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The impact of quality management practices on performance: an empirical study

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Received 19 November 2015
Revised 9 January 2016
Accepted 9 January 2016

Abstract

Purpose – The purpose of this paper is to explore the relationship between quality management (QM) and performance, specifically how the infrastructure and core QM practices affect quality and business performance, in Indian manufacturing organizations.

Design/methodology/approach – In this study, the empirical data were drawn from 262 manufacturing organizations in India. The research model was tested using the structural equation modeling technique.

Findings – The findings of the empirical study revealed that infrastructure QM practices have a positive effect on core QM practices and indirectly on quality performance, whereas, core QM practices have a positive effect on quality performance. Also, quality performance has a positive effect on business performance.

Research limitations/implications – This study considered QM from two dimensions (infrastructure and core quality practices), the study further contributes to the understanding of the different roles played by diverse QM dimensions in determining business performance in terms of increased return on investment, shareholder and stakeholder value.

Practical implications – The study showed that infrastructure quality practices support the application of core quality practices. Therefore, managers must develop and maintain their organization's quality system and sufficient resources need to be allocated to both types of practices in order to achieve the superior business performance.

Originality/value – This study considers both total quality management and Six Sigma practices for defining a new set of infrastructure and core QM practices in Indian manufacturing organizations.

Keywords Six Sigma, India, SEM, TQM, Quality performance, Quality practices

Paper type Research paper

1. Introduction

In the present world the major challenge for organizations is to meet the ever-increasing demands of the customer. This pushes many organizations to shift their manufacturing activities to the developing nations. They are either outsourcing their production to the organizations in the developing countries or establishing their own manufacturing bases in those countries. This has given rise to a new category of organizations in the developing countries which have acquired world class manufacturing practices and are also rated among the best. These manufacturing organizations are at par with the best in the world. They are continuously enhancing their performance by improving quality of their products and services through various quality management (QM) practices (Patyal and Koilakuntla, 2015b). The policy makers in these countries are also insisting on product quality, efficiency, and productivity for their manufacturing competitiveness. Recently, Government of India launched "Make in India" campaign that aims to increase the share of manufacturing in GDP from 16 to 25 percent by 2022 and create 100 million jobs (Quartz, 2016). There is a need to understand the role of QM practices in improving the performance of manufacturing organizations in these emerging economies.

QM provides a paradigm shift in management philosophy for improving the organization's effectiveness (Barker and Emery, 2006). QM improves labor productivity

Benchmarking: An International Journal
Vol. 24 No. 2, 2017
pp. 511-535
© Emerald Publishing Limited
1463-5771
DOI 10.1108/BIJ-11-2015-0109

and profitability in labor-intensive manufacturing organizations (Belay *et al.*, 2014). QM comprises observable aspects of quality. QM practices help in achieving quality goals and support managers in attaining quality improvement (Sousa and Voss, 2002). Moreover, contemporary insights given by Sinha *et al.* (2015) advocated that total quality management (TQM) is progressively more being implemented in emerging economies like India across many industries in pursuit of higher market share and enhanced customer satisfaction. This study considers both TQM and Six Sigma practices for defining a new set of infrastructure and core QM practices (Patyal and Koilakuntla, 2015a) in Indian manufacturing organizations.

The purpose of this study is to empirically determine the relationships between two dimensions of QM (infrastructure and core QM practices) and quality/business performance in Indian manufacturing organizations and to statistically analyze the results to finally yield a robust model that elucidates the interrelationship. The study intends to answer the following research questions:

RQ1. How do infrastructure QM practices relate to core QM practices?

RQ2. How do infrastructure and core QM practices relate to quality performance?

RQ3. How does quality performance relate to business performance?

The remainder of this paper is organized as follows. Section 2 discusses the theoretical background and the relationship between QM and performance, which helps to formulate the research hypotheses. Section 3 describes the research methodology, followed by the presentation of results and data analysis in Section 4. The findings and discussion have been outlined in Section 5. Penultimate section contains conclusions and research implications followed by limitations and future research directions.

2. Theoretical background and hypotheses development

Flynn *et al.* (1995) have outlined the categorization of QM practices into core and infrastructure. This categorization effectively examined the complex relationships between QM practices and performance (Sousa and Voss, 2002). In the case of core QM practices, the aspect of QM involves a range of production techniques such as statistical process control and quality function deployment, reflecting the production orientation of the QM gurus. On the other hand, infrastructure QM is more concerned with customer awareness and the management of human resources (Flynn *et al.*, 1995). The prior literature on QM stands undecided on how different QM practices, specifically infrastructure and core QM practices, affect performance (Sousa and Voss, 2002). According to Zu (2009), the mixed results of both (infrastructure and core) QM practices and performance might be due to arbitrary categorizations of QM practices, different levels of performance measures, and use of diverse analytical methods. The confounding categorization of both infrastructure and core QM practices is evident in several studies (Ho *et al.*, 2001; Taylor and Wright, 2006; Zeng *et al.*, 2015). A few studies have attempted to formulate the interrelationship between infrastructure and core QM practices and how either impacts quality and business performance. For instance, Naor *et al.* (2008) reported that infrastructure QM practices have a greater impact on manufacturing performance than core QM practices, and infrastructure QM practices do not affect core quality practices, positively impacting performance without their presence. Contrastingly, Zu (2009) mentioned that core QM directly leads to improved quality performance and the infrastructure QM contributes to quality performance by supporting the core QM. This observation was reconfirmed by Zeng *et al.* (2015). Hence, it may be concluded that the above mentioned studies have shown mixed results and are therefore, inadequate for drawing any definite conclusions about which dimension is more important to yield superior performance in QM practices-performance relationships (Kaynak, 2003; Sousa and Voss, 2002).

The literature remains equivocal regarding the relation between QM practices and performance. Several authors such as Dow *et al.* (1999), Powell (1995), Samson and Terziovski (1999) stated that infrastructure QM practices are stronger predictors of performance than core QM practices. Ho *et al.* (2001) reported that core QM practices completely mediated the effect of supportive QM practices on quality performance. The results of Rahman and Bullock (2005) demonstrated a partial mediating effect of hard QM on the relationship between soft QM and performance. Also, Dubey and Gunasekaran (2015) mentioned that soft quality dimensions, such as human resource, quality culture, motivational leadership, and relationship management are important for successful implementation of TQM. Zu *et al.* (2008) integrated, through an empirical study, three new Six Sigma practices to the existing set of QM practices. These practices are Six Sigma role structure, Six Sigma structural improvement procedure, and Six Sigma focus on metrics (Zu *et al.*, 2008; Shafer and Moeller, 2012). Recently, Patyal and Koilakuntla (2015a) added three distinct Six Sigma practices given by Zu *et al.* (2008) to the existing set of infrastructure and core QM practices and tested the same in the context of Indian manufacturing organizations. Figure 1 shows the proposed relationships between infrastructure quality practices and core quality practices, and quality and business performance.

