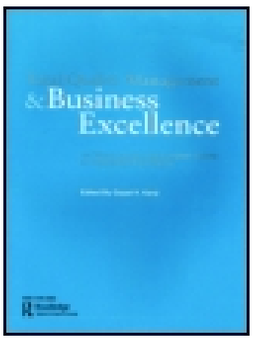

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Application of interpretive structural modelling for analysing barriers to total quality management practices implementation in the automotive sector

G. Muruganantham[a], S. Vinodh[b*], C. S. Arun[b] and K. Ramesh[b]

[a]*Department of Management Studies, National Institute of Technology, Tiruchirappalli 620 015, Tamil Nadu, India;* [b]*Department of Production Engineering, National Institute of Technology, Tiruchirappalli 620 015, Tamil Nadu, India*

In the recent era of globalisation and competitive scenario, quality plays a vital role in ensuring customer satisfaction. Total quality management (TQM) involves the implementation of appropriate tools/techniques to provide products and services to customers with best quality. In order to ensure the success of TQM practices in a modern automotive component manufacturing scenario, barriers and their mutual interactions need to be systematically analysed to enable practicing managers for effective deployment. In this context, this study depicts an interpretive structural modelling (ISM)-based approach to understand the mutual influence of TQM barriers. A total of 21 barriers have been identified for TQM practices and ISM model has been developed. The barriers are grouped under four categories (dependent, independent, autonomous and linkage) based on MICMAC analysis. The conduct of the study enabled the decision-makers to systematically analyse the influential barriers for effective deployment of TQM concepts in modern automotive component manufacturing, which is one of the rapidly growing sectors in the Indian scenario.

Keywords: total quality management; interpretive structural modelling; barriers; structural model; MICMAC analysis; Indian automotive sector

Introduction

During the past decade, manufacturing organisations have been adopting total quality management (TQM) as a philosophy for bringing about quality improvements. TQM enables the organisations to attain business excellence. TQM emphasises continuous improvement as one of the top goals and it enables organisations to achieve business excellence. TQM includes guiding principles and management practices that lead to continuous improvement in quality and providing quality products to customers. TQM focuses on management commitment and involvement, customer focus, teamwork, motivation and employee involvement. In addition, modern automotive manufacturing organisations have adopted advanced quality tools such as Quality Function Deployment, Failure Mode and Effect Analysis and Six Sigma. In order to compete in the globalised market, the organisations must inculcate TQM concepts into all activities of the organisation effectively (Mahapatra & Sekhar, 2004). TQM practices have been widely acknowledged as a disciplined management process in different sectors such as manufacturing, and service in order to deal with changes in the marketplace and focus on product and service quality. It provides a set of guidelines that will help to improve the organisation performance.

*Corresponding author. Email: vinodh_sekar82@yahoo.com

A perfect strategic planning enables benchmarking organisation's activities and practices with reference to their competitors (Saravanan & Rao, 2006), as well as to utilise available human resources effectively to overcome issues such as inadequate use of empowerment and teamwork, no proper benchmarking and human resource barrier.

Automotive component manufacturing is the fast-growing sector in the Indian context and it significantly contributes to gross domestic product (GDP) of the country (Bhadauriya & Gupta, 2015). In order to sustain in the competitive situation, the organisation has to implement advanced quality concepts. Many factors facilitate continuous improvement; one among them is quality of products manufactured by organisations, which enhances customer base. Hence, in the automotive component manufacturing sector, TQM practices play a vital role to bring the product to market at higher quality levels than customer expectations. There is a significant impact of organisational culture on TQM implementation in Indian small and medium-scale enterprises (SMEs) in the auto components manufacturing sector (Sinha, Garg, Dhingra, & Dhall, 2016). The research gap addressed in the present study is to deploy a structured approach for the identification and analysis of barriers that are influencing the adoption of TQM practices in the automotive sector. Prior studies focused on the service sector and no attempt has been made to analyse the barriers for TQM practices in the automotive component manufacturing sector, which is one among the fastest growing sector in the Indian scenario. The research objective of the present study is to identify and rank barriers for TQM practices and to analyse interactions among barriers using an interpretive structural modelling (ISM) approach. Upon analysing these barriers, management and practicing managers can understand major barriers that influence them and their linkages. Hence, the management decision-making tool ISM is used to analyse the interrelationship between each individual barriers and to identify dominant barriers that have to be assigned more importance. ISM is a tool for understanding complex situations and enables effective planning (Sarkis, Hasan, & Shankar, 2006).

