanding why defects have taken place as well as comparing and prioritizing opportunities for advance betterment. *Improve* step focuses on the use of experimentation and statistical techniques to generate possible improvements to reduce the amount of quality problems and/or defects. The last stage, *Control* within the DMAIC process ensures that the improvements are sustained and that ongoing performance is monitored. Process improvements are also documented and institutionalized.

De Koning and De Mast conclude that these various accounts have enough commonalities to consider them variations of a single method, thus claiming convergent validity for the method [34]. From a large number of sources, the functions of the DMAIC stages and their steps and prescribed actions are reconstructed as in Table 1. De Koning and De Mast also link techniques and tools to these DMAIC stages. From their analysis of the contents of the method, they arrive at the following characterization of Six Sigma's method:

- The method prescribes that problems are parameterized and quantified.
- Improvement actions are derived from discovered relationships among variables.
- In particular, Six Sigma's method and techniques are largely driven by causal modeling, in which a process's Criticalto-Quality (CTQ) characteristics are regarded as the effects of causal influence factors (the Xs).
- Techniques such as design and analysis of experiments, process capability study, and gage R&R study1 are iconic for Six Sigma.

Table-1: Rational reconstruction of the DMAIC procedure, after De Koning and De Mast [34]

Define: problem selection and benefit analysis
D1. Identify and map relevant processes
D2. Identify stakeholders
D3. Determine and prioritize customer needs and requirements
D4. Make a business case for the project
Measure: translation of the problem into a measurable form, and measurement of the current situation; refined definition of objectives
M1. Select one or more CTQs
M2. Determine operational definitions for CTQs and requirements
M3. Validate measurement systems of the CTQs M4. Assess the current process capability M5. Define objectives
Analyze: identification of influence factors and causes that determine the CTQs' behavior
A1. Identify potential influence factors
A2. Select the vital few influence factors
Improve: design and implementation of adjustments to the process to improve the performance of the CTQs
I1. Quantify relationships between Xs and CTQs
I2. Design actions to modify the process or settings of influence factors in such a way that the CTQs are optimized
I3. Conduct pilot test of improvement actions
Control: empirical verification of the project's results and adjustment of the process management and control system in order that improvements are sustainable
C1. Determine the new process capability
C2. Implement control plans

METHODS

The design of this study combines qualitative and quantitative approaches. The data used in this research were primary and secondary data. Primary data was obtained through an interview with the experts which directly related to the supply chain activity. While the secondary data were obtained from the DSM, Finance, Quality, and Warehouse department in the case at one of the textile dyes company. The operational approach on the SCOR method refers to Supply Chain Council [20].

The research stages are combining literature study approach, expert interview for validation and consensus for Indonesia's chemical industry supply chain performance indicators, development of chemical industry supply chain performance management framework with SCOR approach, analysis of supply chain performance of chemical industry case on textile dye products, identification performance aspects that require improvement based on analysis gap using DMAIC, and recommendation of performance *improvement* on the textile dyes product of the company's supply chain. The assessment of supply chain performance by utilizing SCOR was broken down into 3 levels where each level was treated as follows:

Level1. Top level defines coverage for the five processes on the core management of SCOR model including plan, source, make, deliver, and return in the company's supply chain and how their performance can be measured.

Level 2. Configuration level defines the form of planning and execution processes in the material flow, by using standard categories such as stock, make-to-order, and engineer-to-order. The company's supply chain could be configured at this level out of the 30 categories of core process.

Level 3. Level element process defines the business process which was used for the transactions of order sales, order purchase, processing order, refund right, inventory replacement and forecasting. This level contains the definition of a process element, input, output, the metric of each single process element and references (benchmark and best practice).

After gaining the score for each metric, then benchmark was carried out to see the achievement of the supply chain performance at case PT HI. The betterment activities were conducted on the metric which possessed score much below the target. Those activities were carried out by utilizing DMAIC Six Sigma for metric/aspect which requires further improvement.

RESULTS AND DISCUSSION

The Selection of SCOR Indicator

The preliminary research was selecting performance indicator for the chemical supply chain performance measurement framework. Indicator selection for the work performance of chemical industry chain supply was conducted through a process of modification *brainstorming* that involved seven experts which represented practitioners and academia until a consensus with 70% cut-off. After going through three cycles, there were 28 indicators which obtained the consensus as presented in Table 2.

