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Six Sigma, organizational learning and innovation: An integration and empirical examination

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An integration and empirical examination

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Abstract

Purpose – The purpose of this paper is to investigate the relationship between Six Sigma, organizational learning and innovation performance. Also, whether organizational learning advance innovation performance by playing a mediating role between Six Sigma and innovation performance, probing the moderating effects of organizational types between six sigma and organizational learning, and also testing a proposed model to explain the relationships among Six Sigma, organizational type organizational learning, and innovation performance through an empirical examination in the Indian industry context.

Design/methodology/approach – Correlations are used to analyze the degree of relationship between constructs and to further understand the direct and indirect effects, as well as the moderating and mediating effects among the constructs in model, structural equation modeling is conducted using AMOS 6.0 on data collected from Indian industries.

Findings – This study proves the positive relationship between Six Sigma and organizational learning. It also confirms that Six Sigma role structure and Six Sigma focus on metrics contributes positively to organizational innovation, however, Six Sigma structured improvement procedure was found to be negatively related to organizational innovation, thus contributing to Six Sigma-Innovation Paradox. This study also rejects moderating effects of organizational type between Six Sigma and organizational learning.

Research limitations/implications – Cultural context is a critical factor not only on Six Sigma, but also organizational learning, and organization innovation for investigating hence future study should consider this aspect. This research suggests the need for more intensive research to explore in more depth the relationship between Six Sigma structured improvement procedure, and the administrative and the technical innovation to identify the existence of potentially mediating variables in order to understand what is named the Six Sigma-Innovation Paradox.

Practical implications – The findings are useful for business managers in developing countries such as India, who want to enhance business performance through implementing Six Sigma practices that support their firm's product and services innovation efforts.

Originality/value – The study has contributed to establishing an empirical research between Six Sigma, organizational learning and organizational innovations that facilitates more quality management research in developing countries. It has contributed to clarifying the disputed relationship between Six Sigma practices and the firm's learning and innovativeness, and shows empirical evidence in India to confirm that the Six Sigma practices deployed by a firm has a positive impact on its organizational learning. Six Sigma focuses on role structure and metrics contributed positively to innovation, however the Six Sigma effect of procedure on organizational innovation is negatively related, thus opening new areas of Six Sigma-Innovation Paradox.

Keywords Six Sigma, Organization learning, Innovation, Organizational culture, Structural equation modeling, India

Paper type Research paper

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1. Introduction

Numerous researchers have avowed that the Six Sigma strategy is a potentially useful tool for fostering learning and escalating a company's competitive advantage. Fast changing markets require the progress of technological innovation, and shorter product lifecycles always challenge the competitive advantage (Baker and Sinkula, 1999; Prajogo and Sohal, 2003; Tidd *et al.*, 1997). As pointed out by Nonaka and Takeuchi (1995) and Bontis *et al.* (2002), the learning ability can stimulate organizational innovation capability and maintain a competitive advantage in tumultuous environments. Deming (1986) states that learning encourages innovation activities, and "quality" is the principal determinant of success in competitive environments. As a result, enterprises can sustain a competitive advantage by continually reproducing of Six Sigma. In addition, above quantitative studies only focused on three types of firms. Some studies indicate a relationship between organizational learning and innovation (Baker and Sinkula, 1999; Hung *et al.*, 2009). As a result, both Six Sigma and organizational learning can independently and effectively encourage innovation. Nonetheless, no previous empirical studies investigate whether organizational learning mediates Six Sigma and innovation performance moderated by type of organization.

The rationale of this study is to scrutinize four things:

(1) Determining the relationships between Six Sigma, organizational type, organizational learning, and innovation performance.

(2) Investigating if organizational learning advance innovation performance play a mediating role between Six Sigma and innovation performance.

(3) Probing the moderating effects of organizational types between Six Sigma and organizational learning.

(4) Testing a proposed model to explain the relationships among Six Sigma, organizational type, organizational learning, and innovation performance through an empirical examination.

2. Theoretical frame work

2.1 Six Sigma

Six Sigma is a new approach to quality management (Su *et al.*, 2006; Kumar *et al.*, 2008). Six Sigma was initiated by Motorola Inc. in the 1980s and has been defined as:

> [. . .] 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. 195).

Some argue that Six Sigma is just a repackaging of TQM (Stamatis, 2000) and that "TQM makes many of the same claims that Six Sigma makes and with some justification" (Flott, 2000, p. 43). However, recent research suggests that Six Sigma introduces new and distinct concept and practices into quality management. In a grounded-theory-based search for the essence of Six Sigma, Schroeder *et al.* (2008) argued that although Six Sigma shares the tools and techniques with traditional quality management methods, it provides an organizational structure not previously seen. They suggested that Six Sigma presents "an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic

objectives" (Schroeder *et al.*, 2008, p. 5). In addition, Zu *et al.* (2008) empirically identified three distinctive practices essential for applying Six Sigma principles and methods, which are Six Sigma role structure, Six Sigma structured improvement procedure, and Six Sigma focus on metrics. Other research about the critical success factors for Six Sigma implementation also supports the existence of these Six Sigma practices (Nonthaleerak and Hendry, 2008; Szeto and Tsang, 2005).

