Impact Analysis: Deciphering the Benefits and Limitations in Improving Processes using Six Sigma, TQM and SCM- A Thorough Study

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Abstract: Six Sigma is both a philosophy and a methodology that improves quality by analyzing data with statistics to find the root cause of quality problems and to implement controls. Statistically, Six Sigma refers to a process in which the range between the mean of a process quality measurement and the nearest specification limit is at least six times the standard deviation of the process.Despite the pervasiveness of Six Sigma program implementations, there is increasing concern about implementation failures. One reason many Six Sigma programs fail is because an implementation model on how to effectively guide the implementation of these programs is lacking. While Six Sigma is increasingly implemented in industry, little academic research has been done on Six Sigma and its influence on quality management theory and application. There is a criticism that Six Sigma simply puts traditional quality management practices in a new package. To investigate this issue and the role of Six Sigma in quality management, this study reviewed both the traditional quality management and Six Sigma literatures. Quality professionals are aware that the six-sigma methodology employs existing, well-known tools developed in quality sciences and are based on the works of Deming, Juran, Ishikawa, Taguchi, and others. Nevertheless six sigma, a Motorola innovation, has been a positive force. A good presentation – black belts and green belts honoring six-sigma experts – can make statistical process improvement, and the systematic six-sigma methodology taste good, and do good work.

Keywords: Lean Manufacturing, Six Sigma, DMAIC, JIT, SCM, TQM,

1. INTRODUCTION

The increasing emphasis on supply chain management is causing researchers to rethink models, constructs, and frameworks for quality management that have been developed for the field of operations management. While some work has been done in this area (Thirumalai et al., 2005; Benton et al., 2005); Flynn et al. (2005)), more scholarly work is needed. Research in quality management has often focused on internal versus external views of quality, with the internal view focusing on process and the external view focusing on the customer. To understand the field of supply chain management (SCM), we must first define the term by deconstructing it. Bowersox et al. (2007) state that supply chain management consists of firms collaborating to leverage strategic position and to improve operating efficiency. This includes partnering with other firms in chains of relationships that result in downstream benefits to customers.

The outbound part of the supply chain (e.g., wholesalers, retailers) plays a key role in delivering the perfect order to customers; it is concerned with where companies make, move, and deliver the products that they sell. On the other hand, the inbound part (e.g., suppliers of raw materials, parts and assemblies, transport providers) refers to where companies design their products, source the components and materials needed to make those products, and procure and manage the plant, equipment and supplies needed to conduct business. The inbound part of the supply chain is often overlooked both by managers and researchers and much attention is paid to the outbound part because it is more visible to the end customer and there is more commonality at this end, while the inbound part is more complex and specialized. Six Sigma is both a philosophy and a methodology that improves quality by analyzing data with statistics to find the root cause of quality problems and to implement controls. Statistically, Six Sigma refers to a process in which the range between the mean of a process quality measurement and the nearest specification limit is at least six times the standard deviation of the process. The statistical objectives of Six Sigma are to centre the process on the target and reduce process variation. A Six Sigma process will approach 'zero defects' with only 3.4 defects per million opportunities (DPMO) for a defect to occur. In comparison, the goal of many quality initiatives throughout the 1980s and early 90s was to obtain a process capability index (Cpk) of at least 1.0, which roughly translates to 3 Sigma. However, this level of quality still produces a defect rate of 66,810 DPMO. Six Sigma differs from other quality programmes in its 'top-down' drive and its rigorous methodology that demands detailed analysis, fact-based decisions, and a control plan to ensure ongoing quality control of a process.

However, despite the immense popularity and the wide-spread adoption of Six Sigma, there is an increasing concern across industries regarding the failure of Six Sigma programs. One reason many Six Sigma programs fail is because an implementation model detailing the sequence of Six Sigma elements/activities is not available. The existing literature identifies many elements of Six Sigma which does enhance our understanding of Six Sigma programs. However, the success of Six Sigma programs hinges on the sequence of many Six Sigma implementation. Many characterize Six Sigma programs as the latest management fad of improvement tools and techniques (Watson, 2006). It is well known that Six Sigma programs involve a host of critical decisions and many researchers have contributed to the existing literature. For example, Schroeder et al. (2008) have identified many critical decisions or elements of Six Sigma programs such as management involvement, improvement specialists, performance metrics, a systematic procedure, and project selection and prioritization. Six Sigma programs improve operational performance in order to enhance customer satisfaction with a company's products and services (Rajagopalan et al., 2004). Over the years, many companies, such as General Electric, Allied Signal, Raytheon, and Delphi Automotive have implemented Six Sigma programs (Treichler et al., 2002), and claimed that these programs have transformed their organizations. Six Sigma programs are heavily promoted in practitioners' books on Six Sigma (e.g., Harry and Schroeder, 2000) A survey of aerospace companies concluded that less that 50% of the respondents were satisfied with their Six Sigma programs (Zimmerman and Weiss, 2005). Another survey of healthcare companies revealed that 54% do not intend to embrace Six Sigma programs (Feng and Manuel, 2007). Companies such as 3M and Home Depot were not satisfied with their implementation of Six Sigma programs (Hindo, 2007). The real question is not whether Six Sigma programs have value, but why do so many Six Sigma programs fail? One reason for Six Sigma program failure is because we lack a model on how to effectively guide the implementation of the perfect efficient Six Sigma program (Wurtzel, 2008).

This paper is part of a wider and critical research project work aimed at exploring and analyzing strategies and supporting concepts used to improve the level of stability within a supply chain , probably combining various tools and techniques used in TQM and supply chain. First part of the paper focuses mainly on the literature review comprising of six sigma and other QM techniques. Next part of the paper systematically focuses on six sigma methodology i.e. how six sigma works, the positives of implementing six sigma , the negatives of six sigma and last part of the paper throws some light on what future work is required to be done by quality professionals in order to achieve the goals set by Japan's Quality gurus.