2.1 The relationship between infrastructure and core QM practices

Kaynak (2003) mentioned that management leadership is necessary when the effectiveness of QM implementation is investigated. Also, organizations with high levels of top management commitment produce advanced quality products. Management provides the resources essential for training, employee relations, supplier QM, and product design, and is indirectly related to quality data, reporting, and process management (Kaynak, 2003). Top management allocates the necessary resources to improve the product and process design and is also responsible for leading the product and process design practices. It lays emphasis on market and consumer needs (Kaynak, 2003). Strategic partnership with key suppliers is essential to realize continuous improvement (Hackman and Wageman, 1995). A few suppliers improve quality and productivity by creating supplier commitment to

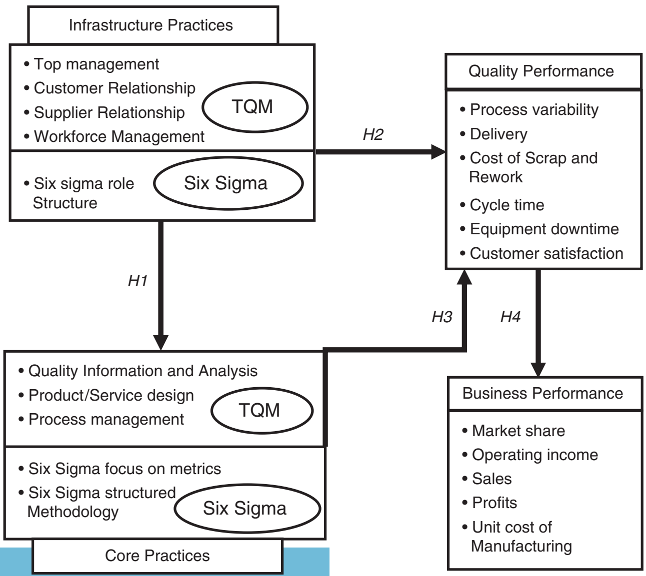

Figure 1.
Proposed conceptual model

product design and quality (Kaynak, 2003). Also, improved supplier relationship enhances process management, which may provide inputs about product or component simplification and standardization and the capabilities of prospective materials and parts (Forza and Filippini, 1998; Kaynak, 2003). Successful customer and supplier cooperation can create inventory reduction benefits (Naor *et al.*, 2008). Six Sigma role structure enhances the traditional workforce management practices and strengthens human resource planning and management (Zu *et al.*, 2008). Also, it encourages employee involvement in QM and supports the use of Six Sigma structured improvement procedure. The infrastructure quality practices stress on a learning and cooperative organizational environment through supporting top management commitment, meeting customer needs and wants, sustaining competent, reliable and flexible suppliers, and encouraging employee involvement in quality decision making with training and empowerment, which is likely to support the application of the core quality practices (Flynn *et al.*, 1995; Rahman and Bullock, 2005). Also, as discussed above, several previous studies tend to model QM practices-performance relationships in a sequence from infrastructure QM practices to core QM practices, up to quality performance and have found an empirical proof that the infrastructure QM facilitates the implementation of core QM. Thus, a comprehensive infrastructure QM system may develop a corporate culture of autonomy, cooperation, and teamwork, which provides an organizational support for the successful implementation of QM techniques and tools (Zeng *et al.*, 2015). Thus, the literature discussed above leads to the following hypothesis:

H1. Infrastructure QM practices positively affect core QM practices.

2.2 Relationship between infrastructure QM practices and quality performance

Infrastructure QM practices focus on establishing a learning and cooperative environment and involvement and commitment of management and employees toward training, learning, and internal cooperation or teamwork promoting the human aspects of the system for QM implementation (Ho *et al.*, 2001; Sousa and Voss, 2002; Zu, 2009). Various authors have mentioned that the foundation of QM practices is laid by the top management. According to Parast *et al.* (2011), the top management's support is a significant variable in explaining the changeability of operational performance of the organization. Leaders play a critical role as drivers of TQM (Tari *et al.*, 2007) and improve performance by influencing other QM practices (Anderson *et al.*, 1995; Flynn *et al.*, 1995). On the other hand, long term, cooperative relationships with a few suppliers result in efficient supplier QM. Supplier relations increase the performance of both suppliers and buyers, and this is particularly true when quality and delivery are buyer's priorities (Flynn *et al.*, 1995). The positive relationship between customers and suppliers with quality performance was reported in many empirical studies (Cua *et al.*, 2001; Kaynak, 2003; Yeung *et al.*, 2005; Parast *et al.*, 2006; Baird *et al.*, 2011). Zu *et al.* (2008) added through an empirical study "one new Six Sigma practice," i.e., Six Sigma role structure, to the existing set of QM infrastructure practices. Six Sigma requires a group of specialists who are highly trained personnel, undergo rigorous statistical training and lead teams in identifying and managing Six Sigma projects (Henderson and Evans, 2000; Linderman *et al.*, 2003). The Six Sigma methodology follows a systematic hierarchical structure for quality improvement across multiple organizational levels (Sinha and Van de Ven, 2005).

Numerous empirical studies have measured the relationship between QM practices and performance, namely, Flynn *et al.* (1995), Powell (1995), Dow *et al.* (1999), Samson and Terziovski (1999), Forza and Filippini (1998), Kaynak (2003), Zatzick *et al.* (2012) Klingenberg *et al.* (2013), O'Neill *et al.* (2016). Infrastructure practices have a direct effect on operational performance (Lakhal *et al.*, 2006). Several studies employing correlation and regression analysis (Ahire and O'shaughnessy, 1998; Rahman and Bullock, 2005) link the infrastructure QM practices directly to quality performance. Several empirical studies have demostrated the direct impact of infrastructure QM on organizational performance (Powell, 1995; Ahire *et al.*, 1996; Dow *et al.*, 1999). Powell (1995) examined the relationship of 12 QM practices individually by conducting an empirical study in 39 QM US companies. The results showed that the QM success is dependent more on the intangible (infrastructure QM) rather than tangible factors (core QM) such as zero defect mentality and process improvement. Similarly, Ahire *et al.* (1996) studied the US automobile manufacturing and component companies and concluded that the product quality is highly correlated with elements of infrastructure QM, namely, employee empowerment, employee training, and employee involvement. Further, Dow *et al.* (1999), in their study of Australian manufacturing companies, proposed that out of the total nine QM factors, only three infrastructure aspects of QM practices had a significant positive association with quality performance. Hence, the following hypothesis can be proposed:

H2. Infrastructure QM practices positively affect quality performance.

2.3 Relationship between core QM practices and quality performance

Core QM is defined as the set of QM practices that lay emphasis on monitoring processes and products, which involve the use of scientific methods and statistical tools in order to satisfy established requirements (Zeng *et al.*, 2015). Process management imparts preventive and proactive techniques to QM such as the decline in process variance reduction and fool proofing, which improves the quality of products in the production stage (Flynn *et al.*, 1995; Cua *et al.*, 2001; Baird *et al.*, 2011). Forza and Filippini (1998) found that quality problems could be reduced by including customers' requirements in new product/service design reviews prior to the production. Further, Kaynak (2003) concluded that there is a direct effect of product/service design on process management, which significantly contributes toward quality performance. The QM literature further highlighted the importance of quality information. The results of empirical studies conducted by several authors (Kaynak, 2003; Ho *et al.*, 2001; Yeung *et al.*, 2005) underline the key role of information and analysis in the decisions taken by managers and in QM practices. The effective use of quality information affects quality performance by providing accurate and timely information about product and service quality and process performance (Zu *et al.*, 2010). The use of quality information should also have direct effect on quality performance by informing the operators and engineers about defective parts immediately so that corrective actions can be taken timely and problems are remedied before the process drifts out of control, producing defectives (Flynn *et al.*, 1995; Kaynak, 2003).

