Application of Six Sigma in Supply Chain Management: Evaluation and Measurement Approach

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Firms have to analyze, monitor and make improvements of their existing Supply Chain Management (SCM) processes in order to beat market competition and stay competitive. In this regard, the Six Sigma is a methodology that enables the firms to review their existing SCM practices and guide them in making improvements. Six Sigma focuses on reducing variation, measuring defects and improving the quality of products, processes and services. Six Sigma-based SCM effectively manages typical disruption issues in supply chain as it ensures the delivery of the most appropriate product, in right time, in right place with the least cost to the customer. This paper develops an integrative framework and the business value-added framework and financial matrix to measure and evaluate the impact of Six Sigma on SCM. As identified and emphasized in this paper, efficiency and effectiveness drivers of SCM and accompanying business values generated by Six Sigma deployment in SCM positively influence an organization's overall business performance.

Introduction

Six Sigma is a logical, systematic and process focused approach to achieving continuous process improvements. This process improvement methodology for enhancing quality levels was developed by Motorola in 1986 for its high volume manufacturing environment in order to increase its competitiveness against Japanese companies. Six Sigma is a well-structured knowledge management approach that focuses on reducing variation, measuring defects and improving the quality of products, processes and services. It is a highly disciplined process that helps organizations to calculate how well a process is performing and focus on developing and delivering near-perfect products and services.

The supply chain represents a process of delivering value to customers by creating and delivering products. Supply chains span from raw materials to manufacturing, distribution, transportation, warehousing and product sales. Supply chain is the network of entities through which material and information flow. Those entities include suppliers, manufacturers, wholesalers, retailers and customers. In today's highly competitive environment, supply chain performance is very vital for the survival of firms because customers judge the performance of firms based on their supply chain performance.

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Competition is no longer between firms, but between entire supply chains. So, supply chain has become an important dimension for firms to give maximum attention in order to excel in a competitive environment. Hence, the importance of Supply Chain Management (SCM), that is, the set of synchronized decisions and activities that effectively integrate suppliers, manufacturers, transporters, warehouses, retailers and customers. It is a good idea to use Six Sigma in supply chain projects in order to improve supply chain measurement metrics as it helps organizations to capitalize on the potential synergy between Six Sigma and SCM. This paper works in this direction and provides various frameworks for Six Sigma deployment in supply chain along with a financial matrix.

Literature Review

There are diverse applications of Six Sigma such as in manufacturing processes, automobile industry and services such as healthcare and retail. Kumar *et al.* (2007) presented a case on application of Six Sigma problem-solving methodology in manufacturing process to identify the parameters causing casting defects and to control these parameters. Krishna *et al.* (2008) presented a case study illustrating how a multinational Indian corporation was able to successfully implement Six Sigma principles to improve its manufacturing operations. Kumar *et al.* (2008) studied a case of implementation of the Six Sigma approach for improvement in service system by a major consumer electronics and appliance retailing company in the USA. Li *et al.* (2008) studied a specific case on implementation of Six Sigma approach to improve the capability of the solder paste printing process by reducing variations in thickness from a nominal value. Kaushik and Khanduja (2008) applied Six Sigma methodology to specific case of thermal power plant for conservation of energy. They implemented Six Sigma project recommendations to reduce the consumption of Demineralized (DM) makeup water from 0.90 to 0.54% of Maximum Continuous Rating (MCR) resulting in a comprehensive energy saving of ₹0.305 mn per annum. Kumar and Sosnoski (2009) highlighted the potential of Six Sigma in realizing the cost savings and improved quality by using the case study of a leading manufacturer of tooling.

Tong *et al.* (2004) designed a case on improvement on the sigma level of the screening process, which is regarded as the most critical process in Printed Circuit Boards (PCB) manufacturing. Chen *et al.* (2005) presented a case study in the context of automobile industry in Taiwan. The study used Six Sigma to measure the performance of customer requirements. Dreachslin and Lee (2007) presented a case on application of Six Sigma techniques in determining the effectiveness of diversity initiatives in healthcare management in the USA. Taner *et al.* (2007) designed five case studies in healthcare to show the performance improvement accomplished by Six Sigma presenting a roadmap for problem-solving and service/process improvement. The findings showed that the healthcare organization gained a greater ability to address challenges across the system; maximized resource utilization; reduced redundancies, waste and rework; diminished bottlenecks related to scheduling; and improved working conditions for healthcare personnel. The results showed that healthcare organizations are able to increase their market share in the long run after Six Sigma implementation.