2.2 Organizational learning

Liaoa *et al.* (2008) states that all humans are born with the ability to learn and it is through learning that they adapt to the changing and evolving environment. Learning leads to new insights and concepts. It often occurs when we take effective actions and when we detect and correct our own mistakes (Argyris and Schon, 1978). As regards to the learning of an organization, Morgan and Ramirez (1983) suggest that organizational learning occurs when members use learning to solve a common problem they are facing. Every organization will develop the most suitable learning method taking into consideration the needs and characteristics of the organization itself (Helleloid and Simonin, 1994). There are two types of organizational learning commonly discussed in the literature. First, exploitative learning (March, 1991) is the acquisition of new behavioral capacities framed within existing insights. Exploitative learning is described in the literature as "single-loop"(Argyris and Schon, 1978, 1996), "operational" (Coopey, 1996), "first-order" (Fox-Wolfgramm *et al.*, 1998), "evolutional", "frame-taking", "reactive" (Weick and Westley, 1996) and "incremental" (Miner and Mezias, 1996).

Second, explorative learning (March, 1991) occurs when organizations acquire behavioral capacities that differ fundamentally from existing insights. Exploration is about discovery, variation, effectiveness, flexibility and innovation (March, 1991; Weick and Westley, 1996). This type of organizational learning is referred to as "double-loop" (Argyris and Schon, 1978, 1996), "strategic" (Coopey, 1996), "second-order" (Fox-Wolfgramm *et al.*, 1998),"revolutionary", "frame-breaking", "proactive" (Weick and Westley, 1996) and "radical" (Miner and Mezias, 1996). Different organizational structures are conducive to different types of learning. Mechanistic structures with tightly coupled relationships between actors foster exploitative learning in stable contexts, while organic structures with loosely coupled relationships are favorable to the occurrence of explorative learning in changing contexts (Burns and Stalker, 1961; Weick and Westley, 1996; Rowley *et al.*, 2000; Hansen *et al.*, 2001). In addition, Clegg *et al.* (2005) propose a perspective that sees learning not as something that is done to organizations, or as something that an organization does; rather, learning and organizing are seen as mutually constitutive and unstable, yet pragmatic, constructs that might enable a dynamic appreciation of organizational life. Therefore, in a long-term development, organizational learning may contain both natures of exploitative and exploration learning on different organization types and development stages in order to keep organization constantly growth. On the other hand, Kim (1993) and Morgan (1997) describe the learning process as the acquisition, interpretation and implementation of new knowledge; and similarly Huber (1991) identifies it as the acquisition, dissemination, interpretation and storage of new knowledge. Argote (1999) view that organizational learning involves three stages: acquisition, sharing and storage. Interpretation is not seen as a discrete stage but more as an activity arising throughout the learning process. Furthermore, implementation is not a necessary element of the process

since as learning refers to the evolution of cognitive capacities, which may or may not lead to action. Therefore, a learning organization has the ability to continuously adjust to new situations and to renew itself according to the demands of the environment (Jaw and Liu, 2003). To enhance its capability to learn, an organization should establish a system where individual learning can be shared among members (Tsang, 1997). Learning by an individual forms the basis of organizational learning; it is through individual learning that an organization will also learn as a whole (Grant, 1996). However, Adams *et al.* (1998) identify inertia as a barrier that hinders an organization's capabilities for learning about markets for new product development. In addition, knowledge inertia may inhibit the learning ability of an individual (Liao, 2002). This may in turn affect organizational learning.

2.3 Six Sigma and organizational learning

Senge (1990) argued that since a corporation cannot achieve a state of sustainable excellence, they require continuous learning while pursuing quality excellence.

Six Sigma entail a radical change in the way that an organization does its business (Rajamanoharan and Collier, 2006; Reger *et al.*, 1994). Employees' attitudes and behaviors are critical for implementing the changes entailed in implementing quality management programs (Van De Wiele *et al.*, 1993). Wiklund and Wiklund (2002) opinions, that without organizational learning there can be no continuous improvement. One of the most important stages in the quality planning process is the implementation stage, and so also in Six Sigma. Education, training and participation are factors that are critical in such a process (James, 1996). Everyone's commitment to the Six Sigma programme should be the natural driving force for managers at all company levels. As pointed out in Senge *et al.* (1994), however, neither training nor team training will be successful unless reinforced by the regular follow-up of an ongoing, systematic change in how work is conducted. Wiklund and Karlsson (1997) also discuss this, and they state that lack of quality learning causes insufficient implementation of quality methods. They define quality learning as the learning necessary for a permanent change in the way of working that is adequate for quality achievements, including both knowledge and ideology. Process consultation (Argyris, 1970) is the primary strategy of organizational development. The most important qualities of a process consultant are described in Porras and Silvers (1991) through four main sets of characteristics: interpersonal competence, theory-based problem-solving capabilities, the ability to create learning experiences and the awareness of one' s own assumptions and models. While an expert consultant is highly competent in the current subject area and is the problem-solver, in process consultancy in contrast to expert consultancy, it is the client him/herself who makes the decisions. Hence, necessary conditions for learning in accordance to Kolb's(1976) learning cycle are created. Thus, our first hypothesis is stated as:

H1. Six Sigma is positively related to organizational learning.

2.4 Innovation performance

Innovation can occur in three broad domains; products, processes, and organizations, and is:

> [. . .] an idea, product or process, system or device that is perceived to be new to an individual, a group of people or firms, an industrial sector, or a society as a whole (Rogers, 1995, p. 11).