Six Sigma structured improvement procedure is expected to corroborate product/service design and process management. Six Sigma focus on metrics enhances product/service design and process management by providing quantitative objective measures to examine product quality and process variability (Zu *et al.*, 2010). Product/service design stresses on improving product design performance with simplified designs and uniform components, and integrating customer needs and expectations to reduce engineering changes and quality problems, which helps in minimizing the costs of scrap and rework, results in increased product reliability, and enhances customer satisfaction (Ahire and Dreyfus, 2000; Flynn *et al.*, 1995; Forza and Filippini, 1998; Kaynak, 2003). Process management improves manufacturing techniques and processes by designing fool-proof processes, which help in detecting flaws that can be discovered in early phases of the process, help reduce process variation (Flynn *et al.*, 1995; Zu *et al.*, 2008) by using preventive maintenance to increase machine reliability and to reduce production interruptions. Hence, the following hypothesis can be proposed:

H3. Core QM practices positively affect quality performance.

2.4 Relationship between quality performance and business performance

Performance measurement is acknowledged as an important part of the manufacturing literature (Parthiban and Goh, 2011; Psomas and Kafetzopoulos, 2014). Relationship between quality performance improves financial and market performance, i.e., business performance (Kaynak, 2003), and the literature offers several explanations for these effects. According to Gravin (1984), quality performance influences business performance in two ways, i.e., manufacturing way and the marketing way (Gravin, 1984; Sousa and Voss, 2002). In the case of manufacturing, enhanced quality performance results in higher efficiency, effectiveness, responsiveness, flexibility, reliability, durability, lower scrap, rework rates, and less waste (Kaynak, 2003; Zu *et al.*, 2008). Low prices can increase market share and sales (Nunnally *et al.*, 1994; Gibson and Birkinshaw, 2004; Reed *et al.*, 1996).

In the case of marketing route, "improved quality increases customer satisfaction that leads to increased sales and larger market share (Ahire and Dreyfus, 2000; Choi and Eboch, 1998). By providing high-quality products and services, the firm has less elastic demand and can charge higher prices, which results in more profits" (Zu *et al.*, 2008; Kaynak, 2003; Sousa and Voss, 2002). Additionally, improvements in quality will result in more satisfied customers with greater loyalty and increased sales (Ahire and Dreyfus, 2000; Choi and Eboch, 1998; Motwani *et al.*, 1994; Hendricks and Singhal, 1997). Thus, the following hypothesis is offered:

H4. Quality performance positively affects business performance.

3. Research methodology

3.1 Questionnaire design

The questionnaire was divided into three parts: Part I: basic information, Part II: organizational background, and Part III: information related to quality practices, and performance measures. Each section was separated from the previous section. Instructions were presented prior to each section to reduce confusion. The survey items were grouped into sets and each set was labeled to strengthen the respondent's perceptions of the within-set similarities and between-set distinctions among items. Such item arrangement assists the respondents in easily comprehending the content and completing the survey.

Initially, the scale consisted of total 86 items, out of which 73 represented QM practices. Remaining 13 items for the dependent variables quality performance and business performance were generated from the literature. The study ensured the content validity through an extensive review of the literature followed by expert review. The content validity specifies the degree to which the scale items represent the domain or universe of the concept under investigation (Talavera, 2004). Specifically, this panel review helped the researcher in determining the comprehensiveness as well as relevance of the identified constructs in the Indian scenario. Further, the research instrument was pre-tested with a group of 15 participants (Malhotra, 2007) consisting of five academicians involved in various operations management related subjects; these experts had been publishing research papers for more than ten years and also held responsible positions like director, dean, or head of the department in their respective organizations. More importantly, they were in-charge of implementing TQM in the institution. The panel was further enriched by five quality experts from different manufacturing industries (two from automobiles, one from heavy engineering, one from electrical appliances, and one from pharmaceutical). These experts had more than 10-15 years of experience in the field of product quality and ranked high enough in seniority to be the head quality or Six Sigma Master Black Belt. In addition, five consultants, with more than 15 years of experience in the area of QM tools and techniques, were chosen to evaluate the instrument. Each participant was asked to assess the instrument for readability, bias, understandability, ambiguity of items, and appropriateness of each item in relevance to the Indian manufacturing setting. Their suggestions were incorporated, and a few minor changes were made to the questionnaire.

3.2 Sampling procedure
This study adopted a non-probabilistic sampling strategy. Purposive sampling was combined with the snowball sampling method to select the manufacturing organizations for the study. The purposive sampling technique, also called judgment sampling, is, simply put, the researcher decides what needs to be known and sets out to find people who can and are willing to provide information by virtue of knowledge or experience (Bernard, 2002; Lewis and Sheppard, 2006). Snowball sampling, which involves asking an informant to suggest another informant, follows purposive sampling (Tran and Perry, 2003). This method was considered to be appropriate to collect sufficient information from the respondents for arriving at a statistically sound inference. Each of these measurement scales had a single respondent from one organization. The target respondents were plant managers, operations managers, quality managers, quality heads, and Six Sigma Master Black Belts and Black Belts.

A total of 500 respondents from manufacturing organizations were approached through e-mail for data collection. These respondents were requested to complete the designed questionnaire. Out of these 500 respondents, 284 respondents agreed and responded, yielding a response rate of 56.80 percent. Out of 284, 22 responses were incomplete. Hence the data collected from 262 manufacturing organizations were used for analysis.

The detailed profile of respondents has been shown in Table I.

3.3 Measures
To operationalize QM practices (infrastructure and core), this study adopted both TQM and Six Sigma practices which included the five infrastructure QM (top management support, workforce management, customer relationship, supplier relationship, and Six Sigma role) and five core QM (quality information and analysis, process control, product design, Six Sigma structure, and Six Sigma metric) practices. Recently, Patyal and Koilakuntla (2015a, b) tested this scale in the Indian manufacturing organizations' context. Further, they have mentioned that in case of TQM, the measures were taken from empirical studies, which considered TQM practices (Douglas and Judge, 2001; Kaynak, 2003; Zu *et al.*, 2008, 2010). The items for three distinct practices of Six Sigma were borrowed from Zu *et al.* (2008, 2010), who reviewed both practitioner literature and academic literature for generating the scale for Six Sigma. The measurement items were calculated through perceptual questions on seven-point Likert scale with end points of "strongly disagree (= 1)" and "strongly agree (= 7)." Quality performance was reflected and measured in various ways in the past empirical studies on QM (Zeng *et al.*, 2015). This study adopted quality and business performance measures from the literature that emphasized on the relationship between QM and performance (Douglas and Judge, 2001; Kaynak, 2003; Zu *et al.*, 2008, 2010; Zu, 2009).

4. Results and data analysis

4.1 Exploratory factor analysis (EFA)
Measurement scales for QM practices (infrastructure and core) as well as quality and business performance EFA were performed using the principal component analysis (PCA) and varimax rotation for extracting factors (Costello and Osborne, 2011) through SPSS 20.0 software. Factor loadings of at least (0.55) are considered acceptable (Hair *et al.*, 2010). The appropriateness of the data was determined by the examination of the Kaiser-Meyer-Olkin (KMO) statistic of sampling adequacy and Bartlett's test of sphericity. For good factor analysis, the value of KMO must be at least 0.60 and above (Tabachnick and Fidell, 2001).