2. LITERATURE REVIEW

2.1. Six Sigma: A Thorough Understanding.

"Six Sigma is a long-term commitment. It won't work well without full commitment from upper management. Six Sigma changes the way a company thinks by teaching fact-based decision making to all levels. The programme changes the 'DNA' of a company by changing the way the leaders think and by improving the management pipeline by developing management and communication skills in people."

elements/activities or a model for

Over the years, many researchers have studied Six Sigma programs and identified many critical decisions of these programs. For example, previous research of Antony and Banuelas (2002), Coronado and Antony (2002), Lakhavani (2003), Lynch et al. (2003), Mcadam and Evans (2004), Gijo and Rao (2005), Szeto and Tsang (2005), Ladani et al. (2006), Savolainen and Haikonen (2007), Davison and Al-Shaghana (2007), recently being Zu et al. (2008) studied the evolving theory of quality management and the role of Six Sigma. While defining Six Sigma programs and uncovering the underlying theory, Schroeder et al. (2008) identified five elements of these programs. One of them is management's involvement in performing many Six Sigma functions, such as selecting improvement specialists, identifying project selection, and facilitating Six Sigma implementation (Gitlow and Levine, 2005; Snee and Hoerl, 2003). Antony et al. (2007) emphasized as Firstly, management's involvement in on-going projects for sustainability of Six Sigma programs need to be defined . Improvement specialists are trained or hired at different Six Sigma competency levels (e.g., Black Belt or Green Belt). Their primary responsibility was to provide technical expertise and leadership in facilitating a specific Six Sigma implementation (Pyzdek, 2003). Third, as Keller (2005) pointed out, Six Sigma programs have performance metrics facilitating Six Sigma implementation (Gitlow and Levine, 2005; Snee and Hoerl, 2003). Fourth, Six Sigma implementation uses a systematic procedure; a five-step DMAIC (Define, Measure, Analyze, Improve, and Control) methodology. A detailed description of DMAIC methodology can be referenced from many papers. Pyzdek (2003) or Keller (2005) focused mainly on DMAIC. Fifth, project selection and prioritization is an important element of Six Sigma programs. The prioritization of projects is determined by many criteria, such as a cost benefit analysis or the Pareto Analysis (Banuelas et al., 2006). While Considering effective implementation of Six Sigma and the cost associated with this, many authors question the return on investment of Six Sigma programs (e.g., Gupta, 2008). The real question is not whether Six Sigma programs have value, but why do so many Six Sigma programs fail? One reason could be because we lack a model on how to effectively guide the implementation of Six Sigma programs (Wurtzel, 2008). Secondly, we lack an understanding of the sequence of these elements/activities, or a model for effectively guiding the implementation of these programs. Because there is no implementation model, practitioners have encountered tremendous difficulty in implementing these programs, and there are reports of wide-spread Six Sigma failures. Zimmerman and Weiss (2005) specifically focused on the failure of Six Sigma Program for aerospace industry and found that less than 50% of the survey respondents from aerospace companies expressed satisfaction with their Six Sigma programs. Mullavey (2005) described the top 10 reasons why Six Sigma implementations fail. Berg (20 06) reported that their

Six Sigma program was expensive and did not yield expected results. Sutton (2006) described nine ways to get the best out of Six Sigma programs. A national survey of Six Sigma programs in healthcare companies revealed that 54% do not intend to embrace Six Sigma programs (Feng and Manuel, 2007). At 3M, a Six Sigma program that was not structurally implemented almost satisfied creativity and innovation of workforce (Hindo, 2007). Home Depot's Six Sigma program negatively affected employee performance, and yielded Home Depot's worst Consumer Satisfaction Index ranking (Hindo and Grow, 2007). Angel and Pritchard (2008, p. 41) reported that "nearly 60% of all corporate Six Sigma initiatives fail to yield desired results''. According to Gupta (2008, p. 22), at times, Six Sigma ''improvement programs cost more than the improvement they drive because of incorrect application''. While reporting cash flow problems of Six Sigma programs in small companies, Foster (2007, p. 19) claims that if these programs are not ''skillfully implemented; the benefits of Six Sigma may be marginal". According to Chandra (2008), one reason Six Sigma programs fail is because these programs are not correctly implemented. The existing literature research related to Six Sigma and other improvement initiatives e.g. Lean or Theory of Constraints are utilized to isolate steps of implementation. Although suggested in different studies, these steps can connect with each other to hypothesize an implementation model. In describing a successful lean (e.g., manufacturing cells) implementation, Chakravorty and Hales (2004) found that the first step in implementing an improvement plan was to perform a customer and market driven strategic analysis. The purpose of this analysis was to direct the operational improvement effort to gain a competitive position in the market. According to Keller (2005), Six Sigma programs have many tools for improvement including Histograms, Pareto Charts, Statistical Process Control (SPC), and Analysis of Variance (ANOVA). Foster (2007) claimed that a common process for implementing improvement tools in Six Sigma is nothing but structured DMAIC methodology, which is similar to Edward Deming's ''Plan-Do-Check-Act" problem solving approach. Lee-Mortimer (2006) considered the DMAIC methodology to be essential to Six Sigma programs and appropriate for delivering business improvements. According to Chakravorty and Franza (2009), a form of DMAIC methodology, Define-Measure-Analyze-Design-Verify (DMADV), was central to a new product development experience. Mast and Bisgaard (2007) considered DMAIC methodology as the scientific method in Six Sigma programs. Keller (2005) points out that the objective of Six Sigma programs is to create a higher perceived value of the company's products and services in the eyes of the customer. Antony et al.(2005) indicated that linking Six Sigma to business strategy and customer needs is critical for successful implementation. Pande et al. (2000)point out that a cross-functional team is necessary to implement Six Sigma programs and the purpose of the team is to provide an on-going involvement of management in the implementation process. According to Harry and Linsenmann (2007), the CEO of DuPont committed complete management support for implementing Six Sigma programs, and ensured that management learned Six Sigma methodology by requiring that managers themselves become Green Belt certified. At DuPont the Six Sigma program was not merely a methodology to get results, but was a management culture created to ensure long-term transformation of the business units. Study revealed that one reason Six Sigma implementation failed in many companies was due to the lack of commitment from management (Gopal, 2008). Management simply pushed Six Sigma programs out to employees, and did not become personally involved in the implementation process. As Mullavey (2005) points out, in order to successfully implement Six Sigma programs, management must understand Six Sigma methodology, must provide leadership, and must guide the implementation process. Mast and Bisgaard (2007) considered DMAIC methodology as the scientific method in Six Sigma programs. Keller (2005) pointed out the objective of Six Sigma programs as to create a higher perceived value of the company's products and services in the eyes of the customer. On the other hand, Antony et al. (2005) indicated that linking Six Sigma to business strategy and customer needs was critical for successful implementation of Six Sigma.