According to Damanpour (1991), organizational innovation combines the development and implementation of new ideas, systems, products, or technologies. In competitive markets, enterprises must increase their knowledge to adapt to new products and technology, and continuously distribute this knowledge to all employees. Based on an organization's internal factors, the nature of innovation can involve technical, product, and process innovation. These internal factors include knowledge and skill resources, physical and management systems, and values and norms. The external factors include customers, competitors, statutes, and technology. A considerable debate exists regarding how to best measure innovation performance (Kanji, 1996; Prajogo and Sohal, 2003).

2.5 Organizational learning and innovative performance

Numerous studies show that cultures that promote organizational learning improve individual, team, and organizational learning, and as a result, improve organizational performance (Egan *et al.*, 2004; Ellinger *et al.*, 2002). From the perspective of organizational learning, the concrete output via knowledge capacity promotes innovative performance. Consequently, innovation often stems from knowledge absorption in the research and design (R&D) and other corporate units (Mansfield, 1983). The learning ability of employees enhances absorption and assimilation of internal information (Cohen and Levinthal, 1990). It also improves an organization's ability to learn and promotes innovation activity efficiency, efficacy, and capabilities (Dodgeson, 1993). Rothaermel and Deeds (2004) showed that promoting learning from a relationship with external partners, positively affected new product development and innovation. According to Baker and Sinkula (1999), companies with learning orientation can scan the external environment for new technological paradigms that result in innovation. Implementing a market-oriented perspective to examine the impact of organizational learning on performance shows that organizational learning improves sales, profit growth, customer satisfaction, and innovation. Companies promote new product development by generating organizational value in learning and actively encouraging employees to collect market data and share/exchange it unselfishly. In addition, innovation itself becomes a process for solving existing problems. Argyris and Schon (1978) suggested that problem solving is a learning process that integrates diverse knowledge types and becomes a basis for establishing knowledge. Acquiring new knowledge is the primary innovation resource (Nonaka and Takeuchi, 1995; Teece *et al.*, 1997). Consequently, whether knowledge flows freely, or organizations utilize existing knowledge to develop new ideas, it promotes productivity and stimulates creation (Davenport and Prusak, 1998). Some empirical studies demonstrate a positive relationship between the creation of new knowledge, and the performance of a firm (Bontis *et al.*, 2002; Tippins and Sohi, 2003). This study proposes that promoting organizational learning improves knowledge capability and enhances innovation performance. Thus, our second hypothesis is stated as:

H2. Organizational learning is positively related in organizational performance.

2.6 Six Sigma and innovative performance

Christensen (2002) believes that innovation is not random; its outcomes only appear to be random because we do not understand all the factors, such as management strategies, degree of company integration, capabilities, and resources, that affect

successful innovation. If we can use Six Sigma to master these variables, the products, processes, and services created will have more predictable outcomes. This implies that Six Sigma can also serve to eliminate waste of time and resources in the conception process by linking it directly to customer wants and needs. Barry Siadat, AlliedSignal's chief growth officer feels that Six Sigma will shorten cycle time and increase speed to market, and finally, it will reduce costs ("Six Sigma secrets," 1998). These sentiments are reflected by Daniel Laux, president of Six Sigma Academy, who feels that Six Sigma can now be applied to all industries and all functions and can even be used in R&D to find innovative products (Gilbert, 2002). With a Six Sigma approach, researchers first find what the customer wants and then look at the process capability study (Sauer, 2001). Then the customer's need and problems can be clearly defined and non-value work eliminated (Management Innovation, 2000), thereby shortening the innovation process. Implementing a customer-focused action induces continual research into customer needs can result in organization development and new product development (Juran, 1988). Continual improvement promoted by organizations can stimulate organization members to creatively evaluate how tasks are organized and performed (Prajogo and Sohal, 2003). Finally, the commitment of top management and employee involvement is also critical to the success of organizational innovation. Consequently, whether or not enterprises introduce Six Sigma directly affects innovation performance. Quality management is not only an important foundation of innovation development, but also a key catalyst in the innovation process (McAdam *et al.*, 1998). In sum, many scholars studying innovation management suggest that the context of innovation management was similar to, Six Sigma (Tidd *et al.*, 1997). Thus, our third hypothesis is stated as:

H3. Six Sigma is positively related to organizational innovation.

2.7 Moderating effect of organization type

Different types of organizations have different organization cultures, which in turn influence organizational learning (Chou, 2003). A study by Hult *et al.* (2003) examined four organization types with different combinations of scale and history, and find that a larger organization with a longer history has better performance in organizational learning. Above literature reviews have shown that different organization types have different cultures, which may in turn influence organizational learning. Hence, our fourth hypothesis probes the influence of organization type on organizational learning and organizational innovation. Thus, our fourth hypothesis is stated as:

H4. Organization type has a moderating effect on the impact of Six Sigma on organizational learning and innovation.

The Figure 1 shows the conceptual model which will be used for the study.