Out of 86 initial items, nine items were dropped because of two prime reasons: items were cross-loading on another factor, and factor loading less than 0.55. The final EFA resulted in 12 factors with the eigenvalue for all being greater than 1. These 12 factors accounted for 68.76 percent variance in analyzed items. Also, the KMO value measured was 0.87,

Classification	No of firms	% to total
Industry category		
Automobile/auto ancillary	118	45.00
Heavy engineering	40	15.30
Aerospace	30	11.50
Electrical equipment's, appliances, components	25	9.50
Pharmaceutical	18	6.90
FMCG	12	4.60
Chemical	10	3.80
Others	9	3.40
Department		
QA/QC	95	36.30
Production	61	23.30
Engineering and design	39	14.90
SCM	24	9.20
Design and development	22	8.40
Others	21	8.00
Employees size		
100-250	27	10.3
250-500	79	30.2
500-1,000	102	38.9
More than 1,000	54	20.6
Turnover		
50-100 Cr	19	7.30
100-500 Cr	79	30.20
500-1,000 Cr	111	42.40
More than 1,000 Cr	53	20.20
Education		
Graduate	135	51.50
Postgraduate	84	32.10
Others	43	16.40
Experience		
Less than 5 yrs	44	16.80
Between 5-10 yrs	89	34.00
Between 11-15 yrs	104	39.70
More than 15 yrs	25	9.50

Table I.
Profile of respondents

indicating the possible applicability of factor analysis to the data collected and suggesting that the data may be grouped into a smaller set of underlying factors. Further, Bartlett's test of sphericity was highly significant (Sig. 0.00), which hypothesized that the correlation matrix was an identity matrix. Table II presents the rotated component matrix.

4.2 Reliability analysis

Reliability test was performed on QM practices (infrastructure and core) as well as performance measures (quality and business). Reliability is broadly defined as the degree to which scales are free from error and, therefore, consistent (Nunnally *et al.*, 1994). This study used Cronbach's α for measuring reliability of the instrument, and detecting consistency of the measurement scale developed on the basis of responses. Nunnally *et al.* (1994) reported that the threshold value of Cronbach's α should be at least 0.60 and is considered highly reliable beyond 0.70. Table II presents the initial Cronbach's α after EFA,

Items	SSM	QP	WM	TMC	SRM	SSS	BP	QIA	CRM	SSR	PM	PSD
					Rotated component matrix							
SSM5	0.89											
SSM11	0.87											
SSM3	0.85											
SSM8	0.81											
SSM10	0.80											
SSM9	0.74											
SSM4	0.74											
SSM13	0.68											
SSM1	0.68											
SSM7	0.68											
SSM12	0.66											
SSM2	0.60											
SSM6	0.51											
QP7		0.89										
QP6		0.82										
QP2		0.82										
QP4		0.77										
QP5		0.71										
QP3		0.56										
QP1		0.62										
WM9			0.90									
WM1			0.85									
WM2			0.82									
WM7			0.81									
WM5			0.69									
WM8			0.67									
WM4			0.65									
WM6			0.60									
TM5				0.73								
TM3				0.70								
TM6				0.70								
TM2				0.66								
TM8				0.61								
TM4				0.63								
TM7				0.53								
SR7					0.78							
SR6					0.77							
SR3					0.72							
SR4					0.70							
SR1					0.64							
SR5					0.58							
SR2					0.63							
SSS1						0.83						
SSS4						0.79						
SSS3						0.77						
SSS2						0.67						
SSS5						0.61						
SSS6						0.59						
BP3							0.80					
BP2							0.77					
BP6							0.69					
BP1							0.69					
BP5							0.68					

(continued)

Table II.
EFA results

Items	SSM	QP	WM	TMC	SRM	SSS	BP	QIA	CRM	SSR	PM	PSD
					Rotated component matrix							
BP4							0.55					
QIA6								0.75				
QIA5								0.71				
QIA3								0.62				
QIA1								0.59				
QIA4								0.58				
QIA2								0.51				
CR2									0.73			
CR3									0.73			
CR4									0.72			
CR1									0.66			
CR5									0.62			
CR6									0.61			
SSR2										0.88		
SSR3										0.80		
SSR6										0.73		
SSR4										0.66		
SSR1										0.62		
SSR5										0.57		
PM7											0.79	
PM4											0.78	
PM5											0.74	
PM3											0.70	
PM8											0.67	
PSD3												0.80
PSD1												0.76
PSD5												0.73
Cronbach's α	0.94	0.92	0.88	0.88	0.89	0.91	0.88	0.86	0.88	0.85	0.82	0.90

Table II.

while Table V shows Cronbach's α value for all the 12 constructs after CFA, and as seen in both Tables II and IV all the scales exceed the lower limit by a substantial margin, indicating a good reliability of measurement scales.

4.3 Common method bias

The potential problems with self-reported, single-respondent data are the possibility of common method variance (CMV). This study conducted Harmon's one-factor test (Podsakoff *et al.*, 2003) to moderate the threat of CMV in the self-reported, single-respondent data set. This test assumes that if a substantial amount of CMV is present, either a single factor will emerge from the unrotated factor analysis or one general factor will account for the majority of the covariance in the independent and dependent variables (Zu *et al.*, 2010). Harmon's single-factor test showed that the 12 factors were extracted from the whole set of variables. The results showed that there is more than one factor in the unrotated PCA solution of all variables and that the first factor explains 24.18 percent of variance out of total 68.76 percent variance. Though the above test does not completely exclude the possibility of CMV, the results indicate that single respondent, self-report bias does not appear to be a major problem in this study.

4.4 Confirmatory factor analysis (CFA)

According to Marsh and Hocevar (1985), CFA is a special application of the structural equation modeling (SEM), which is also known as the linear structural relationship model

(Jöreskog and Sörbom, 2004) or covariance structure. The measurement model for the present study was developed using the AMOS V20.0 and the maximum likelihood method was performed on the entire set of items. The measurement model was evaluated by examining the goodness-of-fit indices, factor loadings, standardized residuals, and modification indices (Zu *et al.*, 2010). The process of evaluating the measurement model resulted in deleting several items. These items were deleted iteratively, based on criteria such as large standardized residuals, modification indices, or factor loadings less than 0.55 (Byrne, 2013; Kaynak, 2003; Nahm *et al.*, 2004). Before deleting a particular item, the item and respective construct were evaluated to assure that their loss would not jeopardize the integrity of the construct (Nahm *et al.*, 2004).

The literature has emphasized the use of the incremental comparative fit index (CFI), incremental fit index (IFI), and Tucker-Lewis index (TLI) and absolute fit indices (root mean square error of approximation (RMSEA), the normed χ^2/df. The RMSEA is a measure of model fit that is not dependent on sample size, whereas other fit measures, such as χ^2 and goodness-of-fit index are highly dependent on sample size (Hair *et al.*, 2010). Hair *et al.* (2010) provided the following guidelines for model fit: starting with RMSEA (RMSEA < 0.05), good model fit ($0.05 <$ RMSEA < 0.10) reasonable model fit, and (RMSEA > 0.10), poor model fit. Also, standardized root mean square residual (SRMR) is an absolute measure of fit and is defined as the standardized difference between observed and predicted correlation values. A value less than 0.08 is generally considered good fit while a value between 0.08 and 0.10 is reasonable model fit (Hu and Bentler, 1999). Moreover, an additional fit index that is most frequently used is the χ^2/df because it is appropriate for sample size. A suggested value of a normed χ^2 is between 1.0 and 3.0 because the small values of a normed χ^2 (< 1.0) can indicate an over-fitted model, and high values (> 3.0) can indicate an under-parameterized model. χ^2 is sensitive to sample size. With large sample size, the χ^2 values will be inflated (statistically significant), thus may wrongly imply poor data to model fit (Schumacker and Lomax, 2004). Therefore, in this study the authors have specified both absolute fit index (directly assess how well a priori model reproduces the sample data) and IFI (measure the proportionate improvement in fit by comparing a target model with a more restricted, nested baseline model). Incremental fit indices (CFI, IFI, and TLI) range from 0 (no fit at all) to 1.0 (perfect fit), and an accepted decision rule is to accept the fit that is approximately above > 0.80 as moderate fit and > 0.90 as a great fit (Naor *et al.*, 2008).