In today's competitive business environments, firms are under intense pressure to systematically produce quality control and quality standards and generate positive bottom line results. In one Six Sigma project, Ford analysts measured inventory levels at one of their plants during production hours and found that levels varied by 20% over a month. They found that one of the major causes of inventory fluctuation was inefficient and inconsistent unloading of parts at the plant docks. Taking actions to improve dock utilization and thus driving out process variability led to annual savings of more than $3.7 mn due to inventory reduction, reduced overtime for unscheduled materials handling and other savings (Moore, 2002).

Six Sigma deployment by organizations reduces cost of poor quality. Cost of poor quality is the cost associated with poor quality of products and services and connects the improvement priorities of a firm with its strategic objectives of enhancing financial performance and greater customer satisfaction. As per statistics, cost of poor quality is 10% of sales for companies who are at "Six Sigma" level, about 15 to 20% of sales for companies who are at "four sigma" level and about 20 to 30% of sales for companies who are at "three sigma" levels (Clark, 1999). Six Sigma has been adopted by many organizations to develop and strive for excellence in quality standards and innovations. Six Sigma is a total quality system developed by Motorola to identify tools, methods and best practices for generating innovation and driving revenue growth (Creveling *et al.*, 2006).

Six Sigma thus focuses on variation and defect reduction (Naslund, 2008; and Kumar *et al.*, 2009), but is also cited in the literature as contributing to process improvement (Lee-Mortimer, 2006; and Buch and Tolentino, 2006), customer satisfaction and financial enhancement (Kumar *et al.*, 2008b). Six Sigma is flexible enough to be applied to different challenges throughout business, also in diverse areas such as SCM. The application of Six Sigma in the manufacturing and supply chain arena has led to next-generation supply chain solutions (Keene *et al.* 2006; and Yeh *et al.* 2007).

Six Sigma is gaining recognition not only in product and manufacturing environment, but also in supply chain operations. Kanji and Wong (1999) and Tan *et al.* (1999) have investigated the impacts of aligning supply chain and quality management strategies with manufacturing goals and business performance. Improving the quality of all supply chain processes leads to cost reduction, improved resource utilization and improved process efficiency (Wang *et al.*, 2004). Yeung *et al.* (2005) and Yeung (2008) studied quality-based supply chain strategies. A major difference between Six Sigma and other quality approaches is that Six Sigma aims at achieving 3.4 defective parts per million (Smith *et al.*, 2002). Six Sigma focuses on reducing the number of opportunities that could result in defects by shifting the emphasis from fixing defective products to making perfect products (Antony and Banuelas, 2001).

Six Sigma is described as a business excellence strategy (Antony *et al.*, 2007) and as being a customer-driven (Nakhai and Neves, 2009), a project-driven (Assarlind *et al.*, 2012) or a business-driven (Savolainen and Haikonen, 2007) methodology, which focuses on decision making based on statistical and non-statistical tools (Manville *et al.*, 2012), to lead towards improving the organization's product, process and service (Savolainen and Haikonen, 2007) or financial performance (Nakhai and Neves, 2009).

According to Nabhani and Shokri (2009), Six Sigma is a powerful strategy that enables companies to use simple and powerful statistical methods to drastically improve their performance. Six Sigma-based methodology is used to reduce cost of poor quality by improving already existing processes, reducing costs, eliminating defects, raising customer satisfaction and significantly increasing profitability of organizations (Tong *et al.*, 2004). Dasgupta (2003) used Six Sigma metrics as a framework for evaluating and benchmarking the performance of supply chain. Using Six Sigma methodology, quality management can be employed in SCM to improve the performance of various issues in the whole supply chain network (Wang *et al.*, 2004). According to Knowles *et al.*, (2005), Six Sigma does have something novel to offer organizations over the contribution of existing approaches to supply chain improvement. Liu (2006) offered an application of Six Sigma to reduce cycle time and defects in clinical report entry.

Kumar *et al.* (2008a) applied Six Sigma in the context of supply chain design to analyze mitigation of container security risk. Yousef *et al.* (2008) emphasized the importance of the concept of Six Sigma as an effective methodology for monitoring and controlling supply chain variables. Chang and Wang (2008) used a case study to show the benefits of Six Sigma improvement model on replenishment forecasting. Nabhani and Shokri (2009) presented a case study to highlight reduction of the delivery lead time with the implementation of the Six Sigma methodology. Chang *et al.* (2012) applied the Six Sigma to improve the performance of the production planning procedures. Wei and Yi-zhong (2013) proposed a framework using Six Sigma metrics to measure and improve supply chain performance. Six Sigma deployment in SCM is important for overall performance and growth of business as it leads to improved productivity, competitiveness, superior value creation and market performance. The paper works in this direction and provides insights of SCM process improvement in terms of efficiency and effectiveness and resultant business value created by proposing various frameworks, along with a financial matrix for measuring overall benefits of Six Sigma deployment in SCM.