3. Research methodology

3.1 Sample

After pretest and amendment, questionnaires were sent out to selected respondents. According to the maximum likelihood estimation (MLE), in order for the sample to be effectual the number of respondents should be between 100 and 150 (Ding *et al.*, 1995). The sample encompasses three organization types, namely public limited companies, private limited companies and private SME enterprises. A total of 1,200 questionnaires

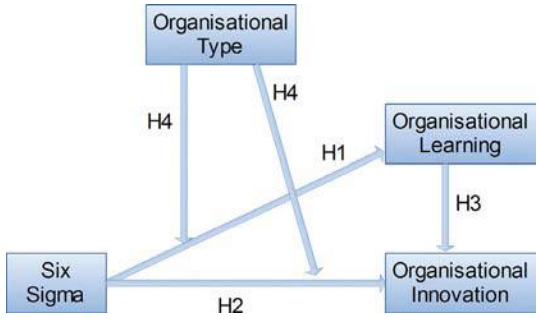

Figure 1.
Conceptual model

were sent out, 400 to each organization type. To ensure that the sample is representative, equal numbers of organizations at north, south, east and west regions of India were included. Private limited companies and private SME enterprises were randomly chosen from 900 and 650 of these enterprises, respectively, listed under the manufacturing and servicing sectors list of company databases in India. Since the top administrators provide reliable information regarding the basic environmental and organizational characteristics of their organizations (Mintzberg and Waters, 1985), senior managers or firm presidents represent the most appropriate sources of information for this study. A questionnaire and cover letter was mailed to the managing director or chief executive officer of each company. This study employed a variety of methods to encourage respondents to complete and return the questionnaires, such as follow-up telephone calls, faxes, and personal connections. To know whether the effect of non-response bias is significant between those who responded early, with those who responded late, this study performed both χ^2-tests and *t*-tests. The null hypothesis of this analysis is that an early respondent has the same characteristics as a late respondent. The observed significant level p for all variables is much higher than 0.05. This indicates that in this study, the extent of a non-response bias is insignificant, and the results adjust to the sampling frame. A total of 1,200 questionnaires were sent out, there were a total of 495 valid responses, for an effective response rate of 41 percent (Table I). Names of all organizations are withheld as per conditions of survey.

3.2 Establishing measures for Six Sigma

Three Six Sigma practices developed by Zu *et al.* (2010) by reviewing the practitioner publications (Bhote, 2003; Breyfogle *et al.*, 2001; George, 2003; Pande *et al.*, 2000, 2002) and the academic research (Choo *et al.*, 2004; Linderman *et al.*, 2003; Schroeder and Harry, 2000) are used in this research. Items were measured on seven-point Likert scales with end points of "strongly disagree (1)" and "strongly agree (7)". The three practices measured were Six Sigma role structures, Six Sigma structures improvement procedure and Six Sigma focus on metrics was used.

3.3 Operational definition and measures of research variables

Table II lists the operational definitions of the three variables, namely Six Sigma, organizational learning and organizational innovation.

Units	Organizational name code/types	Sampling no.	Valid no.
1	A, (public limited companies)	50	26
2	B, (public limited companies)	50	24
3	C, (public limited companies)	50	18
4	D, (public limited companies)	50	13
5	E, (public limited companies)	50	16
6	F, (public limited companies)	50	22
7	G, (public limited companies)	50	18
8	H, (public limited companies)	50	19
9	I, (private limited companies)	50	13
10	J, (private limited companies)	50	22
11	K, (private limited companies)	50	19
12	L, (private limited companies)	50	21
13	M, (private limited companies)	50	23
14	N, (private limited companies)	50	27
15	O, (private limited companies)	50	20
16	P, (private limited companies)	50	24
17	Q, (private SME enterprises)	50	18
18	R, (private SME enterprises)	50	20
19	S, (private SME enterprises)	50	17
20	T, (private SME enterprises)	50	24
21	U, (private SME enterprises)	50	27
22	V, (private SME enterprises)	50	18
23	W, (private SME enterprises)	50	24
24	X, (private SME enterprises)	50	22
	Total	1,200	495

Table I.
Organizational samples and responses

3.4 Questionnaire development

3.4.1 Reliability analysis. Reliability of a construct refers to the consistency and stability of the questions. Table III lists the Cronbach's α of the constructs. All constructs have Cronbach's α above 0.7, which indicates high reliability (Nunnally, 1978).

3.4.2 Validity analysis

- *Convergent validity*. Table IV displays the parameter estimates of the constructs and their corresponding *t*-values. As can be seen, all constructs have *t*-values greater than 2, revealing good convergent validity.
- *Discriminant validity*. Anderson and Gerbing (1988) suggest the following procedure to test the discriminant validity of a variable: first, the constructs of a variable are set to be correlated and be termed the unconstrained model. Second, the unconstrained model is modified with one of correlations set to be 1.0 and then to be call constrained model. If the χ^2 difference between the two models is significant, this implies that the two constructs of the variable are different significantly and should not be merged as one construct. It can be noted that all the χ^2 differences between two constructs in Table V are significant; therefore, the discriminant validities are verified.