Tabel -2: The validation result on performance indicator of chemical industry supply chain using SCOR model

Level	Notation	Rounde 1	Rounde 2	Rounde 3	Consensus
1	Reliability	100%	100%	100%	Yes
2	A1	100%	100%	100%	Yes
3	A11	86%	86%	86%	Yes
4	A111	29%	29%	29%	No
4	A112	43%	43%	43%	No
4	A113	57%	57%	100%	Yes
3	A12	71%	71%	71%	Yes
4	A121	43%	43%	43%	No
4	A122	57%	86%	86%	Yes
3	A13	71%	71%	71%	Yes
4	A131	100%	100%	100%	Yes
4	A132	57%	86%	86%	Yes
4	A133	100%	100%	100%	Yes
4	A134	100%	100%	100%	Yes
3	A14	57%	57%	86%	Yes
4	A141	43%	43%	43%	No
4	A142	57%	57%	57%	No
4	A143	57%	57%	57%	No
1	Responsiveness	100%	100%	100%	Yes
2	B1	100%	100%	100%	Yes
3	B11	100%	100%	100%	Yes
4	B111	57%	100%	100%	Yes
2	B12	57%	57%	57%	No
3	B121	100%	100%	100%	Yes
1	Flexibility	100%	100%	100%	Yes
2	C1	57%	57%	57%	No
3	C11	29%	29%	29%	No
4	C111	100%	86%	86%	Yes
4	C112	43%	43%	43%	No
4	C113	57%	57%	100%	Yes
3	C12	57%	57%	57%	No
4	C121	57%	100%	100%	Yes

Tabel-2: Continue

Level	Notation	Rounde 1	Rounde 2	Rounde 3	Consensus
3	C13	57%	57%	57%	No
4	C131	100%	100%	100%	Yes
3	C14	71%	71%	71%	Yes
4	C141	57%	57%	57%	No
1	Cost	100%	100%	100%	Yes
2	D1	100%	100%	100%	Yes
3	D11	100%	100%	100%	Yes
3	D12	57%	57%	100%	Yes
3	D13	100%	100%	100%	Yes
3	D14	100%	100%	100%	Yes
3	D15	71%	71%	71%	Yes
1	Asset Management	100%	100%	100%	Yes
2	E1	57%	57%	57%	No
3	E11	86%	86%	86%	Yes
4	E111	57%	57%	57%	No
4	E112	43%	43%	43%	No
3	E12	57%	57%	57%	No
4	E121	57%	100%	100%	Yes

The assessment towards the SCOR measurement metric refers to Bolstorff & Rosenbaum, Simchi-Levi *et al*., and Sillanpaa & Kess [9, 35,36]. They categorized SCOR measurement metric for the overall manufacturing industry into five groups, as follows major opportunity, disadvantage, medium, advantage, and best in class. Supply chain performance measurement in the chemical industry is presented in Table 3.

Based on the categorization of metrics, a gap is calculated for each measurement metric, the results are presented in Table 4. There was only a few previous research that carried out benchmark from the results of SCOR in the entire manufacturing field or benchmark with similar industries [5, 35, 37, 38]. In this study, a general benchmark was performed in the entire manufacturing industry. The company decided that the SCOR score for each aspect stood at *advantage* level, which stood at the range of 60-80%. Generally the scores for all aspects are between the *advantage* range, with the score of around 63-93%.

Table-3: Validation of industrial supply chain performance indicators using SCOR model

Aspect	SCOR
Reliability	0.72
Responsiveness	0.63
Flexibility	0.93
Cost	0.74
Asset management cost	0.73

Table-4: The framework of performance measurement on the chemical industry supply chain model SCOR

Aspect	Indicator	Achievement (%)	Best in class gap (%)	Advantage gap (%)	Medium gap (%)
Reliability	% of order delivery in full	84%	-16%	4%	24%
	Inventory accuracy	91%	-9%	11%	31%
	% stock out	91%	-9%	11%	31%
	Deliver cycle time	97%	-3%	17%	37%
	Perfect condition	93%	-7%	13%	33%
	% order received defect free	98%	-2%	18%	38%
	% faultless invoices	97%	-3%	17%	37%
	Incoming material quality	23%	-77%	-57%	-37%
	Documentation accuracy	100%	0%	20%	40%
Responsiveness	Order fulfillment cycle time	24%	-76%	-56%	-36%
	Source cycle time	56%	-44%	-24%	-4%
	Receive product cycle time	100%	0%	20%	40%
	Fill rate by line item	67%	-33%	-13%	7%
Flexibility	Current on hand inventory	91%	-9%	11%	31%
	Forecast accuracy	62%	-38%	-18%	2%
	Delivery volume	97%	-3%	17%	37%
	Deliver return volume	98%	-2%	18%	38%
	Supply chain Source return flexibility and adaptability	100%	0%	20%	40%
Asset Management	Days Payable Outstanding	57%	-43%	-23%	-3%
	Dead Stock	84%	-16%	4%	24%