Six Sigma Deployment in SCM

Firms relate to upstream partners such as suppliers and downstream partners such as customers through a supply chain—a network of suppliers, factories, warehouses, distribution centers and retailers, through which raw materials are acquired, transformed, produced and delivered to customers. The chain consists of activities associated with the flow and transformation of goods from raw materials to products delivered to the end user.

Thus, supply chain encompasses all parties involved, directly or indirectly, in fulfilling a customer request (Chopra and Meindl, 2004). As such, supply chain includes all the activities related to the processing of materials and the conversion of goods from the stage of raw materials to the stage of delivery to final customer, along with coordinated and integrated management (Harrison and van Hoek, 2008). Given the diversity of entities and activities in a typical supply chain, firms need to manage the chain effectively to reap its benefits.

SCM is defined as the coordination of resources and the optimization of activities across the value chain to obtain competitive advantages (Gunasekaran *et al.*, 2008). SCM is a concept that integrates all parties over the value chain into one whole system. It involves not only logistic activities (e.g., inventory management, transportation, warehousing and order processing), but also other business processes (e.g., customer relationship management, demand management, order fulfillment, procurement, and product development and commercialization). SCM adds value to an organization through the effective integration and alignment of various business functions in pursuit of achieving strategic objectives (Pettersson and Segerstedt, 2013). SCM adopts a systematic and integrative approach to managing the operations and relationships among the different parties in supply chains. SCM is also focused on processes within supply chain (Nabhani and Shokri, 2009).

The short-term objective of SCM is to enhance productivity and reduce inventory and lead time, whereas on the other hand, the long-term objective is to increase companies' market share and have external integration of the supply chain process (Koh *et al.*, 2007). The field of SCM has become a key strategic factor/tool for firms to improve their performance and secure their competitiveness in a market place. Knowles *et al.* (2005) underscored that Six Sigma does have something novel to offer organizations over the contribution of existing approaches to supply chain improvement. A well planned and executed Six Sigma-based SCM will enable organizations to reduce their costs and enhance customer services (Chong and Ooi, 2008). Six Sigma deployment in SCM ensures that the right product or service is distributed in the right quantities and quality to the proper locations in a timely manner to the satisfaction of the customer.

Lambert *et al.* (1998) proposed that all functions within a supply chain should be reorganized as key processes. The integration of Six Sigma and SCM follow from the fact that both have been strongly recognized as 'process approaches'. The usefulness of Six Sigma metrics in measuring performances of various kinds of processes and functions has been strongly established. Pullim (2002) believed SC performance is impaired because of different variation causes, such as demand fluctuations, supplier deliveries, quantity and quality, people and equipment inconsistencies which need to be controlled or worked upon. Wang *et al.* (2004) investigated how quality management can be employed in SCM to improve the performance of various issues in the whole supply chain network using Six Sigma methodology.

Too often, as SCM project teams move on to future projects, the past process improvement successes become just that—"past" successes—rather than a sustained base of continuous improvement on which to build process further. The link between planning and execution through feedback (i.e., closed-loop) has been an important issue in SCM in general and manufacturing planning and control system in particular (Vollmann *et al.*, 1997). Six Sigma is a methodology which would, by its nature, drive a heightened usage of quantitative analysis (Breyfogle, 1999). Quantitative data about operational activities and performance was abundant, but not used sufficiently for problem solving or decision making. Quantitative strength of Six Sigma with appropriate usage of numerical data uncovers flaws in SCM processes and further enhances the quality of SCM decisions.

Both SCM and Six Sigma are process-oriented approaches. Six Sigma uses a structured process of Defining, Measuring, Analyzing, Improving and Controlling (DMAIC) processes, which provides the discipline to deal with operational vulnerabilities and variability in business operation (Hammer, 2002). The process focus in supply chain is well established and clearly offers very significant benefits in driving down levels of waste and therefore contributing to supply chain improvement. Yang *et al.* (2007) also emphasized the role of Six Sigma and SCM techniques for process and quality improvement with the help of a Samsung case study.