3.4.3 Correlation analysis. Table VI displays the means, standard deviations of constructs and their correlations. As can be seen, the following relationships exist between the research variables:

Variable	Operational definition of construct	No. of questions	Source
Six Sigma	Six Sigma role structure: the organization uses a group of improvement specialists who are developed through Six Sigma training and certification programs and ranks based on their expertise	6	Zu *et al.* (2010)
	Six Sigma structured improvement procedure: there is an emphasis on following a standardized procedure in planning and conducting improvement projects. Teams apply the appropriate QM tools and techniques as prescribed in each step of the structured procedure	6	Zu *et al.* (2010)
	Six Sigma focus on metric: quantitative metrics are used to measure process performance and product quality performance, and to set improvement goals. Business-level performance measures and customer expectations are integrated with process-level performance measures	13	Zu *et al.* (2010)
Organizational learning	Commitment to learning: organization regards learning as its most important basic value.	6	Baker and Sinkula (1999) and Lin (2001)
	Shared vision: organization chiefs share future vision with its members	6	
	Open-mindedness: organization does not stick to its old way of thinking but embrace innovative ideas	5	
Organizational innovation	Administrative innovation: innovative operations with respect to planning, organization personnel, leadership, management and service	9	Daft (1982) and Tsai (1997)
	Technical innovation: innovations with respect to products, manufacturing and facilities	7	

Table II.
Operational definition of variables

Variable	Construct	No. of questions	Cronbach' α
Six Sigma	Six Sigma role structure	6	0.984
	Six Sigma structured improvement procedure	6	0.973
	Six Sigma focus on metric	13	0.964
Organizational learning	Commitment to learning	6	0.861
	Shared vision	6	0.882
	Open-mindedness	5	0.823
Organizational innovation	Administrative innovation	9	0.907
	Technical innovation	7	0.870

Table III.
No. of questions for each construct and its Cronbach's α

- Relationship between Six Sigma and organizational learning: Six Sigma role structure is positively related to organizational learning, meaning that organization uses of group of improvement specialists who are developed through Six Sigma training and certification programs and ranks based on their expertise indeed contribute to organizational learning. Six Sigma structured improvement procedure and Six Sigma focus on metric, is also found to be positively related to organizational learning meaning that the standardized procedure in planning and

Table IV.
Convergent validity of constructs

Variable	Construct	No. of questions	Estimate	*t*-value
Six Sigma	Six Sigma role structure	6	0.301-0.444	9.431-13.440
	Six Sigma structured improvement procedure	6	0.230-0.402	6.187-9.296
	Six Sigma focus on metric	13	0.290-0.401	7.484-10.257
Organizational learning	Commitment to learning	6	0.484-0.682	13.332-18.881
	Shared vision	6	0.592-0.754	16.143-22.541
	Open-mindedness	5	0.422-0.727	11.044-21.366
Organizational innovation	Administrative innovation	9	0.524-0.710	15.593-20.660
	Technical innovation	7	0.372-0.661	11.948-21.755

Table V.
Discriminant validity of constructs

Variable	Model	χ^2	df	$\Delta\chi^2$
Six Sigma	Unconstrained model	299.54	76	–
	1. Six Sigma role structure – Six Sigma structured improvement procedure	373.81	74	77**
	2. Six Sigma role structure – Six Sigma focus on metric	378.53	76	74.87**
	3. Six Sigma structured improvement procedure – Six Sigma focus on metric	381.32	78	76.25**
Organizational learning	Unconstrained model	614.408	116	–
	1. Commitment to learning-shared vision	690.655	117	76.247**
	2. Commitment to learning-open-mindedness	641.388	117	26.98**
	3. Shared vision-open-mindedness	620.109	117	5.701**
Organizational Innovation	Unconstrained model	308.644	89	–
	1. Administrative innovation-technical innovation	348.664	90	40.138**

Notes: Significant at: *p-value < 0.05, **p-value < 0.01 levels; $\Delta\chi^2 = \chi^2$ (unconstrained model) $- \Delta\chi^2$(constrained model); A-B implies that constructs A and B are set to be completely correlated

Table VI.
Correlation matrix

Constricts	Mean	SD	1	2	3	4	5	6	7	8
1. Six Sigma role structure	2.124	0.743	1.79							
2. Six Sigma structured improvement procedure	3.507	0.894	−0.29*	0.64						
3. Six Sigma focus on metric	3.752	0.812	−0.37	0.24*	0.73					
4. Commitment to learning	3.498	0.795	0.42*	0.23*	0.26*	0.81				
5. Shared vision	3.538	0.849	1.4*	0.22*	0.27*	0.72*	0.85			
6. Open-mindedness	3.609	0.876	0.38*	0.25*	0.38*	0.76*	0.81*	0.81		
7. Administrative innovation	3.866	0.862	0.41*	−0.18*	0.29*	0.77*	0.79*	0.82*	0.90	
8. Technical innovation	3.876	0.795	0.45*	−0.21*	0.33	0.71*	0.74*	0.82*	0.86*	0.84

conducting improvement projects, appropriate QM tools and techniques as prescribed in each step of the structured procedure and quantitative metrics used to measure process performance and product quality performance, and to set improvement goals all contribute to organization learning.

- Relationship between Six Sigma and organizational innovativeness: Six Sigma role structure is positively related to organizational innovations meaning that the improvement specialist executing Six Sigma does contribute to organizational Innovations. On the contrary Six Sigma structured improvement procedure is negatively related to organizational Innovativeness meaning the structured improvement stratergy impedes innovation. This is What we call Six Sigma-Innovation Paradox.
- Relationship between organizational learning and organizational innovativeness commitment to learning, shared vision and open-mindedness all show positive correlation with both administration and technical innovation. This implies that high organizational learning can foster organizational innovation.

As it is well known that correlations can only disclose the degree of relationship between constructs. To further understand the direct and indirect effects, as well as the moderating and mediating effects among the constructs, further analysis by structural equation model is required

3.4.4 Structural equation model

- *Partially mediating model (theoretical model).* This examines the impact of Six Sigma on organizational learning and organizational innovation and explores the direct influence of organizational learning on organizational innovation.
- *Direct model.* This examines the direct impact of Six Sigma and organizational learning on organizational innovation.
- *Completely mediating model.* This model assumes that the organizational learning is the mediating variable between Six Sigma and organizational innovation (Figure 2).