0%-20% Major opportunity; 20%-40% Disadvantage; 40%-60% Medium; 60%-80% Advantage; 80%-100% Best in class

The Improvement Supply Chain Performance with DMAIC

The preliminary stage of the DMAIC method is the defining stage or problem identification. The combination with the AHP method has been largely undertaken by previous research in terms of determining which aspects are important for the improvement [39].

The process for determining of the performance improvement can be done with traffic light indicator method [40-42]. Indicator that have red color or indicator that have the largest gap which has been determined in the gap analysis, is used as the basis for further improvement using the DMAIC method. The *responsiveness* aspect becomes a priority to conduct the improvement with the achievement gap that reached 37%. The indicator that had the biggest gap from the *target* (*advantage* gap) was the indicator of order fulfillment cycle time with the biggest target determined, that was 56%.

The problem of *order fulfillment cycle time* indicator identified that the supply chain was not responsive enough in fulfilling the order. Out of the whole order in 2015, 70% out of the order consisted of the range of 81-120 days, 20% within 41-81 days and the rest was 10% in the range of 0-40 days. *The improvement* was needed towards meeting the customers' order so the company supply was *responsive* in meeting the customers' needs. Furthermore, CTQ (*Critical to Quality*) was determined as a fulfilling order process based on *brainstorming* result with the practitioners and the experts. Han *et al*. stated that CTO is an indicator which has a very tight connection that could influence productivity performance of an element [23]. The result from brainstorming showed three CTQs including *demand analysis*, *machine breakdown*, and *raw material issue.*

The measurement on CTQ was conducted to find out how many failures caused by those CTQs. In 2015 there were 5441 orders accepted by the company with the total order production as many 693 orders. The counting of failure number in each CTQ can be seen from the data of *closing confirmation process order* which existed at production department and inventory data as well the company's backorder. The *demand analysis* has become the main factor of the causes that lack its response to company's supply chain to fulfill the customers' order.

Based on the *measuring* stage, the dominant cause was the reliability of *demand analysis*, RM *issue*, and engine *breakdown*. Then it was evaluated to determine the cause of each defect with a diagram of cause and effect. The cause and effect diagram was a structured approach that allowed more detailed analysis to find the causes of a problem, discrepancy, and gaps. The result of the cause and effect diagram become an input for FMEA calculation. Failure Mode and Effect Analysis (FMEA) generated a Risk Priority Number (RPN) value that indicated the fix priority scale.

The ***control*** stage was the final step in the DMAIC approach. Basically, this stage was a control action to the stages that had been previously done so that documentation and control become an important thing to maintain consistency of improvements made for quality improvement.

CONCLUSION

The research succeeded in establishing the *framework* for measuring the performance of supply chain in chemical industry which referred to the *benchmark* of manufacturing industry. The measurement result of the chemical industry supply chain performance in the textile dye case resulted in the highest achievement consecutively in the flexibility aspect which was 93 percent, the cost reached 74 percent, the reliability achieved 72 percent, the asset management cost was 71 percent, and the responsiveness got 63 percent. The priority aspect for improvement was *responsiveness* with a gap of 37 percent.

Through the DMAIC procedure for *responsiveness* aspects, three CTQs were created. They where *demand analysis*, *raw material issue*, *and breakdown machine*. The recommended improvements were *training demand analysis*, training on the use of SAP, communications with regional parties, the alternative of vendor provision, improving *raw material* arrival, the availability of *buffer stock* for *raw material* crystals and scheduling *preventive maintenance*.

In the study using SCOR, the traceability to see who was responsible for not achieving KPI was quite complicated. This is because SCOR was a measure of performance at the organizational level. SCOR was set up to eliminate local performance appraisals to ensure that the responsibility of the organization's KPIs was a shared responsibility. Therefore, it takes a mutual agreement from every expert in their field to build an indicator framework which has to be achieved and targeted.

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