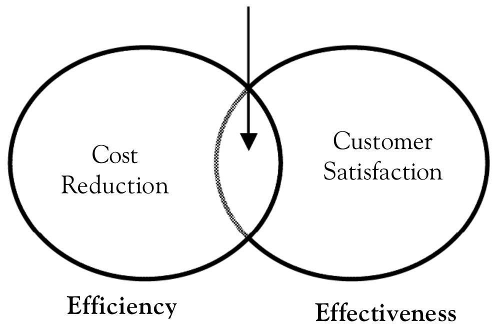
Key Benefits

There has been much interest in the Six Sigma methodology as a way of reducing variability in processes (George, 2002). Unlike many manufacturing processes, supply chain processes are often measured against time (e.g., on time deliveries, picking rates, etc.), as opposed to some physical dimension or quantity (e.g., picking accuracy, product tolerances, etc.). Supply chains must focus on time compression, in order to reduce lead times (Waters, 2003) and achieve pipeline efficiency (Burton and Boeder, 2003). Time compression can be used to improve product availability through lead-time management to ensure shorter order cycles (Christopher, 1998). It requires a synchronization of flows and activities inside the organization and throughout the supply chain (Towill, 1996). McAdam and Lafferty (2004) acknowledged the significance of Six Sigma methodology for integration of quality and business strategy, in that the competitive nature of supply chains demands quality and perfection in both production and service.

As Six Sigma techniques help to squeeze out variability in time, it enhances reliability of lead-times and reduces safety stock levels in supply chain. Besides, lead-times across multiple activities or processes can be compressed, thus improving overall operation responsiveness to customer requirements whilst improving financial performance by reducing costs through reduced levels of cycle stock. Hence, Six Sigma deployment in supply chain results in increase of both efficiency (in terms of cost reduction) and effectiveness (in terms of higher customer satisfaction) (Figure 1).

Once the definition of the defect in the SCM is identified and data of the existing process are acquired, a preliminary analysis of possible benefits, such as improvements in

Figure 1: Six Sigma Deployment in SCM: Higher Efficiency and Effectiveness: A Major Source of Competitive Advantage



the level of service and cost reduction, etc., can be developed. Throughout the improve and control stages of the Six Sigma deployment, the results are compared with industry benchmarks. This identifies the company's advantages and opportunities to improve its supply chain performance. Six-Sigma deployment can be considered as the driving force for financial benefits (cost reduction with higher efficiency of process) and service improvement (customer satisfaction with higher effectiveness of process) in SCM (Table 1).

Table 1 Six Sigma Deployment in SCM: Key Benefits

S. No.	Six Sigma Deployment in SCM	
	Financial Benefits (Efficiency Advantages)	**Service Level Improvements (Effectiveness Advantages)**
1.	Reduced total inventory level (finished goods, raw material)	On time delivery
2.	Low carrying cost of inventory	Order completeness
3.	Reduced inventory obsolescence	Order correctness
4.	Reduced third-party storage	Damage-free and defect-free delivery
5.	Administrative saving: (order management, purchasing, production labor and process cycle time)	High customer service level: (order fill rate, order cycle time, etc.)
6.	Reduced cost of poor quality	Low stock out level
7.	Higher efficiency of SCM	Higher effectiveness of SCM

Following are the major operational issues that cause disruption in a typical supply chain:

- Late delivery of materials from suppliers.
- Large waiting time for semi-finished products in process.

- Insufficient stock levels in warehouse.
- Failure in prediction of demands.
- Improper delivery to the customer.
- Delayed transmission of orders to logistic companies.

As shown in Table 1, deployment of Six Sigma in SCM resolves operational issues and leads to service level improvement.

Methodology

A two-stage methodological approach is adopted in this paper for evaluating and measuring benefits of Six Sigma deployment in SCM. In the first stage, the paper focuses on development of various frameworks for analyzing the benefits of Six Sigma deployment in SCM. An integrative framework identifies key drivers of performance improvement in SCM, while business value-added framework identifies key processes of SCM value chain and emphasizes resultant business value added. The second stage involves the design of a financial matrix for analyzing, measuring and evaluating the overall benefits envisaged on Six Sigma deployment in SCM.