In order to implement Deming's style of quality management, Hales and Chakravorty (2006) also found that after identifying the tools for improvement to be used, the next step was to understand the overall operations, and to set priorities for the project. One way to understand overall operations is by developing a process map. There are several important points worth discussing about the implementation model. The first step of the model is to perform Strategic Analysis, which needs to be market/customer driven. Various implementation experience shows that the reason for Six Sigma implementation was to improve customer expectations through operational excellence. Many Six Sigma programs are implemented to gain operational efficiency. Unfortunately, many of these operational gains do not directly provide enhanced customer satisfaction or value. Bendell (2006) claims that Six Sigma is a strategic approach and improvement projects should be selected based on improving customer satisfaction and operational efficiency. In reality, a majority of the improvement projects are selected based on cost perspective and, therefore, the approach becomes suboptimal, diverting from basic purpose of improving quality of the goods and services to Cost effectiveness. According to Andel (2007, p. 1) the cost minimization approach usually translates into a cutting headcount exercise. It is important to learn more about how to identify projects and how to prioritize them. This could be scope for future work.

One reason many Six Sigma improvement programs fail is because improvement projects are not

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correctly identified and prioritized (Zimmerman and Weiss, 2005). Over the years, many researchers have worked on prioritizing improvement projects by mixing tools such as Six Sigma, Quality, Lean, or Theory of Constraints tools. For example, Chakravorty and Atwater (1998) showed how to prioritize quality improvement projects using Theory of Constraints. Chakravorty and Sessum (1995) showed how to prioritize Lean improvement projects using Theory of Constraints. Chakravorty (1996) mixed Lean and Theory of Constraints concepts to improve the performance of manufacturing operations. Recent empirical research (e.g., Banuelas et al., 2006) found that companies prioritize improvement initiatives by mixing these tools. More research is necessary on how to mix these tools to correctly identify and prioritize improvement projects. Lean thinking is part of the culture right across operational domains, coupled with Six Sigma approaches in quality (e.g., Banuelas et al., 2006,Nave, 2002).

TABLE 1.1 Sigma Table

Sigma	Defects Per Million	Yield
6	3.4	100.00%
5	233	99.977
4	6,210.00	99.379
3	66,807.00	93.32
2.5	158,655.00	84.1
2	308,538.00	69.1
1.5	500,000.00	50
1.4	539,828.00	46
1.3	579,260.00	42.1
1.2	617,911.00	38.2
1.1	655,422.00	34.5
1	691,462.00	30.9
0.5	841,345.00	15.9
0	933,193.00	6.7

Initially Six Sigma practice was developed considering in view the yield as shown in table 1.1. Note that above yield can only be achieved if processes monitored and improved on continual basis. Six Sigma deployment need to be monitored strictly.

Zimmerman and Weiss (2005) point out companies need to pay attention to the human side of Six Sigma implementation. The human side of Six Sigma implementation is an important area for future research. This research will be greatly helpful for practicing managers wanting to effectively implement Six Sigma programs to achieve sustained results in their business environment.

Due to an increasing pace and complexity of business environments, organizations no longer compete on processes but the ability to continually improve processes (Teece, 2007). At the same time numerous organizations that have deployed continuous improvement initiatives have not been successful in getting what they set out to achieve.

The implementation of dynamic capabilities involves repeated cycles of organizational learning (Cyert and March, 1963; Mahoney, 1995; Scho¨n, 1975). Similarly, process improvement involves organizational learning to make changes in operating routines. Continuous improvement (CI) is an ongoing activity aimed at raising the level of organization-wide performance through focused incremental changes in processes (Bessant and Caffyn, 1997; Wu and Chen, 2006). A CI initiative provides a planned and organized system for the continual discovery and implementation of such process changes. CI initiatives consist of two broad areas of action required for sustained improvements, namely the execution and the coordination of process improvement projects. Continuous improvement thus fits into Helfat et al.'s (2007, p. 5) notion of dynamic capability as patterned activity, in contrast to "a one-time idiosyncratic change to the resource base of an organization." When appropriately implemented, continuous improvement initiatives help to integrate operations processes and enhance the organization's ability to make cohesive and quick process changes to improve performance. For continuous improvement to create and support dynamically changing operational capabilities it is critical that it include a coherent infrastructure (Eisenhardt and Martin, 2000; Garvin, 1993b). However, existing studies tell us little about the constituent elements of such an infrastructure. In seeking these elements for CI infrastructure we rely on the theoretical relationship between organizational learning and dynamic capability (Zollo and Winter, 2002). CI infrastructure can add a dynamic dimension to CI initiatives by institutionalizing organizational learning, manifested in the form of process improvements (Linder-manetal., 2004; Molinaetal., 2007). It can serve as the right context for dynamic capability by facilitating the involvement of middle and lower levels of management in strategy deployment and creating a culture for organizational learning (Neilson et al., 2008). Results of a 2007 survey of US manufacturers showed that while 70% of plants had deployed lean manufacturing techniques, 74% of these were disappointed with the progress they were making with lean (Pay, 2008). An earlier study found that only 11% of companies considered their continuous improvement initiatives to be successful . Although operations management executives realize the importance of continually improving processes, they have found that managing continuous improvement is a challenging task (Kiernan, 1996; Pullin, 2005). The challenge lies in creating an infrastructure to coordinate continuous improvement projects (Choo et al., 2004; Wruck and Jensen, 1998). Dynamic capability is defined as "a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness." (Zollo and Winter, 2002, p. 340).

2.2 Just in time

Since the importance of just-in-time (JIT) was recognized in the early 1980s, there have been numerous studies discussing implementation of JIT and its effectiveness in US manufacturing firms from various dimensions. White et al. (1999) investigated both large and small US manufacturers to see which had greater differences and improvements in performance due to JIT implementation. Their study was conducted based on the set often JIT management practices identified by White et al. (1990). The ten JIT practices were: quality circles, total quality control, focused factory, total productive maintenance, reduced setup times, group technology, uniform workload, multifunction employees, Kanban, and JIT purchasing. Although there has been a consensus on the notion that JIT is an overall organizational phenomenon and the greatest possible gains from JIT can be achieved when JIT practices operate as an integrated system (for example, see Sakakibara et al., 1997), the JIT purchasing practice has attracted more attention than any other practices from academicians and practitioners.