A 77 items 12 factor confirmatory factor model was studied using AMOS 20.0. For improving model fit 19 items were deleted. The final confirmatory model resulted in a 58-item 12 factor model demonstrating good model-fit indices (χ^2/df $= 1.76$, CFI $= 0.86$, TLI $= 0.905$, IFI $= 0.918$, SRMR $= 0.0721$, RMSEA $= 0.044$).

4.5 Convergent and discriminant validity

Construct validity measures the extent to which the items in a scale assess the same multivariate construct (Zeng *et al.*, 2015). This study calculated both convergent and discriminant validity. The convergent validity can be observed by detecting whether the maximum likelihood loading of each indicator is significant to its underlying construct (Anderson and Gerbing, 1988; Arnold and Reynolds, 2003; Peter, 1981). The convergent validity is demonstrated when the relationships between the items and the construct are significant, i.e., *t*-values are greater than 1.96 at the level of 0.05 (Al-Hawari *et al.*, 2005). All scale items of QM practices and performance measures CFA loadings ranged from 0.51 to 0.96 (Table V), which exceeds the minimum threshold limit of 0.50. Hence, the convergent validity of all measures was evident. Also, Hair *et al.* (2010) recommended that the composite reliability (CR) of all measures needed to be above 0.70. QM practices and performance measures are above the minimum threshold limits of 0.70 (Table III). All these estimates demonstrate a high degree of convergence between the items with their

Table III.
Assessment of convergent and discriminant validity

Constructs	Composite reliability	Average variance extracted	Maximum shared variance	Average shared variance
Top management commitment (TMC)	0.88	0.59	0.34	0.19
Customer relationship management (CRM)	0.84	0.57	0.32	0.15
Supplier relationship management (SRM)	0.86	0.60	0.33	0.15
Workforce management (WM)	0.84	0.50	0.13	0.05
Six Sigma role structure (SSR)	0.83	0.55	0.18	0.09
Quality information and analysis (QIA)	0.78	0.50	0.34	0.19
Product/service design (PSD)	0.76	0.58	0.33	0.13
Process management (PM)	0.81	0.57	0.01	0.06
Six Sigma structure (SSS)	0.89	0.62	0.34	0.19
Six Sigma metric (SSM)	0.90	0.58	0.18	0.07
Quality performance (QP)	0.89	0.54	0.33	0.18
Business performance (BP)	0.92	0.65	0.34	0.14

respective constructs. Moreover, the CR should be greater than average variance extracted (AVE) CR > AVE, and AVE should be above 0.50 (Hair *et al.*, 2010). All the factors of QM practices and performances measures possess AVE values above 0.50 minimum threshold values as shown in Table III.

The discriminant validity can be examined by comparing the shared variance between measures with the AVE of the individual measures (Fornell and Larcker, 1981). Additionally, Hair *et al.* (2010) discussed that for computing discriminant validity, maximum shared variance (MSV) should be less than AVE, i.e., (MSV < AVE) and average shared variance (ASV) should be less than AVE, i.e., ASV < AVE. The comparison between the AVEs and shared variance of QM practices and performance are presented in Table III. Also, the square root of AVE must be greater than inter-construct correlations as shown in Table IV. The results showed that the shared variance between the measures was less

Table IV.
Discriminant validity assessment

Constructs	QIA	SSM	BP	QP	WM	SSS	TMC	CRM	SRM	SSR	PM	PSD
Quality information and analysis (QIA)	0.68											
Six Sigma metric (SSM)	0.20	0.76										
Business performance (BP)	0.58	0.19	0.80									
Quality performance (QP)	0.58	0.41	0.50	0.74								
Workforce management (WM)	0.21	−0.01	0.26	0.15	0.69							
Six Sigma structure (SSS)	0.49	0.43	0.53	0.52	0.22	0.79						
Top management commitment (TMC)	0.50	0.34	0.38	0.52	0.36	0.58	0.77					
Customer relationship management (CRM)	0.50	0.16	0.31	0.43	0.31	0.50	0.57	0.76				
Supplier relationship management (SRM)	0.45	0.17	0.38	0.41	0.28	0.38	0.52	0.52	0.78			
Six Sigma role structure (SSR)	0.42	0.37	0.24	0.41	0.18	0.43	0.27	0.15	0.27	0.74		
Process management (PM)	0.037	0.07	0.11	0.12	0.09	−0.01	0.08	0.11	0.003	0.09	0.76	
Product/service design (PSD)	0.38	0.29	0.38	0.29	0.27	0.38	0.43	0.41	0.57	0.31	−0.01	0.76

Note: Average extracted variance (AVEs) is represented by diagonal values and shared variance is represented by all other entries than the AVEs of the individual measures of QM practices and performance measures, which in turn confirms the discriminant validity. Thus, all items correspond to their respective scales, indicating good construct validity (Table V).

4.6 Structural model

After establishing the measurement model (i.e. CFA), the hypotheses were tested by using the SEM technique (Hair *et al.*, 2010; Maruyama, 1997) employing the maximum likelihood method. The testing confirms the model's goodness-of-fit and the hypothesized paths between constructs. First, loading estimates were examined to ensure that they had not changed substantially from the measurement model indicating parameter stability among the measured items, which further supports the measurement model's validity (Hair *et al.*, 2010). The structural model was found to fit the data well, as supported by goodness-of-fit indices. The χ^2 upon the degree of freedom (χ^2/df = 2.76) was below the cut off value of 5 (RMSEA = 0.082, SRMR = 0.080, GFI = 0.83, CFI = 0.88, TLI = 0.88, IFI = 0.88). Even RMSEA and SRMR were below the cut off value of 0.08 (Hair *et al.*, 2010). The fit indices indicated high parameter stability among the measured items in the model. From these fit statistics, it can be concluded that the model overall demonstrates a good fit.

The results of the proposed structural equation model analysis are also presented in Table VI. Among the four hypotheses, three were supported while one was rejected. The results demonstrated that infrastructure quality practices have a positive impact on core quality practices ($\beta = 0.95$, $p < 0.01$), supporting *H1*. Further, the results showed that core quality practices had a significant impact on quality performance ($\beta = 0.75$, $p < 0.01$), supporting *H3*. Quality performance was found to have a positive effect on business performance ($\beta = 0.55$, $p > 0.01$). However, infrastructure quality practices were depicted to have no direct impact on quality performance ($\beta = -10.5$ $p > 0.01$), suggesting the rejection of *H2*.

The square multiple correlations (also known as R^2) indicated that core quality practices can explain a large amount of variance in quality performance and, thus, are vital in determining quality performance ($R^2 = 0.56$). Also, the R^2 for core quality practices explained by the infrastructure quality practices was high ($R^2 = 0.73$), suggesting that the infrastructure quality practices strongly influence the core quality practices. Further, the amount variance explained by quality performance on the business performance determined was estimated as $R^2 = 0.31$ (Figure 2).

5. Findings and discussion

The overall objective of this study is to examine the nature of QM practices and its relationship toward quality and business performance in the Indian manufacturing organization:

H1. Infrastructure QM practices positively affect core QM practices.

The results of the study revealed that infrastructure QM practices have a significant effect on core QM practices (supports *H1*):

H2. Infrastructure QM practices positively affect quality performance.

The path between infrastructure QM practices and quality performance did not improve the model. Moreover, infrastructure QM practices did not show a significant change in quality performance (rejects *H2*).