Development of Various Frameworks

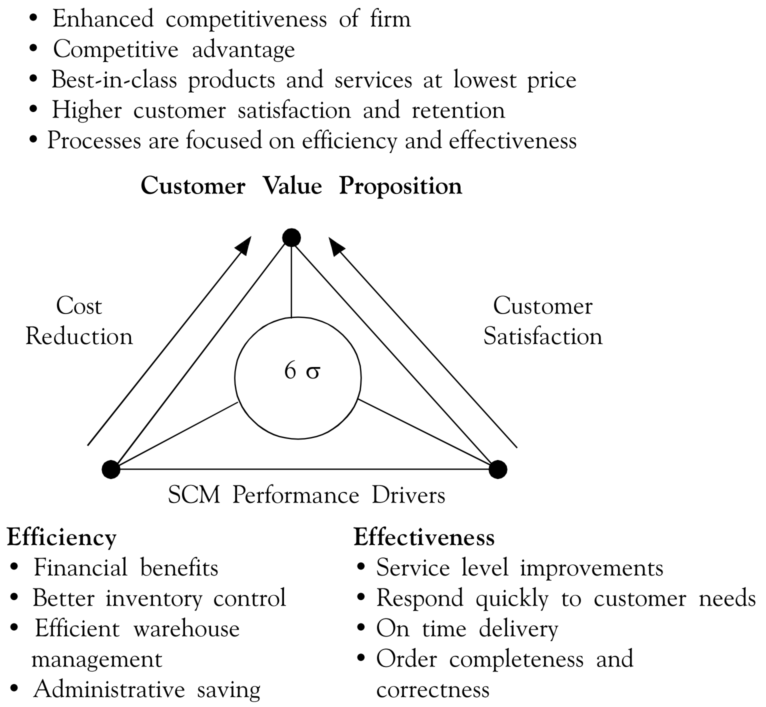
An Integrative Framework

The deployment of Six Sigma in SCM has twin objectives; the objective of the customer satisfaction (to mobilize overall supply chain partners, effort to improve levels of service and enhance responsiveness) and objective of cost reduction (to link supply chain processes effectively to reduce variability and enhance revenue and generate a profit). As shown in Figure 2, an integrative framework combines two kinds of performance measures such as efficiency (focus on financial performance measures and underlying financial benefits) and effectiveness (focus on operational performance measures and underlying operational improvements) in evaluation. In general, increase in sales that results from higher customer satisfaction and cost reduction that results from the decreases in material, inventory and transportation expenses are examples of financial performance measures. Operational performance measures include improvement in cycle time, lead time, utilization rate and forecast accuracy, etc. Six Sigma deployment in SCM has a positive impact on the entire supply chain network and enhances customer value proposition (Figure 2).

Business Value Added Framework

Value chain analysis describes the activities within and around an organization and links them to the organizations' competitive position. Therefore, it evaluates which value each particular activity adds to the organizations' products or services. According to Brown (1997), the value chain is a tool to segregate a business into strategically relevant activities. This classification enables identification of the source of competitive advantage

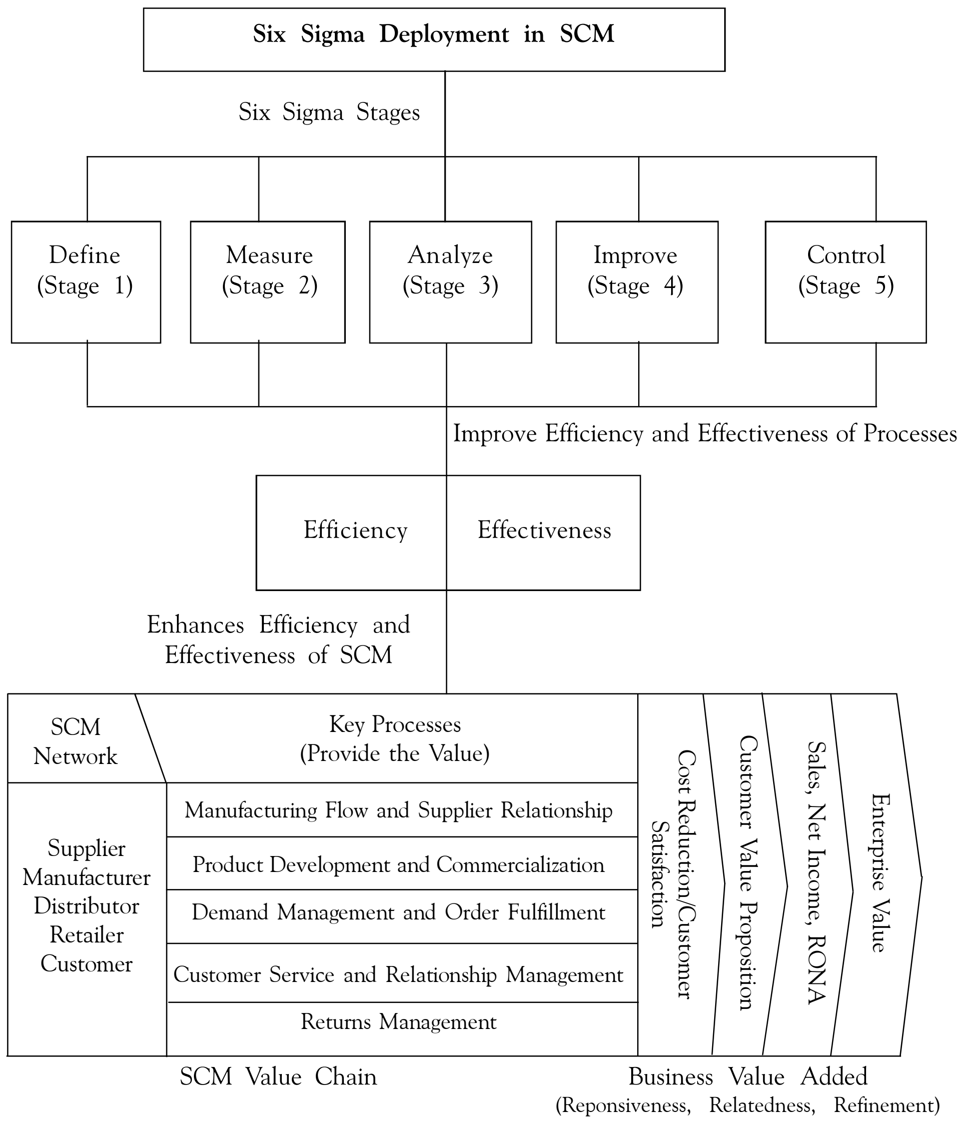
Figure 2: Six Sigma Deployment in SCM: An Integrative Framework