2.3 Supply chain management

While several definitions of supply chain management have been proposed in Larson et al. (1998), an underlying thread is the integration of processes throughout the supply chain with the goal of adding value to the customer. Despite the fact that this suggests the need to integrate transportation, logistics, and purchasing functions with manufacturing processes, in practice and in the literature, supply chain management has typically reflected either the management of logistics or the supply base. The logistics focus views SCM as the coordination of the logistics operations of Grms in the value chain (Tan et al., 1998). Pulling materials through the supply chain in response to demand patterns rather than pushing them in response to forecasts, allows organizations to respond to demand uncertainty more effectively, improve flows within the supply chain, manage inventory more effectively, and improve service levels (Davis T.,1993, Scott et al., 1991).

2.4 Implementing Six Sigma

Implementing a typical Six Sigma programme begins at top management level with training in fact-based decision making and evaluation of a company's strategic goals. The objective behind training is to define what process variables are critical to product quality and to define the gaps between goals and current performance that will become Six Sigma projects. Black Belts and Master Black Belts are chosen to become Six Sigma experts and be dedicated full-time to run Six Sigma projects. Green Belts, who keep their regular jobs while they work part-time on Six Sigma projects, are also chosen. Six Sigma uses a group of improvement specialists, typically referred to as champions, master black belts, black belts, and green belts (Henderson and Evans, 2000; Linderman et al., 2003). Those specialists receive intensive differentiated training that is tailored for their ranks and is designed to improve their knowledge and skills in statistical methods, project management, process design, problem-solving techniques, leadership skill, and other managerial skills (Barney, 2002a; Gowen and Tallon, 2005; Linderman et al., 2003; Snee and Hoerl, 2003). Same has been tried to summarize the six sigma deployment in fig.1.1 as shown below. With assigning the improvement specialists to take different levels of roles and responsibilities in leading the continuous improvement efforts, the organization builds a Six Sigma role structure for quality improvement. In the Six Sigma role structure, there is a hierarchical coordination mechanism of work for quality improvement across multiple organizational levels (Sinha and Van de Ven, 2005). For example, the senior executives serve as champions for making the organization's strategic improvement plans and black belts under them lead Six Sigma projects and mentor green belts in problem solving (Barney, 2002a,b; Sinha and Van de Ven, 2005). This mechanism helps to coordinate and control work across organizational levels to ensure that the tactical tasks match with the overall business strategy (Sinha and Van de Ven, 2005).

Six Sigma structured improvement procedure is as explained below.

Six Sigma applies a structured approach to managing improvement activities, which is represented by Define–Measure–Analyze–Improve–Control (DMAIC) used in process improvement or Define–Measure–Analyze–Design–Verify (DMADV) used in product/service design improvement (Linderman et al., 2003). Both of these procedures are grounded in the classic Plan–Do–Check–Act (PDCA) cycle, but Six Sigma specifies the QM tools and techniques to use within each step, which is unique to Six Sigma (Linderman et al., 2003). The Six Sigma structured improvement procedures provide teams a methodological framework to guide them in the conduct of improvement projects

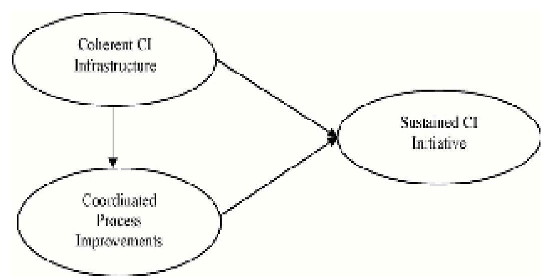

Figure 1 : Six Sigma Deployment

The Six Sigma structured improvement procedure is expected to support product/service design and process management. Both product/service design and process management practices involve using different managerial and technical tools and their effectiveness is dependent on how well teams actually use these tools (Ahire and Dreyfus, 2000). The DMAIC/DMADV procedures offer a standardized approach for the teams to follow, and prescribe appropriate tools to use at each step, as well as systematic project management tools, which enhances their problem-solving ability (Antony and Banuelas, 2002; Choo et al., 2004; Kwak and Anbari, 2004). In addition, these structured procedures guide the teams search for solutions to complicated problems by breaking complex tasks into elementary components to reduce task complexity so that the teams can be focused, which will increase their productivity (Linderman et al., 2003, 2006). Likewise, the use of Six Sigma metrics is more effective and efficient when teams follow the structured procedures in conducting Six Sigma projects. These procedures not only entail a 'measure' step to identify measurable customer requirements and to develop baseline defect measures, but also request using metrics throughout the project, e.g., from determining project goals in the 'define' step to establishing on-going process measures to continuously control the key processes in the 'control' step (Pande et al., 2002). Linderman et al. (2006) found that when teams strictly follow the DMAIC steps and faithfully complete each step, they are more likely to meet the project goals, especially those challenging goals, and to achieve improved project performance.

2.5 Involving Lean Manufacturing

Many companies are now combining implementation of Six Sigma and Lean Manufacturing programmes. Lean Manufacturing is a method for reducing lead-time across the value chain, which improves cash flow, eliminates waste, reduces inventory and increases on-time delivery. In process industries, such as the chemical and plastics industries, key Lean Manufacturing tools are reduction in setup time and Total Productive Maintenance (TPM), comments Bonnie Smith, managing director at the Time Based Management Consulting Group (TBM). Reducing set-up time allows a company to run smaller batches cost-effectively or make more frequent transitions, which is necessary for reducing inventory. TPM focuses on improving machine maintenance to decrease downtime. "While Six Sigma alone improves firsttime yield and eliminates some waste in a manufacturing process, Lean significant, breakthrough waste elimination,". Applying both Lean Manufacturing and Six Sigma tool sets results in far better improvements than can be obtained with either method alone.