As shown in Table VII, the completely mediating model has the smallest χ^2-value 3.878 and is the only model that χ^2-value and degree of freedom are close to each other. The completely mediating model also possesses the largest overall model fit index GFI, NFI, CFI and the smallest RMSR (0.996, 0.999, 1.000, 0.008, respectively). Therefore, the completely mediating model has the best-fitted model compared to the partially mediating model and the direct model. This result indicates that the influence of the Six Sigma on organizational innovation occurs by way of organizational learning.

The path parameters (γ and β) of the completely mediating model are estimated by the MLE method. The MLEs of the parameters are shown in Table VIII. The *t*- values of these estimates are all significant (>2) under significant level 0.05.

The model estimation results reveal the following relationships among three research variables:

(1) *Relationship between Six Sigma and organizational learning.* As seen in Table VIII, parameter estimates of the hypothesized relationships between Six Sigma role structure and the three constructs of organizational learning positive and significant, indicating positive impact of Six Sigma role structure on

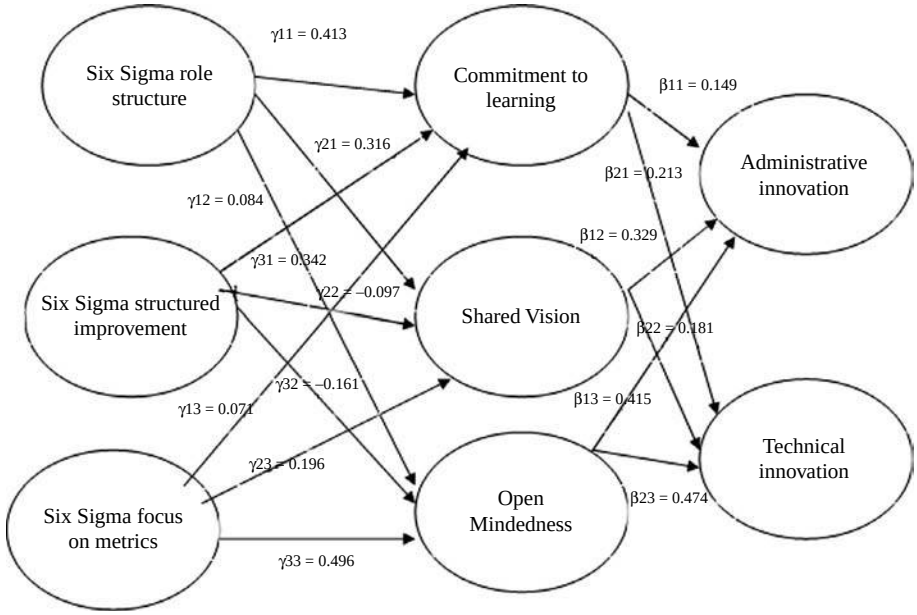

Figure 2.
Path diagram of mediating variables

Model	χ	$\Delta\chi^2$	df	GFI	NFI	CFI	RMSR
1) Partially mediating model	171.94	–	1	0.912	0.972	0.982	0.033
2) Direct model	108.98	63.04**	6	0.948	0.967	0.978	0.176
3) Completely model	3.878	I68.37**	4	0.997	0.999	1.0	0.008

Notes: Significant at: *p-value 0.05 ($\chi^2 = 3.84$), **p-value $<$0.0l ($\Delta\chi^2 = 6.63$); $\Delta\chi^2$ is based on partially mediating model

Table VII.
Model comparisons among direct, partially mediating, and completely mediating models

organization learning. On the other hand the parameter estimates of Six Sigma improvement procedure on commitment to learning is positive and significant, however, Six Sigma improvement procedure over shared vision and open-mindedness is not supported, hence *H1* is partially supported.

(2) *Relationship between organizational learning and organizational innovation.* As seen in Table VIII, parameter estimates of the hypothesized relationships between the three constructs of organizational learning and the two constructs of organizational innovation are positive and significant, indicating positive impact of organizational learning on organizational innovation. In other words, higher organizational learning ability will lead to better performance in administrative and technical innovation; hence *H3* is supported (Figure 2).

3.4.5 Moderating effect of organization type. To facilitate further understanding whether or not the path parameters will be influenced by the group variable (organization type), Jaccard and Wan's (1996) multi-group method is adopted to test the moderating effect of organization type. The hypothesized model assumes that the path parameters of the three

Path hypothesis		Parameter estimate	*t*-value
Six Sigma role structure → commitment to learning	γ11	0.413*	6.419
Six Sigma improvement procedure → commitment to learning	γ12	0.084*	2.314
Six Sigma Focus on Meirics → commiment to learning	γ13	0.071	3.154
Six Sigma role structure → shared vision	γ21	0.316*	5.164
Six Sigma impovement procedure → shared vision	γ22	−0.097*	−2.161
Six Sigma focus on metrics → sna red vision	γ23	0.196*	3.217
Six Sigma role structure → open-mindedness	γ31	0.342*	7.194
Six Sigma improvement procedure → open-mindedness	γ32	−0.161	−4.167
Six Sigma focus on metrics → open-mindedness	γ33	0.496	3.784
Commitment to learning → administrative innovation	β11	0.149*	3.656
Shared vision → administrative innovation	βI2	0.329*	6.486
Open-mindedness → administrative innovation	β13	0.415*	8.427
Commiment to learning → technical innovation	β21	0.213*	4.742
Shared vision → technical innovation	β22	0.181*	3.681
Open-mindedness → technical innovaiion	β23	0.474*	9.236