by performing these activities more cheaply or better than its competitors. Intensive competition in the market place has enforced organizations to focus on process performance for enhancing the customer value. In the pursuit of improved operational performance and higher customer satisfaction, Six Sigma has been recognized as a systematic and structured methodology that attempts to improve process capability through focusing on customer needs (Dasgupta, 2003). The Six Sigma can be used to develop a model for assessing, improving and controlling quality in the supply chain network.

Porter (1980) described customer value as the advantage that a firm creates for its customers by either lowering its customers' costs or by raising its customers' performance in real and perceived terms. Slywotzky and Morrison (1997) used a 'customer-centric' approach to propose a modern value chain in which the customer is the first link to all that follows. The role of added value has long been accepted as a means of securing competitive advantage (Normann and RamõÂrez, 1994; and Naumann, 1995) and long-term success of the firm (de Chernatony and McDonald, 1998). To demonstrate the ways in which Six Sigma deployment can generate overall business values in SCM, Porter's (1985) value chain framework is used as a basis to present a business value-added framework, as shown in Figure 3.

Figure 3: Six Sigma Enabled Business Value-Added Framework for SCM



Six Sigma DMAIC methodologies improve SCM performance by simplifying processes, increasing flexibility, inventory reduction, smooth material flow, reducing time between order and fulfillment and reducing sources of waste and delay. Six Sigma focuses on building quality into supply chain by identifying what customers want/need, translating these into critical-to-quality characteristics and deploying these through specific process improvement stages. Six Sigma deployment in SCM has a positive impact on the entire supply chain network and creates values for an organization in terms of responsiveness, relatedness and refinement. Responding quickly is essential in the current era of intensive competitiveness. With Six Sigma deployment in SCM, organization is able to respond more quickly to the market demand. It also helps to deliver the most relevant information to related parties in supply chain network. Finally, it refines the operational process in the areas of logistics, inventory management, demand management and Customer Relationship Management (CRM).

The business values that are generated by using Six Sigma in supply chain can help firms advance the operations in logistics and inventory management. Such Six Sigma deployment can enable large savings in time and labor costs in inventory management, and enable a rapid response when unexpected problems occur. In addition, it can help improve the use of space in warehouses, distribution centers and retail stores. Six Sigma reduces variation within and across the value-adding steps in a supply chain. Six Sigma deployment in SCM refines the operational process in the areas of logistics, inventory management and CRM. Improved performance in these major activities will, in turn, enhance the overall efficiency of a firm, generate more sales volume and increase profits eventually. All these will contribute to the competitiveness of individual firms in supply chain and subsequently may change the business ecology of the entire supply chain partners.

The major emphasis of the business value-added framework is the creation of superior customer value. Six Sigma DMAIC methodology identifies key requirements, deliverables, task and standard tools for SCM when tackling problem. Six Sigma methodology can effectively be employed in SCM to measure, monitor and improve the performance of the whole supply chain network. With Six Sigma deployment in SCM, organizations reduce cost and enhance customer satisfaction. Such organizations create value for the customers by enhancing customer value propositions. Organizations also create value for themselves by reducing cost. As such, cost reduction and higher customer satisfaction result in higher sales, profitability and Return on Net Asset (RONA) for organizations and ultimately higher enterprise value.