3. Advantages of Implementing Six Sigma

Six Sigma emphasizes using a variety of quantitative metrics in continuous improvement, such as process Sigma measurements, critical-to-quality metrics, defect measures, and traditional quality measures like process capability (Breyfogle et al., 2001; Dasgupta, 2003; Linderman et al., 2003; Pyzdek, 2003). Six Sigma metrics are used to set improvement goals (Linderman et al., 2003; Pande et al., 2002). Objective data helps in reducing corporate use of political agendas to drive solutions (Brewer, 2004). As suggested by Linderman et al. (2003), using explicit, challenging goals in Six Sigma projects can increase the magnitude of improvements, reduce performance variability of the projects, and increase employees' improvement efforts and commitment to quality. Moreover, Six Sigma integrates business-level performance, process measures, and project metrics into a systematic review process so that managers can manage the organization quantitatively and translate the business strategy into tactical tasks (Barney, 2002a). Quality management (QM) has developed into a mature field with sound definitional and conceptual foundations (Sousa and Voss, 2002), but new QM methods continue to grow. For example, Six Sigma, which is ''an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates'' (Linderman et al., 2003, p. 194), generates intense interest in industry. Since its initiation at Motorola in the 1980s, many companies including GE, Honeywell, Sony, rpillar, and Johnson Controls have adopted Six Sigma and obtained substantial benefits (Pande et al., 2000; Snee and Hoerl, 2003).

Garvin's (1984) quality performance model suggests that quality performance affects business performance through two routes—the manufacturing route and the marketing route (Sousa and Voss, 2002). In the manufacturing route , improved quality performance results in fewer defects, lower scrap and rework rates, less waste, and more dependable processes, which lead to lower manufacturing costs, lower warranty and liability costs, higher efficiency and productivity, and increased return on assets and profitability (Handfield et al., 1998; Kaynak, 2003; Reed et al., 1996). In the marketing route, improved quality increases customer satisfaction that leads to increased sales and larger market share (Ahire and Dreyfus, 2000; Choi and Eboch, 1998; Handfield et al., 1998). By providing high quality products and services, the firm has less elastic demand and can charge higher prices, which brings about more profits (Kaynak, 2003; Sousa and Voss, 2002).

The QM literature has unanimously emphasized the importance of top management support for QM (Beer, 2003). This study once again confirms that top management support is critical for traditional QM and it is also important for Six Sigma. Top management support directly supports the Six Sigma role structure in an organization. The success of executing substantial changes required for Six Sigma deployment relies on whether top management understands and accepts Six Sigma principles and whether they are willing to support and enable the restructuring of the organization's policies (Antony and Banuelas, 2002; Lee and Choi, 2006).

4. Limitations of implementing Six Sigma

The main hurdles in successful implementation of Six Sigma , in the views of researchers are , One organization's own management and employees , two active supplier participation and three active customers participation. The same are explained in detail in continued discussion.

Neither quality information nor the Six Sigma structured improvement procedure has a direct effect on product/service design or process management, but those two practices are found to have a significant effect on the Six Sigma focus on metric which in turn directly affects product/service design and process management (Linderman et al.2003, 2006). Six Sigma is criticized as offering nothing new and simply repackaging traditional QM practices (Clifford, 2001; Stamatis, 2000). It is argued that the large returns from Six Sigma at some companies were due to the initial quality level of these companies being so low that anything would have drastically improved their quality (Stamatis, 2000). Although there have been numerous case studies, comprehensive discussions, books and websites addressing Six Sigma, very little scholarly research has been done on Six Sigma and quality management theory and application (Goffnett, 2004; Schroeder et al., 2005).

Top management support is crucial in Six Sigma implementation, as demonstrated by chief executives such as Jack Welch of GE, Bob Galvin of Motorola, and Lawrence Bossidy of AlliedSignal, who each led Six Sigma implementation in their firm (Henderson and Evans, 2000; Slater, 2000). Top management makes the strategic decisions required for Six Sigma adoption (Lee and Choi, 2006). Six Sigma role structure can only be established if top management uses its authority and power to integrate the Six Sigma black and green belt system into the organization's human infrastructure, to adjust the performance appraisal and compensation policy to incorporate Six Sigma performance, and to provide resources for Six Sigma training (Antony and Banuelas, 2002; Bhote, 2003; Breyfogle et al., 2001; Hendricks and Kelbaugh, 1998).

Execution of the Six Sigma focus on metrics also requires support from top management. Top management sets its organization's strategic visions and objectives. This puts restriction on implementation and achieving six sigma goals. It has been observed that the ultimate aim of top management is always to earn healty profits even in falling market scenario. Six sigma aims at achieving highest quality standards. (Ahire and O'Shaughnessy, 1998). The creation of a partnership with key suppliers is one major intervention that companies should make to realize continuous improvement (Hackman and Wageman, 1995).

Six Sigma connects employees' promotion and rewards with the level of their Six Sigma certifications and their involvement and achievement in Six Sigma projects (Henderson and Evans, 2000; Lee and Choi, 2006), which ignites the employees' interest in quality improvement and increases their commitment to the organization's goal of high quality (Linderman et al., 2003). But at the same time the negative effect of employees misunderstanding about this comes into picture i.e. if he or she fails to deliver expected quality product their promotion and reward will be low.

The Six Sigma structured improvement procedure is expected to support product/service design and process management. Both product/service design and process management practices involve using different managerial and technical tools and their effectiveness is dependent on how well teams actually use these tools (Ahire and Dreyfus, 2000). Also from the entire study , we can easily conclude that

- Quality information is positively related to supplier relationship.
- Quality information is positively related to product/service design.
- Quality information is positively related to process management.(Ahire and Dreyfus,2000; Flynn et al., 1995; Forza and Flippini, 1998; Kaynak, 2003; Gowen and Tallon, 2005; Kwak and Anbari, 2004; Lee and Choi, 2006 ;X. Zu et al.,2008).

Six Sigma is simply a repackaging of traditional QM methods or provides a new approach to improving quality and organizational excellence. This question has created some confusion about Six Sigma (Goffnett, 2004), and also put managers in a dilemma: on one hand, if they do not adopt Six Sigma because it is considered to be the same as traditional QM methods, their company may lose the opportunity to gain substantial benefits as GE and other companies practicing Six Sigma have achieved from their Six Sigma efforts; on the other hand, if Six Sigma is different, there lacks solid answer to what are the new practices that the company needs to implement to improve the current QM system (Schroeder et al., 2008).

5. Conclusion and Scope

Six Sigma is an effective approach to a broad-based quality control program. It is far more than the traditional approach, in which internal teams are created to reduce production defects, solve problems within one department, and address problems in isolation. Six Sigma is more than a quality control program with another name; it is a quality-based system for reorganizing the entire approach to work in every aspect: productivity, communication, involvement at every level, and external service.