Notes: $\chi^2 = 3.878$, GFI = 0.997, NFI = 0.997, CFI-1.0, $RMS_r = 0.008$; *T > l.96

Table VIII.
MLE of path parameters

organizations are the same. The alternative model assumes that path parameters of the three organizations are the same with the exception of only one path parameter. In case the χ^2 difference between the hypothesized model and the alternative model is greater than the critical value $\chi^2_{1\_}\alpha$ (2) (5.99 and 9.21 for a = 0.05 and 0.01, respectively), it will indicate that the moderating effect of the organization type will be significant significant. What's more, if the moderating effect does exist, there should be further discussion about the path parameters of the three types of organizations.

The Table IX posits this analysis and it is revealed that organization type does not have moderating effect on the organizational learning. In other words, no matter what the type of organization, in this case public limited companies, private limited companies and private SME's, the effect on organizational learning and innovation. Hence from this it is proved that *H4* is not supported.

4. Implications and contributions

- Our findings reveal that Six Sigma exerts a complete mediating effect on organizational innovation through organization learning. Hence, when assessing and formulating measures for promoting organizational innovation, organizations should consider the mediator variable of organizational learning to avoid misjudgment and achieve better performance.
- The results in our research has established a positive relationship between Six Sigma and organizational learning. Six Sigma role structure, Six Sigma structured improvement procedure and Six Sigma focus on metric, is found to be positively related to organizational learning. This provides empirical evidence for views put forth by Hakan and Pia (2002), Leopoldo *et al.* (2009) and Rodney and Hazlett (2010).

Path/hypothesis		Organization type 1 Public limited companies ($n = 156$)	2 Private limited companies ($n = 169$)	3 Private SME ($n = 170$)	χ^2	$\Delta\chi^2$
Six Sigma role structure → commitment to learning	γ11	−0.392*	−0.386*	0.371*	114.6	0.18
Six Sigma improvement procedure → commitment to learning	γ12	0.085	0.074	0.132*	113.44	1.34
Six Sigma focus on metrics → commitment to learning	γ13	0.084	0.387	0.0472	112.5	2.15
Six Sigma role structure → shared vision	γ21	−0.328*	−0.182*	−0.287*	109.96	4.82
Six Sigma improvement procedure → shared vision	γ22	0.145*	0.121*	0.062	112.03	1.85
Six Sigma focus on metrics → shared vision	γ23	−0.138*	0.237*	0.247*	114.04	1.45
Six Sigma role structure → open-mindedness	γ31	−0.364*	0.268*	0.467*	112.13	3.01
Six Sigma improvement procedure → open-mindedness	γ32	−0.219*	−0.319*	−0.287*	111.17	3.63
Six Sigma focus on metrics → open-mindedness	γ33	0.091	0.139*	0.167*	113.09	1.58

Table IX.
Moderating effect of organization type

Notes: Organization type column: *[T] > 1.96; hypothesized model: $\chi^2 = 114.78$, df = 54; Aye column: *p-value < 0.05 ($\Delta\chi^2 = 5.99$), **p-value < 0.01 ($\Delta\chi^2 = 9.21$)

- With respect to the first research question of whether Six Sigma practices, in general, support the organization innovation, our findings in indicate that Six Sigma focus on role structure and Six Sigma focus on metrics positively impacts on the administrative and technical innovation. In other words the use of improvement specialists developed through Six Sigma training and certification programs and ranked based on their expertise does positively contribute to administrative and organizational innovativeness. Similar views were expressed by Caroline and Raghu (2009) where they stated that innovation requires the coordinated efforts of many skilled actors. It is also found that quantitative metrics used to measure process performance and product quality performance, and to set improvement goals also positively effects organizational innovativeness thus supporting views expressed by Dobni (2008) and Desouza *et al.* (2009).
- A surprising finding, however was Six Sigma structured improvement procedure is negatively related to organization innovativeness. In other words standardized procedure in planning and conducting improvement projects, appropriate QM tools and techniques as prescribed in each step of the structured procedure, etc. is negatively related to organizational innovativeness. This provides a numerical evidence proposed for qualitative paper by Sanders (2007) on quality-creativity paradox. An argument by Goh (2002) that Six Sigma is

increasingly being touted as the route to organizational and business excellence, but it must be noted that it is hardly a formula for creativity, breakthrough or entrepreneurship is a relevant point to be considered in support of our research. Our result suggests the need for more intensive research to explore in more depth the relationship between Six Sigma structured improvement procedure, and the administrative and the technical innovation to identify the existence of potentially mediating variables in order to understand what we call Six Sigma-Innovation Paradox.