A few research studies have reported that infrastructure QM practices had a direct effect on all performance measures (Rahman and Bullock, 2005; Naor *et al.*, 2008; Dow *et al.*, 1999; Powell, 1995; Samson and Terziovski, 1999). Besides, several empirical studies have examined the impact of QM practices on performance in the sequence – infrastructure QM practices to core QM practices and then to quality performance (Anderson *et al.*, 1995;

Table V.
Scale measurement properties

Constructs	Items	Cronbach's α	CFA loading	Square multiple correlation	Item mean
Top management commitment (TMC)	TM3	0.86	0.72	0.52	5.92
	TM4		0.64	0.40	6.08
	TM5		0.77	0.59	6.27
	TM6		0.93	0.86	6.27
	TM8		0.72	0.52	6.22
Customer relationship management (CRM)	CR1	0.80	0.96	0.92	6.36
	CR2		0.79	0.62	6.13
	CR3		0.56	0.32	6.10
	CR4		0.55	0.26	6.09
Supplier relationship management (SRM)	SR2	0.79	0.70	0.50	5.97
	SR3		0.55	0.26	5.51
	SR5		0.95	0.91	6.03
	SR7		0.80	0.63	5.96
Workforce management (WM)	WM2	0.86	0.86	0.73	5.76
	WM4		0.55	0.30	5.78
	WM6		0.74	0.55	5.65
	WM7		0.76	0.58	5.95
	WM8		0.81	0.65	5.79
Quality information and analysis (QIA)	QIA1	0.78	0.65	0.42	5.68
	QIA3		0.65	0.42	5.68
	QIA4		0.68	0.46	5.74
	QIA5		0.71	0.51	5.73
Product/service design (PSD)	PSD1	0.75	0.59	0.35	5.85
	PSD3		0.81	0.65	5.71
	PSD5		0.75	0.56	5.72
Process management (PM)	PM4	0.83	0.83	0.69	5.24
	PM5		0.80	0.64	5.26
	PM7		0.75	0.56	5.20
	PM8		0.58	0.33	5.81
Six Sigma role (SSR)	SSR1	0.78	0.55	0.28	5.35
	SSR2		0.67	0.45	5.52
	SSR3		0.80	0.64	5.71
	SSR6		0.74	0.55	5.75
Six Sigma structural improvement procedure (SSS)	SSS2	0.84	0.74	0.55	5.52
	SSS3		0.67	0.44	5.18
	SSS4		0.62	0.38	5.18
	SSS5		0.75	0.57	5.60
	SSS6		0.75	0.56	5.55
Six Sigma metrics (SSM)	SSM1	0.90	0.67	0.45	5.43
	SSM3		0.76	0.58	5.49
	SSM4		0.68	0.47	5.46
	SSM5		0.72	0.52	5.30
	SSM8		0.75	0.57	5.23
	SSM10		0.68	0.46	5.28
	SSM12		0.71	0.50	5.27
Quality performance (QP)	QP1	0.85	0.69	0.47	6.29
	QP2		0.62	0.38	5.71
	QP3		0.61	0.37	5.85
	QP4		0.66	0.44	5.84
	QP5		0.72	0.52	6.07
	QP6		0.70	0.49	5.83
	QP7		0.73	0.53	5.87
Business performance (BP)	BP1	0.85	0.76	0.58	5.71
	BP2		0.78	0.61	5.61
	BP3		0.72	0.52	5.82
	BP4		0.67	0.45	5.63
	BP5		0.73	0.54	5.46
	BP6		0.71	0.51	5.51

Flynn *et al.*, 1995; Forza and Filippini, 1998; Pannirselvam and Ferguson, 2001; Kaynak, 2003; Naor *et al.*, 2008; Zu, 2009; Zeng *et al.*, 2015). Owing to mixed results in the literature on the relationship between infrastructure and core QM practices (Sousa and Voss, 2002; Nair, 2006), this study retested these relationships:

H3. Core QM practices positively affect quality performance.

Core QM practices strongly impact quality performance (supports *H3*). Zeng *et al.* (2015) have reported that at the plant level, core QM practices can exhibit a dominant positive influence on quality performance in terms of conformance, which is in complete agreement with *H3*. Therefore, core QM practices result in full mediation between infrastructure QM practices and quality performance. A successful implementation of core QM practices is accomplished through well-established infrastructure quality practices.

The findings of this study provide an answer for both *RQ1* and *RQ2* by providing a robust support for full mediation while refuting the report of partial mediation of core QM practices between infrastructure QM practices and quality performance (Ho *et al.*, 2001). These results underline the significance of soft human-oriented quality practices in developing a competitive advantage that is difficult to imitate (Powell, 1995). These findings indicate that both infrastructure and core quality practices should be established in the organization to create an effective QM system (Sousa and Voss, 2002):

H4. Quality performance positively affects business performance.

Finally, the results of this study revealed that quality performance had a direct and significant effect on business performance (supports *H4*). These results corroborated with those of Kaynak (2003) and Zu *et al.* (2008). This study operationalized business performance as financial and marketing performance. Also, Kaynak (2003) studied the effect of quality practices on financial and market performance (i.e. business performance) and reported that improvements in operating performance result in increased sales and market share, thereby providing a competitive edge to organizations. Effective implementation of quality practices will contribute to better financial, marketing, and even innovation performance by improving quality performance and/or operational performance (Kaynak, 2003; Nair, 2006; Prajogo and Sohal, 2003; Sousa and Voss, 2002; Yeung *et al.*, 2005; Zu *et al.*, 2008).

Quality practices were originally intended to enhance quality performance; achieved quality performance then results in the improvement of business performance (Zu, 2005). This answers *RQ3*, as quality must be attained first as a sequential precedent to other strategic capabilities (Rönnbäck and Witell, 2008), moreover it costs organizations money to invest in quality programs such as TQM and Six Sigma. This finding supports the argument that quality investments can provide a positive return in investment for the organization, as reported by Adam *et al.* (1997), Flynn *et al.* (1995), Kaynak (2003), Sousa and Voss (2002), Zu (2005). Recently, Zeng *et al.* (2015) mentioned that improving quality performance would lead to the achievement of other strategic competitive priorities in a cumulative fashion.

Hypotheses	Relationships			Direct effect	Remarks
H1	Infrastructure practices	→	Core practices	0.852 (0.001)**	Supported
H2	Infrastructure practices	→	Quality performance	0.015 (0.937)***	Rejected
H3	Core practices	→	Quality performance	0.742 (0.001)**	Supported
H4	Quality performance	→	Business performance	0.554 (0.001)**	Supported

Notes: χ^2/df = 2.81, RMSEA = 0.083, SRMR = 0.082, CFI = 0.87, TLI = 0.86, IFI = 0.87; square multiple correlations: core practices = 0.73, quality performance = 0.55, business performance = 0.31. **Significant at $\alpha < 0.01$ (two-tailed test). *p*-values are in parentheses; ***non-significant