Some of below conclusions can be drawn from this study. At a strategic level, linkages exist between JIT and SCM. While some companies may understand the inherent relationships between the two and actively exploit their synergy, those that do not maybe inadvertently achieving the benefits of synergy. By explicitly and effectively integrating JIT and SCM practices into operations strategy, the potential exists to add value and to better position oneself to respond to competitive pressures. At an operational level, JIT and SCM practices can be deployed together to create value. The extent to which various practices correlate with each other and with performance is evidence that while the three may have distinct characteristics and goals, there are elements of each that are common and which can be successfully reinforced by each other. Lastly, in addition to having a focus on quality, understanding supply chain relationships is a key driver of performance.

Researchers need to better understand Six Sigma so that they do not over hype it or too quickly dismiss it as nothing new. By better defining and adequately understanding Six Sigma, scholars can develop a deeper and richer knowledge of this phenomenon. The implementation of QM in an organization requires two types of decisions: what to do and how to do it (Sousa and Voss, 2002). The findings of this study suggest that Six Sigma implementation requires three key practices to work with other QM practices in order to enhance the organization's ability of improving quality. Further research exploring how these Six Sigma practices are adopted in different organizational contexts is needed, since different organizations have different maturity levels of QM implementation and the strengths and weakness of their existing QM systems vary. It is desirable to explore the critical contextual factors influencing the integration of Six Sigma practices into an organization's existing QM system.

Despite the limitations discussed above, this study contributes to the scholarly research beginning to examine Six Sigma. Schroeder et al. (2008) started with a definition of Six Sigma and its underlying theory to argue that although the Six Sigma tools and techniques appear similar to prior QM approaches, Six Sigma provides an organizational structure not previously seen.

Still further study is deeply required to find solutions to the following questions

- How does internal and external system variation and uncertainty impact supply chain?
- How and why do different strategies limit such variation and uncertainty?
- How and why does the trade-off concept support the strategy development process?
- How can a company use investments in inventory and capacity to provide greater stability in the internal and external phases of a delivery system?

Another area suggested for further study and research is the investigation on how Six Sigma works with other improvement methods such as lean manufacturing. There are common characteristics between lean manufacturing and Six Sigma in reducing waste and improving process (Breyfogle et al., 2001). As mentioned earlier, many plants sampled in this study have implemented lean manufacturing in addition to TQM or Six Sigma. Lean Six Sigma is becoming a new continuous improvement approach in industry (Devane, 2004; George, 2003). Based on the results of this study, researchers may explore how the QM/Six Sigma practices interact with lean manufacturing practices in creating a unique approach to organizational excellence. (X. Zu et al.,2008)

Finally, Six Sigma be viewed as an organization change process. This might provide improved ways for implementation of the Six Sigma process and a more enlightened analysis of what needs to be changed. It might also improve management of the change management process itself. There is certainly ample literature about organizational change that could be used as a starting point (Van de Ven and Poole, 1995).

REFERENCES

[1] Ahire, S.L., Dreyfus, P., 2000. The impact of design management and process management on quality: an empirical examination. Journal of Operations Management 18, 549–575.

[2] Ahire, S.L., O'Shaughnessy, K.C., 1998. The role of top management commitment in quality management: an empirical analysis of the auto parts industry. International Journal of Quality Science 31, 5–37.

[3] Andel, T.,2007.Lean & Six Sigma Traps to Avoid. Material Handling Management, March /http://www.mhmonline.com/viewStory.asp? nID=5423S.

[4] Angel, D.C., Pritchard,C.,2008. Behaviortests SixSigma. Industrial Engineer (August),41.

[5] Antony,J.,Banuelas,R.,2002. Key in gredients for the effective implementation of Six Sigma program. Measuring Business Excellence 6(4), 20–27.

[6] Banuelas, R., Tennant, C.,Tuersley, I.,Tang, S., 2006. Selection of Six Sigma projects in the UK. The TQM Magazine 18(5), 514–527.

[7] Barney, M., 2002a. Macro: Six Sigma. The Industrial Organizational Psychologist 39 (4), 104–107.

[8] Barney, M., 2002b. Motorola's second generation. Six Sigma Forum Magazine 1 (3), 13–16.

[9] Beer, M., 2003. Why total quality management programs do not persist: the role of management quality and implications for leading a TQM transformation. Decision Sciences 34, 623–642.

[10] Belson, K., 2004. Japanese capital and jobs flowing to China. New York Times, February 17, C, p. 1.

[11] Bendell, T.,2006.Are view and comparison of Six Sigma and the lean organizations. The TQM Magazine18(3), 255–262.

[12] Berg, M., 2006. Six Sigma shortcomings. Industrial Engineer(October), 45.

[13] Bessant, J., Caffyn, S., 1997. High-involvement innovation through continuous improvement. International Journal of Technology Management 14 (1), 7–28.

[14] Bhote, K.R., 2003. The Power of Ultimate Six Sigma: Keki Bhote's Proven System for Moving Beyond Quality

Excellence to Total Business Excellence. AMACOM American Management Association, New York, NY.

[15] Bremner, B., Edmondson, G., Dawson, C., Welch, D., Kerwin, K., 2004. Nissan's boss: Carlos Ghosn saved Japan's no. 2 carmaker. Now he's taking on the world. Business Week, October 4, 50–58.

[16] Brewer, P.C., 2004. Six Sigma helps a company create a culture of accountability. Journal of Organizational Excellence 23 (3), 45–59.

[17] Breyfogle,F.,Cipello,J.,Meadows,B.,2001.ManagingSixSigma. Wiley Inter Science, New York, NY.

[18] Chakravorty,S.S.,Atwater,J.B.,1998.Implementingqualityimp rovement programs using the focusing steps of the array of constraints. International Journal of Technology Management 16 (4/5/6/), 544–555.

[19] Chakravorty,S.S., Atwater, J.B., 2006. Bottleneck management : theory and practice. Production & Planning Control17 (5), 441–447.

[20] Chakravorty, S.S., Sessum,J.L., 1995. Developing effective strategies to prioritize setup reduction in multi machine production system.

[21] Cheng, J.L., 2006. DMAIC integration necessary for success. ASQSIX Sigma Forum Magazine5(4),22–28.