Development of a Financial Matrix

Performance evaluation is one of the key issues in any management philosophy. One of the pertinent issues in the context of Six Sigma deployment in SCM is to derive the right metrics to evaluate the performance of the entire supply chain, individual members or subsets of members. The traditional performance measures based on financial numbers such as sales, profit and ROI do not match entirely with the competencies and skills firms require to face today's challenging business environment. The operational measures such as low stock out level, responsiveness and customer service level are the drivers of future financial performance and financial success is the logical consequence of doing the fundamentals well. It is thus necessary for any organization to consider performance measurement of the entire supply chain and all of its entities as a strategic issue. In this context, performance of supply chain network is measured in terms of efficiency and effectiveness drivers of SCM.

Six Sigma can be a powerful toolbox for supply chain process in terms of continuous improvement and hence business performance. However, there has been little theoretical analysis and conceptual development of underlying Six Sigma deployment in supply chain. It is mainly because of the practitioner-oriented nature of Six Sigma. Hence, this paper develops a financial matrix for measuring performance improvement caused by Six Sigma deployment in SCM (Table 2). Importance of financial metrics is highly recognized as it served as a tool for comparing organizations and evaluating an organization's behavior over time (Holmberg, 2000).

By deploying Six Sigma in SCM, firms can enhance business competitiveness and overall customer value proposition. Deployment of Six Sigma by firms will produce profitability estimates that are more consistent with actual results and will in turn benefit from more consistent and predictable financial returns. These result in decreased information asymmetry between supply chain partners and other stakeholders, and with a decrease in information risk premium, the market risk of the firm will also decrease. Hence, it also decreases the seasonality, cyclicality, and volatility of operating cycle and hence ultimately reduces the working capital requirement and investment in assets.

As Six Sigma deployment in SCM increases customer satisfaction, it results in long-term customer relationship and higher customer retention rate. Superior customer satisfaction coupled with improved operational and financial performance levels should lead to better overall firm performance. Such performance is often measured via two profit-statement effects: top-line growth and bottom-line profitability. As an income statement represents a relationship between revenue and cost functions of a firm, it is used as a basis to represent a framework for measuring Six Sigma benefits. With this evaluation matrix, it is possible to calculate net income, return on sales, asset turnover and subsequently increase in RONA (Table 2).

A look at this evaluation matrix reveals that the line items between revenue to net income address virtually all expenses of a business. As explained in Table 2, all line items of the financial matrix are segregated according to SCM performance drivers as they are positively influenced by Six Sigma deployment. As a resultant impact of Six Sigma deployment in SCM, net income increases, investment in assets decreases and ROA increases, as shown in the evaluation framework (Table 2). Application of this evaluation framework is explained in the following illustration (Table 3).

Illustration

In the following hypothetical illustration of a firm, it is envisaged that the Six Sigma deployment in supply chain generates a 1% positive impact across various income statement line items and investment in assets. Table 3 represents a financial evaluation matrix for a hypothetical illustration of a firm (base case) and after positive impact of Six Sigma deployment in SCM (new case). All figures are in millions of US dollars.

Table 2: Six Sigma Deployment in SCM: A Financial Matrix				
S. No.	Net Income and RONA Calculation	Impact of Six Sigma Deployment in SCM	SCM Performance Drivers	Performance Improvement (Overall Value Added)
A. Net Income Calculation				
1.	Sales Revenue	Increase	Effectiveness	• Faster response to market • Increased availability of products • Higher customer retention rate
2.	COGS	Decrease	Efficiency	• Optimized labor and material • Better transparency and visibility
3.	Gross Profit = (1) – (2)	Increse	Efficiency Effectiveness	• Increase in gross profit
4.	Depreciation	Decrease	Efficiency	• Improved asset utilization
5.	Selling Expense	Decrease	Effectiveness	• Lower customer acquisition cost
6.	G and A (General and Administrative) Expense	Decrease	Efficiency	• Reduced transaction expenses
7.	Logistics Expense	**Decrease**	Efficiency	• Optimized transportation expenses • Better management of inventory
8.	Operating Profits = (3) – (4) – (5) – (6 – (7)	Increase	Efficiency Effectiveness	• Increase in operating profit
9.	Interest Expense	**Decrease**	Efficiency	• Reduced working capital need with shorter operating cycle
10.	Net Income = (8) – (9)	Increase	Efficiency Effectiveness	• Increase in net income
B. RONA Calculation				
11.	Investment in Fixed Assets	Decrease	Efficiency	• Decrease in assets
12.	Base Inventory	Decrease	Efficiency	
13.	Variable Inventory	Decrease	Efficiency	
14.	Receivables	Increase	Effectiveness	
15.	Payables	Decrease	Efficiency	

Table 2 (Cont.)