Table VI. Results for QM practices and performance SEM

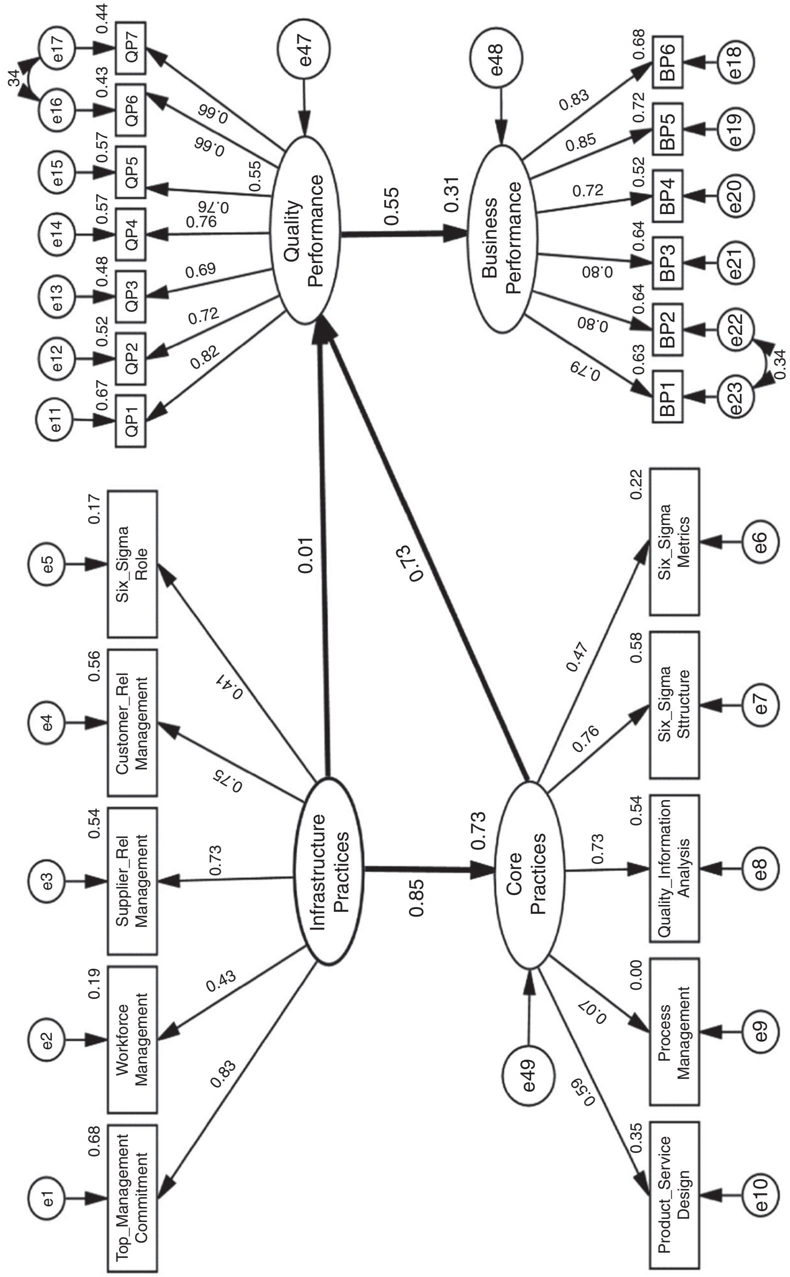

Figure 2.
Final structural model

QM must be implemented as an integrated approach of both infrastructure and core QM practices (Kaynak, 2003; Yeung *et al.*, 2005). QM practices are interdependent, therefore organizations must follow QM practices effectively in order to achieve enhanced business outcomes (Zu *et al.*, 2008).

6. Conclusion

This study provided an experimental proof of the roles of infrastructure and core QM practices in determining quality and business performance. The structural model supports the indirect and direct effects of infrastructure and core QM practices on quality performance, respectively, and hence, help to ascertain how these two types of QM practices influence quality performance. This study contributes significantly to the body of knowledge of the QM literature in a number of ways. First, this research provided a theoretical framework that integrated Six Sigma practices with TQM practices. In addition, the study tested a new set of infrastructure and core quality practices in the context of Indian manufacturing organizations. Second, this study contributed to the QM literature by re-examining the relationship between QM practices and performance. As, Nair (2006) and Sila (2007) pointed out that it is important to retest this relationship because the past studies have obtained mixed results (Hendricks and Singhal, 2001; York and Miree, 2004; Flynn *et al.*, 1995). Third, this study explored the relationship between infrastructure and core QM practices. Sousa and Voss (2002) recommend the elucidation of the interplay between these two dimensions, while some studies (Zu, 2005, 2009) affirm that the integration between infrastructure and core quality practices is crucial to enhance performance. Other studies (Dow *et al.*, 1999; Powell, 1995; Naor *et al.*, 2008) suggest that infrastructure practices can improve performance even without core practices. This study aligns with the first view, indicating that infrastructure quality practices do not affect quality performance directly but indirectly through core practices.

6.1 Scholarly implications

The research contributes significantly to the body of knowledge of the QM literature in a number of ways. First, this study provides a theoretical framework that integrates the TQM practices with the Six Sigma practices by considering a new set of infrastructure and core QM practices in the context of Indian manufacturing organizations. Second, this study provides valid and reliable scales to measure the constructs of infrastructure and core quality practices. Third, by visualizing QM from two dimensions – infrastructure and core quality practices – this study further contributes to the understanding of the different roles played by diverse QM dimensions in determining business performance in terms of increased return on investment, and shareholder and stakeholder value.

6.2 Managerial implications

The findings of this study provide important implications for managers. This study recommends that both infrastructure and core QM practices are essential for market and financial performance, and infrastructure QM practices support the application of core quality practices. Therefore, managers must develop and maintain their organization's quality system and sufficient resources need to be allocated to both types of practices in order to achieve the highest business performance. The combined effect of quality performance on business performance may help managers to dedicate continuous efforts involving employees into quality improvement initiatives to foster innovation in due course. This study recommends that implementation of QM practices can affect business performance, which allows firms to adapt to the market changes. This is an encouraging finding for practicing managers, as it demonstrates the fruitfulness of simultaneous pursuit of multiple competitive advantages in both quality and business. To attain enhanced business performance through quality practices, managers are suggested to leverage the diverse roles played by infrastructure and core quality practices in determining business performance. Organizations can foster market and financial performance through QM by highlighting the establishment of a routine base through QM tools and techniques, which can be facilitated by the concurrent use of teamwork, training, employee empowerment, and problem-solving approaches.

6.3 Limitations and future research directions

Certain limitations of this study, which were entirely unavoidable, are discussed as follows: first, the data were collected through a mail survey questionnaire; the usual limitations associated with this research are lack of control over who actually completes the survey and the inability to ascertain causality. Future research may extend this study using different methodologies including interviews, field studies, or case studies. Second, the results of this study were based on cross-sectional data from relevant Indian manufacturing organisations. Future research may focus on a longitudinal design, which will allow researchers to examine possible changes and developments of a phenomenon and the relationship between the variables of this study over a period. Third, the results of this study are limited to Indian manufacturing organizations, but owing to the cultural dissimilarities, a similar study may be carried out in other developing countries to examine if the structural model fits into their operations, which in turn may provide further validation of the proposed model. Fourth, the results of the study are limited to manufacturing organizations, as a result it limits its generalizability and contributions. In future the same model may be used to test the relationship in service organizations. Fifth, the findings of this study are based on self-reported survey data, which may be affected by response biases. Therefore, future studies may use multiple sources of data which would minimize the concerns over CMV. Sixth, this research did not consider the number of QM practices implemented by organizations. Although, some organizations have adopted multiple work practices, others have adopted only one or a few. Therefore, employees perceived different degrees of organizational support, which may have caused bias in this study.

This study has considered only QM practices. However, future studies may include other practices in infrastructure and core practices like lean manufacturing, kaizen and others to get more concrete results. Also, future research work may need to incorporate the influence of moderating variables in the proposed conceptual model for industry type or government vs private organizations. Further, future research work may investigate the effect of QM practices on other performance measures like innovation, competitive performance, and R&D performance. Moreover, future research may be undertaken to service industries to understand the effect of infrastructure and core QM practices on performance. Further, future study may be pursued with a larger sample size to re-test the results of this study, enhancing the statistical power to generalize the findings.