Based on literature analysis and expert opinion, appropriate barriers of TQM practices have been identified. The study presents a systematic analysis of barriers of TQM implementation in the automotive component manufacturing sector using an ISM approach. MICMAC analysis is used for the categorisation of barriers into driver, dependent, autonomous and linkage clusters in this study. The novelty of this study is that it presents an approach for the systematic analysis of barriers of TQM practices in the modern automotive sector.

Literature review

Successful implementation of TQM practices helps the automotive sector to stay in the competitive edge by providing better quality products to the market. In addition, it helps to achieve desired outcomes such as increased organisation performance, profitability and improved customer satisfaction. However, there are certain barriers that hinder an organisation from attaining those desired outcomes. This literature survey aims to identify major barriers that need to be considered and actions to be taken during the implementation of TQM practices in the automotive sector, which influences organisational performance and enables customer satisfaction. Based on the literature review and expert opinion, a list of 21 barriers is identified and used in the study.

Identification of barriers to implementation of TQM practices

Kumar, Garg, and Garg (2011) performed a study to explore the advantages of implementing TQM practices and drawbacks of TQM and to explore differences between the service

sector and the manufacturing sector. They collected certain success factors from a literature review and surveyed among manufacturing and service industries located in the northern part of India. The identified success factors include teamwork, employee training, feedback, effective communication, management commitment, customer satisfaction and customer involvement. The survey was conducted to rank these seven success factors in both sectors and found that all seven factors possess lower weightage for TQM practices in service industries as related to manufacturing industries in the Indian scenario. They emphasised that both sectors recognised the importance of committed management to TQM practices. Catalin, Bogdan, and Dimitrie (2014) presented various barriers for implementing TQM concepts in all sectors. Based on literature studies and expert opinion, they identified a list of 50 barriers and fitted them into 5 categories, namely strategic, structural, human resources, contextual and procedural. Talib, Rahman, and Qureshi (2011b) developed an ISM-based structural model to analyse the barriers for implementing TQM practices in service organisations. They identified 12 barriers from literature reviews and expert opinion. They concluded that the lack of top management commitment and lack of coordination between departments are the most dominant barriers, possessing high driving power and low dependence power.

Lin and Chang (2006) explored TQM practices, manufacturing goals and their relationships with organisational performance progress using stepwise regression and canonical correlation analysis. They observed a strong linkage of TQM and manufacturing goal as well as organisational performance. In addition, they concluded that for effective TQM practice by firms, flexibility and delivery time are mostly contributing towards organisational performance. Firms should nurture their service quality to improve their performance. Hafeez, Malak, and Abdelmeguid (2006) conducted a survey and identified that organisations face much difficulty in translating TQM concepts into practice. Only few organisations successfully implemented a holistic approach to TQM philosophy and adopted technology elements of TQM. In addition, they stated that companies have not yet fully realised financial outputs and non-financial benefits of implementing TQM practices. Soltani, Lai, Sayed Javadeen, and Hassan Gholipour (2008) investigated the role of senior management commitment for the successful implementation of TQM practices. In addition, they also determined reasons for low commitment from top management. Rahman (2001) analysed the effect of quality management factors on organisational performance for SMEs in Western Australia with and without ISO 9000 certification. They found that except for the factor 'Process control', results indicated no significant difference between the impacts of TQM practices on organisational performance for firms. Also, they classified the firms into high, moderate and low levels of TQM firms and analysed the influence of ISO 9000 certification in each type and found that there is no significant difference between the impacts of TQM practices and organisational performance for firms with and without ISO 9000 certification.