S. No.	Net Income and RONA Calculation	Impact of Six Sigma Deployment in SCM	SCM Performance Drivers	Performance Improvement (Overall Value Added)
16.	Net Working capital = (12) + (13) + (14) – (15)	Decrease	Efficiency Effectiveness	• Decrease in working capital
17.	Investment in Net Assets = (11) + (16)	Decrease	Efficiency Effectiveness	
18.	Return on Sales = (10) / (1) (%)	Increase	Efficiency Effectiveness	
19.	Asset Turnover = (1) / (17)	Increase	Efficiency Effectiveness	• Increase in asset turnover
20.	RONA = (18) × (19) (%)	Increase	Efficiency Effectiveness	• Increase in RONA

Table 3: Six Sigma Deployment in SCM: An Illustration of Financial Evaluation Matrix

S. No.	Net Income and RONA Calculation	SCM Performance Drivers	Base Case*	New Case**	Net Impact
A.	***Net Income Calculation***				
1.	Sales Revenue	Effectiveness	100	101	1.00
2.	COGS	Efficiency	65	64.99	-0.01
3.	**Gross Profit =** (1) – (2)	Efficiency Effectiveness	35	36.01	1.01
4.	Depreciation	Efficiency	4	3.96	–0.04
5.	Selling Expense	Effectiveness	7	6.93	–0.07
6.	G and A (General and Administrative) Expense	Efficiency	3	2.97	–0.03
7.	Logistics Expense	Efficiency	8	7.92	–0.08
8.	Operating Profits = (3) – (4) – (5) – (6) – (7)	Efficiency Effectiveness	13	14.23	1.23
9.	Interest Expense	Efficiency	5	4.95	–0.05
10.	Net Income = (8) – (9)	Efficiency Effectiveness	8	9.28	1.28
11.	Increase in Net Income (%)				16.00

Table 3 (Cont.)

S. No.	Net Income and RONA Calculation	SCM Performance Drivers	Base Case*	New Case**	Net Impact
B.	**RONA Calculation**				
12.	Investment in Net Assets	Efficiency	25	24.75	–0.025
13.	Return on Sales = (10)/(1) (%)	Efficiency Effectiveness	8	9.19	1.19
14.	Asset Turnover = (1)/(12)	Efficiency Effectiveness	4	4.08	0.08
15.	RONA = (13) × (14) (%)	Efficiency Effectiveness	32	37.50	5.50
16.	**Increase in RONA (%)**				**17.19**

Note: *Pre-Six Sigma Implementation; **Post-Six Sigma Implementation.

With 1% improvement in sales revenue, triggered by deployment of Six Sigma in supply chain, new sales become $101 mn. As Cost of Goods Sold (COGS) varies directly in proportion with sales, COGS has increased to $65.65 mn. After considering the impact of 1% improvement (reduction) in COGS, new COGS is reduced to $64.99 mn. Similarly, decrease in various line items of the framework, caused by deployment of Six Sigma in SCM and corresponding increase in gross profit, operating profit, net income and RONA is shown in Table 3. Taken together, as calculated in Table 3, even a small improvement in financial and operational measures across the value proposition can have a profound effect on the bottom line, lift net income of a firm by approximately 16%, and increase RONA by 17%.

Research Implications and Directions for Future Research: Firms have to analyze, monitor and make improvements of their existing SCM processes in order to beat market competition and stay competitive. In this regard, the Six Sigma is a methodology that enables the firms to review their existing SCM practices and guide them in making improvements. Six Sigma-based SCM effectively manages typical disruption issues in supply chain as it ensures the delivery of the most appropriate product, in right time, in right place with the least cost to the customer.

An integrative framework and the business value-added framework and financial matrix developed in this paper set a succinct research agenda on how efficiency and effectiveness drivers of SCM and accompanying business values generated by Six Sigma deployment in SCM may affect an organization's business performance. An empirical investigation that quantifies the business value created and overall benefits generated from Six Sigma deployment may also be the subject of future research. Future research should be directed to the examination of the challenges in pursuing such methodology and measuring its benefits and should also focus on other improvement processes such as lean Sigma that can enhance SCM performance.

Conclusion

Six Sigma offers a route to creating more robust supply chain processes that reduce the risk of nonconformance and hence produce a more reliable and consistent output. Six Sigma is a data-driven, continuous improvement methodology that seeks to bring processes under control and to improve process capability. Six Sigma would enforce a more disciplined approach to SCM projects and ensure that SCM projects were defined rigorously and executed methodically. Also Six Sigma's analytical emphasis would steer the improvement projects to investigating and resolving root causes, rather than mere symptoms of SCM problems. Six Sigma is a customer-focused improvement strategy. With Six Sigma deployment, improvement in the quality of all supply chain processes leads to the simultaneous reduction of costs and enhancement of services. Both Six Sigma and SCM are complementary in nature and hence considered as two pillars of business improvement.⌘

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