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Further reading

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Appendix

Table AI. Measurement scales for infrastructure and core QM practices, quality and business performance

Infrastructure QM practices

Top management commitment

1 The top management of your organization (i.e. top executives and major department heads) assumes responsibility for quality performance (TM1)
2 The top management of your organization provides personal leadership for quality products and quality improvement (TM2)
3* Your organization's top management is evaluated for quality performance (TM3)
4* In your organization, major department heads participate in the quality improvement process (TM4)
5* In your organization, "Quality issues" are reviewed in top management meetings (TM5)
6* In your organization, top management views quality performance as a major objective (TM6)
7 In your organization, strategic decisions are affected by top management (TM7)
8* In your organization, quality policy is developed by top management (TM8)

Supplier relationship management

1 Your organization believes in long-term relationships with suppliers and takes effort for the same (SR1)
2* Your organization trusts on a small number of high-quality suppliers (SR2)
3* Your organization allows supplier's active participation in product design/redesign process (SR3)
4 Your organization evaluates suppliers based on parameters related to quality, delivery and price (SR4)
5* Your organization has a systematic supplier rating system (SR5)
6 Your organization appreciates supplier's participation in quality training programs (SR6)
7* Your organization provides technical assistance to suppliers (SR7)

Customer relationship management

1* Your organization believes in maintaining consistent contact with customers (CR1)
2* Your customers provide feedback on quality and delivery performance (CR2)
3* Your organization measures customer satisfaction of external customer (CR3)
4* Customer requirements are used as the basis for quality in your organization (CR4)
5 Your employees are aware about your customers (CR5)
6 Your customers visit your plant (CR6)

Workforce management

1 Your organization form teams to solve problems (WM1)
2* Your organization provides feedback to employees on their quality performance (WM2)
3* Contractual employees are also involved in quality decisions in your organization (WM4)
4 Supervisors encourage teamwork in your organization (WM5)
5* Quality-related training is given to contractual employees (WM6)
6* Quality-related training is given to managers and supervisors in your organization (WM7)
7* Your organization provides quality training as "total quality concept" (i.e. philosophy of company-wide responsibility for quality) (WM8)
8 Your organization provides training on basic quality techniques such as histogram and control charts, cause and effect, etc. to employees (WM9)

Six Sigma role structure

1* Black/green belt role structure or equivalent structure is used for continuous improvement in your organization (SSR1)
2* Black/green belt role structure or equivalent structure is used for preparing and deploying individual employees for continuous improvement programs (SSR2)
3* In your organization, roles and responsibilities of members of quality improvement teams are specifically identified (SSR3)
4 *Black/green belt role structure or equivalent structure helps your organization to recognize the depth of employees' training and experience (SSR4)
5 An employee's role in the black/green belt structure or equivalent structure is considered for compensation and promotion decisions in your organization (SSR5)
6* Your organization adopts differentiated training for providing necessary knowledge and skills to employees who have different roles in the black/green belt role structure or equivalent structure (SSR6)

(continued)

Core QM practices	
Process management	
1	Processes in your organization are designed to minimize the chances of errors (PM1)
2	Your organization meets daily production schedule (PM3)
3*	In your organization, production is stopped immediately for quality problems (PM4)
4*	Your organization conducts preventive equipment maintenance (PM5)
5	Your organization provides clear process instructions (PM6)
6*	In your organization, shop floors are well organized and clean (PM7)
7*	Your organization has adopted statistical process control (PM8)
8	Your organization extensively utilizes statistical techniques for reducing variance in processes (PM9)
Product/service design	
1*	Your organization reviews new product/service designs in detail before the production of product/service (PSD1)
2	Various departments of your organization such as marketing, manufacturing, and purchasing, etc. coordinate in the product/service development process (PSD2)
3*	In your organization, manufacturing and quality personnel are involved in the product/service development process (PSD3)
4	Your organization designs for manufacturability (PSD5)
5*	Your organization takes effort for clearly needed specifications in the design process (PSD6)
Six Sigma structure improvement procedure	
1	In your organization, breakthrough improvement projects are conducted by following a systematic procedure (such as DMAIC – define, measure, analyze, improve and control) (SSS1)
2*	Your organization follows a structured approach to manage quality improvement activities (*SSS2)
3*	*Your organization pursues a formal planning process to decide the major quality improvement projects (SSS3)
4*	Your organizations all improvement projects are reviewed regularly during the process (SSS4)
5*	Your organization maintains every record related to Breakthrough improvement project (SSS5)
6*	In your organization, the product design process follows a systematic procedure (SSS6)
Six Sigma metrics	
1*	Your organization systematically follows a set of measures (such as defects per million opportunities, sigma level, process capability indices, defects per unit, and yield) to evaluate process improvements (SSM1)
2	Quality performance w.r.t. critical-to-quality (CTQ) characteristics are measured by your organization (SSM2)
3*	Your organization measures performance of core processes against customers' requirements (SSM3)
4*	Your organization considers financial performance (e.g. cost savings, sales) as one of the criteria for evaluating the outcomes of quality improvements (SSM4)
5*	*Expected financial benefits of a quality improvement project are identified during the project planning phase in your organization (SSM5)
6	Measures for quality performance are connected with the organization strategic quality goals in your organization (SSM6)
7	*Your organization sets strategic goals for quality improvement in order to improve plant financial performance (SSM7)
8*	Your organization has a comprehensive goal-setting process for quality (SSM8)
9	Quality goals are clearly and specifically defined in your organization (SSM*)
10*	Quality goals are clearly communicated to employees in your organization (SSM10)
11	Quality goals are challenging in your organization (SSM11)
12*	Customers' needs and expectation are translated into quality goals by your organization (SSM12)
13	Your organization determines the appropriate measures for each quality improvement project (SSM13)
Quality information and analysis	
1*	Your organization manages useful data pertaining to quality (such as error rates, defect rates, scrap, defects, cost of quality, etc.) (QI1)
2	In your organization, data are accessible to managers, supervisors, and engineers (QI2)
3*	In your organization, data are available to contractual employees (QI3)
4*	Your organization manages data timely (QI4)
5*	Your organization use data for managing quality (QI5)
6	Your organization use data for evaluating supervisory as well as managerial performance (QI6)

Table AI.

Note: The items marked with * were retained after testing the measurement models

Table AII. Performance scale

Quality performance	
1*	Quality of your organization products and services has been improved over the past 3 years (QP1)
2*	Process variability in your organization has decreased over the past 3 years (QP2)
3*	Delivery of your products and services has been improved over the past 3 years in your organization (QP3)
4*	Cost of scrap and rework as a percentage (%) of sales has decreased over the past 3 years in your organization (QP4)
5*	Over the past 3 years, cycle time (from receipt of raw materials to shipment of finished products) has decreased in your organization (QP5)
6*	Customer satisfaction with the quality of products and services has increased over the past 3 years in your organization (QP6)
7*	Equipment downtime in your organization has decreased over the past 3 years (QP7)
Business performance	
1*	Your organization sales have grown over the past 3 years (BP1)
2*	Your organization's market share has grown over the past 3 years (BP2)
3*	Unit cost of manufacturing has decreased over the past 3 years in your organization (BP3)
4*	Your organization's operating income has grown over the past 3 years (BP4)
5*	Your organization's profits have grown over the past 3 years (BP5)
6*	Return on assets of your organization has increased over the past 3 years (BP6)

Note: The items marked with * were retained after testing the measurement models

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