[22] Choi, T.Y., Eboch, K., 1998. The TQM paradox: relations among TQM practices, plant performance, and customer satisfaction. Journal of Operations Management 17, 59–75.

[23] Choo, A.S., Linderman, K.W., Schroeder, R.G., 2004. Method and context perspectives on learning and knowledge creation in quality management. Journal of Operations Management 25 (4), 918–931.

[24] Clifford, L., 2001. Why you can safely ignore Six Sigma. Fortune January, 140.

[25] Coronado, R.B.,Antony,J., 2002. Critical success factors for the successful implementation of Six Sigma projects in organisations. The TQM Magazine 14(2),92–99.

[26] Cyert, R.M., March, J.G., 1963. A Behavioral Theory of the Firm. Prentice-Hall, Englewood Cliffs, NJ.

[27] Dasgupta, T., 2003. Using the six-sigma metric to measure and improve the performance of a supply chain. Total Quality Management & Business Excellence 14 (3), 355–367.

[28] Davison,L.,Al-shaghana,K.,2007. The link between Six Sigma and quality culture — an empirical study. Total Quality Management 18(3), 249–265.

[29] Davis T. Effective supplychain management. Sloan Management Review 1993;12:35–46. Economist, 2004. (Still) made in Japan, April 7.

[30] Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: what are they? Strategic Management Journal 21 (October–November Special Issue), 1105–1121.

[31] Feng, Q.,Manuel,C.M.,2007.Under the knife: an ational survey of Six Sigma programs in US health care organizations. International Journal of Health Care Quality Assurance 21(6),535–547.

[32] Flynn, B.B., Sakakibara, S., 1995. Relationship between JIT and TQM: practices and performance. Academy of Management Journal 38 (5), 1325–1360.

[33] Forza, C., Flippini, R., 1998.TQMimpact on quality conformance and customer satisfaction: a causal model. International Journal of Production Economics 55, 1–20.

[34] Foster,S.T.,2007.Does Six Sigma improve performance? The Quality Management Journal14(4),7–20.

[35] Garvin, D., 1988. Managing Quality: The Strategic and Competitive Edge. Free Press, New York, NY, p. 22.

[36] Garvin, D.A., 1993b. Manufacturing strategic planning . California Management Review 35 (4), 85–106.

[37] Gijo,E.V.,Rao,T.L.,2005. Six Sigma implementation— hurdles and more hurdles. Total Quality Management 16(6),721–725.

[38] Goffnett, S.P., 2004. Understanding Six Sigma: implications for industry and education. Journal of Industrial Technology 20 (4), 1–10.

[39] Gopal, R.,2008. 10 ways to failure for a new Six Sigma program. /http://www.isixsigma.com/library/content/c071203a.asp S.

[40] Gowen III, C.R., Tallon, W.J., 2005. Effect of technological intensity on the relationships among Six Sigma design, electronic-business, and competitive advantage: a dynamic capabilities model study. Journal of High Technology Management Research 16 (1), 59–87.

[41] Gupta, P.,2008. Reducing the cost of failures. Quality Digest 47 (1), 22.

[42] Hackman, J., Wageman, R., 1995. Total quality management: empirical, conceptual, and practical issues. Administrative Science Quarterly 40 (2), 309–343.

[43] Hales, D.N., Chakravorty,S.S., 2006.Implementation of Deming's style of Quality management : an action research study. International Journal of Production Economics 103,31–148.

[44] Handfield, R ., Ghosh, S., Fawcett, S., 1998. Quality driven change and its effects on financial performance. Quality Management Journal 5 (3), 13–30.

[45] Harry,M.J., Linsenmann, D.R.,2007. The Six Sigma Field book : How Du Pont Successfully Implemented the Six Sigma Breakthrough Strategy. Double day Business of Random House, Inc.,NewYork, NY.

[46] Helfat, C.E., Finkelstein, S., Mitchell, W., Peteraf, M.A., Singh, H., Teece, D.J., Winter, S.G., 2007. Dynamic Capabilities: Understanding Strategic Change in Organizations. Blackwell Publishing, Malden, MA.

[47] Henderson, K.M., Evans, J.R., 2000. Successful implementation of Six Sigma: benchmarking general electric company. Benchmarking: An International Journal 7 (4), 260–281.

[48] Hendricks, C.A., Kelbaugh, R., 1998. Implementing Six Sigma at GE. The Journal of Quality and Participation 21 (4), 48–53.

[49] Hindo, B.,2007.At3M, a struggle between efficiency and creativity. Business Week,June11.

[50] Hindo, B.,Grow,B.,2007. Six Sigma: so yesterday. BusinessWeek, June 11.

[51] Kaynak, H., 2003. The relationship between total quality management practices and their effects on firm performance. Journal of Operations Management 21 (4), 405–435.

[52] Keller,P.,2005. Six Sigma: Demystified. McGraw-Hill, NewYork, NY.

[53] Kiernan, M.J., 1996. Get innovative or get dead. Business Quarterly 61 (1), 51–58.

[54] Kwak, Y.H., Anbari, F.T., 2004. Benefits, obstacles, and future of Six Sigma approach. Technovation 26 (5/6), 708–715.

[55] Ladani, L.J.,Das,D., Cartwright,J.L., Yenker,R., Razmi,J., 2006.Implementation of Six Sigma system in celestica with practical examples. International Journal of Six Sigma and Competitive Advantage 2(1), 69–88.

[56] Lakhavani,S.T.,2003. Six Sigma implementations: trials, tribulations, and lessons learned. ASQ's Annual Quality Congress Proceedings 57, 643–647.

[57] Larson PD, Rogers DS. Supply chain management: definition, growth and approaches. Journal of Marketing 1998;6(4):1–5.

[58] Lee , Choi ,2006. Six Sigma: a vital improvement approach when applied to the right problems, in the right environment. Assembly Automation26(1), 10–18.

[59] Lee-Mortimer, A., 2006. Six Sigma: a vital improvement approach when applied to the right problems, in the right environment. Assembly Automation26(1),10–18.