- A literature review has shown that there have been few studies on the role of organization type as a moderator. Different organization types when implementing Six Sigma have different cultures, which we believe may in turn influence organizational learning. To capture this we have considered three different types of organizations, public limited companies, private limited companies and private SME. Our study finds no evidence of organization type exerting moderating effect on the impact of Six Sigma on organizational learning. In other words, organization type will not change the relationship between Six Sigma and organizational learning in other words whatever the type of organization Six Sigma will promote organizational learning. Although the hypothesis is not supported by this study, the relationship between organization type and organizational learning merits further exploration.
- On the other hand, cultural context is a critical factor not only on Six Sigma, but also organizational learning, and organization innovation for investigating their relationships. However, the contextual' influence of a specific culture is not considered in the paper. Thus, authors might incorporate cultural context factor into the future study.
- Organizational learning and organizational innovativeness commitment to learning, shared vision and open-mindedness all show positive correlation with both administration and technical innovation. Thus, confirming with studies of Liaoa *et al.* (2008). This implies that high organizational learning can foster organizational innovation.
- In summary, when promoting organizational innovation, care must be taken to avoid Six Sigma structured improvement procedure not to negatively administrative and technical innovation, and efforts should be made to encourage innovative practices even while following structured quality improvement practices. Also encouragement for acquisition of new knowledge and exploring new ideas and approaches should be adequately rewarded.

5. Conclusion

This research examines the relationships between Six Sigma, organizational learning and organizational innovation and the impact of Six Sigma on organizational learning and organizational behavior. Our findings reveal that Six Sigma exerts a complete mediating effect on organizational innovation through organization learning. Six Sigma role structure, Six Sigma structured improvement methodology and focus on metrics enhances commitment to learning, shared vision and open-mindedness thereby promoting organizational learning. On the other hand, Six Sigma focus on role structure and metrics have positive effect on both administrative and

technical innovations. Thus, this paper suggest that when assessing and formulating measures like Six Sigma for promoting organizational innovation, organizations should consider the mediator variable of organizational learning to avoid misjudgment and achieve better performance. On the other hand, this study finds no evidence of organization type exerting moderating effect on the impact of Six Sigma on organizational learning. However, the relationship between organization type and organizational learning could merit further exploration on this research issue. The contributions of this study lie in offering new directions of exploration and widening the scope of Six Sigma, organizational learning and innovation.

6. Managerial Implications

Our study proposes considering that Six Sigma promotes organizational learning and organizational innovativeness because organizational learning and innovativeness jointly to promote organizational entrepreneurship and to increase competitive advantages. First, organizations must innovate as a necessary requisite to obtaining high performance levels. Understanding and managing the organizational innovativeness process becomes a vital capability that organizations must learn. Second, when implementing Six Sigma in organizations, organizational learning processes must be carried out to provide firms with a series of mechanisms through which to achieve advantages that the competitors find difficult to imitate, generating higher performance.

We empirically reflect the need to strengthen different strategic Six Sigma factors/capabilities to achieve an adequate level of both organizational learning and thus improve organizational innovation. More specifically, Six Sigma role structure or in other words use of certified Six Sigma experts encourages organizational learning and Innovations. This specifically effects organizational commitment to learning, shared vision and open-mindedness. Similar results were obtained on Six sigma structured improvement procedure and Six Sigma focus on metrics on all three dimensions of organizational learning.

Our study proves that Six Sigma role structure and focus on metrics positively effects organizational innovations. However, Six Sigma focus on structured improvement methodology negatively effects administrative and technical innovation. This proves organizations' managers have an important job to do, creating the conditions that facilitate the development of these strategic factors/capabilities for improving innovation. First, they must encourage the organization's members to achieve high levels of commitment to learning, since this development will enable them to take more initiative, to broaden and deepen their sense of responsibility for their work and to learn and innovate faster. They must work to foster a climate in which the principles of personal mastery are practiced. Nothing is more important to an individual committed to his own growth than a supportive environment. This environment can be provided by continually encouraging personal vision.

Second, they must encourage shared vision and open-mindedness as a style of management when implementing Six Sigma. Only so will consciousness and acceptance of the Six Sigma proposals and mission grow, creating a shared vision, open-mindedness and enabling the formulation of organizational strategies and structures that enable the organizations to confront the challenges of the knowledge society.

Third, an Six Sigma organizational commitment to organizational learning, shared vision and open-mindedness would be naive and foolish if organizational leaders

lacked the capability of building a shared vision. The leader must prepare the organization and shape the mental models. Without an effective awareness of the changes needed and a deep, genuine commitment by top management, moving toward this vision would be impossible. The firm's strong and weak points must be analyzed and its environment examined in order to question the organizations future and develop the strategy to reach it.

Four, the leader will play an important role in linking the Six Sigma, organizational learning and innovations. One must be ready to seize the opportunity for organizational innovativeness and organizational learning, and opportunity usually favors ready minds. Leaders can do a lot to prepare the organization's minds. They can create a context that legitimates innovative behavior and allocates resources to innovation and learning, a context whose structure/culture nurtures the development and implementation of both capabilities. Five, an organization that is inward-looking and unable to tackle changes proactively in the environment, due to Six Sigma implementation, would not survive, despite the sophisticated knowledge and technology it possesses. The managers' proactivity perception of the environment will determine the organization's innovation and learning behaviour. Thus, management must know and manage practically the strategic factors/capabilities that affect OI/OL and that lead to improvements in organizational performance. The essence of Six Sigma organizations is their ability not only to make themselves competitive but also to maintain their competitive position through innovation and learning. An organization that promotes entrepreneurship will learn and innovate, encouraged by the presence of key preexisting internal/external attributes that enable it to change, renew and reinvent itself.

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