[60] Linderman, K., Schroeder, R.G., Choo, A.S., 2006. Six Sigma: the role of goals in improvement teams. Journal of Operations Management 24 (6), 779–790.
[61] Linderman, K., Schroeder, R.G., Zaheer, S., Choo, A.S., 2003. Six Sigma: a goal-theoretic perspective. Journal of Operations Management 21 (2), 193–204.
[62] Linderman, K., Schroeder, R.G., Zaheer, S., Liedtke, C., Choo, A.S., 2004. Integrating quality management practices with knowledge creation processes. Journal of Operations Management 22 (6), 589–607.
[63] Lynch,D.P., Bertolino,S., Cloutier,E., 2003. How to scope DMAIC projects. Quality Progress36(1),37–41.
[64] Mahoney, J.T., 1995. The management of resources and the resource of management. Journal of Business Research 33 (2), 91–101.
[65] Mast, J.D., Bisgaard,S., 2007. The science in Six Sigma. Quality Progress 40 (1),25–29.
[66] Mcadam, R., Evans, A., 2004. Challenge to Six Sigma in a high technology mass-manufacturing environments. Total Quality Management 15 (5/6), 699–706.
[67] Mullavey,F., 2005. Shack led by bad Six Sigma. Quality Digest, September /http://www.qualitydigest.com/sept05/articles/03_article.shtmlS.
[68] Neilson, G.L., Martin, K.L., Powers, E., 2008. The secrets to successful strategy execution. Harvard Business Review 86 (6), 60–70.
[69] Ostram, D., 2000. Corporate Japan's restructuring efforts: a progress report. Japan Economic Institute Report, 20, May 19.
[70] Pande, P. S., Robert, P. N., & Roland, R. C. (2002). The Six Sigma way team field book. New York: McGraw-Hill.
[71] Pande, P.S., Neuman,R.P., Cavanagh,R., 2000. The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing their Performance. McGraw-Hill, NewYork, NY.
[72] Pullin, J., 2005. Room for improvement. Professional Engineering 18 (15), 38–138.
[73] Pyzdek, T.,2003. The Six Sigma Handbook: A Complete Guide for Green Belts, Black Belts, and Managers at All Levels. McGraw-Hill, New York, NY.
[74] Rajagopalan,R.,Francis,M.,Suarez,W.,2004.Developing novel catalysts with Six Sigma. Research Technology Management 47,13–16.
[75] Reed, R., Lemak, D.J., Montgomery, J.C., 1996. Beyond process: TQM content and firm performance. Academy of Management Review 21, 173–202.
[76] Sakakibara, S., Flynn, F., Schroeder, R., Morris, W., 1997. The impact of just-in-time manufacturing and its infrastructure on manufacturing performance. Management Science 43 (9), 1246–1257.
[77] Savolainen,T., Haikonen,A., 2007. Dynamics of organizational learning and continuous improvement in Six Sigma implementation. The TQM Magazine 19(1), 6–17.
[78] Schon, D.A., 1975. Deutero-learning in organizations: learning for increased effectiveness. Organizational Dynamics 4 (1), 2–16.
[79] Schonberger, R.J., 2008. Best Practices in Lean and Six Sigma Process Improvement. John Wiley & Sons, Hobokon, NJ.
[80] Schroeder,R.G., Linderman, K., Liedtke, C., Choo, A.S., 2008. Six Sigma: definition and underlying theory. Journal of Operations Management 26 (4),536–554.
[81] Scott C, Westbrook R. New strategic tools for supplychain management. International Journal of Physical Distribution and Logistics 1991;21(1):23–33.
[82] Sinha, K.K., Van de Ven, A.H., 2005. Designing work within and between organizations. Organization Science 16 (4), 389–408.
[83] Slater, R., 2000. The GE Way Fieldbook: Jack Welch's Battle for Corporate Revolution. McGraw-Hill, New York, NY.
[84] Snee, R.D.,Hoerl,R.W.,2003.Leading Six Sigma. Wiley, Hoboken, NJ.
[85] Sousa, R., Voss, C.A., 2002. Quality management re-visited: a reflective review and agenda for future research. Journal of Operations Management 20, 91–109.
[86] Stamatis, D.H., 2000. Who needs Six Sigma, anyway? Quality Digest May. Available at http://www.qualitydigest.com/may00/html/sixsigmacon.html.
[87] Sutton, C., 2006. Getting the most out of Six Sigma. Quality Management (March), 46–48.
[88] Szeto, A.Y. T., Tsang, A.H.C., 2005.Antecedent to successful implementation of Six Sigma. International Journal of Six Sigma and Competitive Advantage1(3),307–322.
[89] Tan KC, Kannan VR, HandGeld RB. Supply chain management: supplier performance and Grmperformance. International Journal of Purchasing and Materials Management 1998;34(3):2–9.
[90] Teece, D.J., 2007. Explicating dynamic capabilities: the nature and micro foundations of (sustainable) enterprise performance. Strategic Management Journal 28 (11), 1319–1350.
[91] Thirumalai, S., Sinha, K.K., 2005. Customer satisfaction with order fulfillment in retail supply chains: implications of product type in electronic B2C transactions. Journal of Operations Management 23 (3/4), 291–303.
[92] Treichler,D., Carmichael,R., Kusmanoff,A., Lewis,J., Berthiez,G., 2002. Design for Six Sigma: 15 lessons learned. Quality Progress 35, 33–42.
[93] Watson,G.,2006. Building on Six Sigma effectiveness. AS Q Six Sigma Forum Magazine 5(4), 14–15.
[94] White, R., Pearson, J., Wilson, J., 1999. JIT manufacturing: A survey of implementations in small and large US manufacturers. Management Science 45 (1), 1–15.
[95] Wruck, K.H., Jensen, M.C., 1998. The two key principles behind effective TQM program. European Financial Management 4 (3), 401–423.
[96] Wu, C.W., Chen, C.L., 2006. An integrated structural model toward successful continuous improvement activity. Technovation 26 (5/6), 697–707.
[97] Wurtzel,M., 2008. Reasons for Six Sigma deployment failures. BPM Institute. June /http://www.bpminstitute.org/articles/article/article/reasons-for-six-sigma-deployment-failures.htmlS.
[98] Zimmerman, J.P., Weiss,J., 2005. Six Sigma's seven deadly sins. Quality 44,62–66.
[99] Zollo, M., Winter, S.G., 2002. Deliberate learning and the evolution of dynamic capabilities. Organization Science 13 (3), 339–351.
[100] Zu, X., Fredendall, L.D.,Douglas,T.J., 2008. The evolving theory of quality management: the role of Six Sigma. Journal of Operations Management 26,630–650.

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