Jun, Shaohan, and Peterson (2004) studied the obstacles to TQM implementation in Mexico's Maquiladora industry. They identified the prevalence of TQM barriers such as high employee turnover, employee training and employee resistance to change. They also found that poor education and training act as a top barrier in the development and deployment of a quality programme. Sebastianelli and Tamimi (2003) identified a list of 25 most commonly influencing obstacles to TQM practices. They explored the relation between obstacles and potential undesirable outcomes as a result of TQM failure. They performed factor analysis to extract obstacles and provided a framework to assess their relative impact on TQM success and found that inadequate resources, inadequate human resources development and management and lack of planning are the most

influencing obstacles. Baladhandayutham, Devadasan, Selladurai, and Senthil (2001) integrated the concept of business process reengineering and TQM and performed comparison for different scenarios. They identified that the application of advanced quality practices will enhance productivity and customer satisfaction. Implementation of quality practices avoids reprocessing of products and improves customer satisfaction. Also, they highlighted that employee attitude towards quality was an important barrier in the effective deployment of any quality programme. Whalen and Rahim (1994) performed a study to identify common barriers for the development and deployment of a TQM programme and they observed various factors influencing the role played by top management in organisational environment with TQM orientation and concluded that quality implementation programmes will ensure success with top management commitment. Mohanty (1997) discussed various issues of TQM implementation and also explained TQM as a revolution of the present scenario to transform contemporary organisations to the best position of quality, to satisfy the needs of customers and to channelise it into constructive means through productive efforts.

Research gap

From the literature analysis, it has been identified that there is no concrete study performed to identify and systematically analyse various barriers influencing the implementation of TQM practices in the automotive component manufacturing sector in the Indian scenario. Systematic analysis of barriers provides a methodological approach for practitioners to understand the TQM barriers. In addition to that, there is no clear framework existing in the past studies depicting the influential barriers of TQM implementation pertaining to the automotive sector. It is necessary to have a clear understanding of the framework of influential barriers before proceeding for the implementation of TQM practices as it provides guidelines to identify the most influential barriers systematically with minimal efforts. In order to ensure practical relevance of the framework, inputs from practitioners working in automotive organisations were used to identify dominant influential barriers enabling smooth deployment of TQM concepts.

Identified barriers are presented in Table 1. B_1 to B_{21} denotes the barriers used in the study.

Methodology

Figure 1 depicts the methodological steps followed in the present study. A survey was conducted among various experts who are involved in the implementation of TQM strategy in their organisations from automotive industries situated in the Tamil Nadu state of India. Based on the inputs from the survey and literature analysis, 21 major barriers influencing TQM implementation have been identified. Then, an ISM approach is used for developing the structural model and MICMAC analysis is done to categorise the barriers.

ISM methodology

In this study, an ISM approach is used for prioritising the barriers influencing TQM implementation.

ISM is a management decision tool, which analyses and prioritises multi-criteria decision factors combining both subjective and quantitative methods (Kannan, Pokharel, & Kumar,

Table 1. Description of barriers.

Barrier notation	Barrier	Description	Author(s)/references
B_1	Lack of top management commitment	Top management commitment enables success of quality implementation programme. Leadership plays a vital role in implementing TQM initiatives	Soltani, Lai, and Gharneh (2005); Soltani (2005); Talib et al. (2011b); Whalen and Rahim (1994); Abdelkrim (2013); Mohanty and Lakhe (1998);
B_2	Attitude of employees towards advanced quality practices	Application of advanced quality practices will enhance productivity and customer satisfaction	Talib et al. (2011b); Mohanty (1997); Baladhandayutham et al. (2001)
B_3	Lack of proper training and education	Poor education and training act as a major barrier for quality programme implementation. Effective training and employee empowerment enable process and service quality	Jun et al. (2004); Ljungstrom and Klefsjo (2002); Kumar et al. (2011); Whalen and Rahim (1994); Talib et al. (2011b); Abdelkrim (2013)
B_4	Poor planning	Lack of strategic planning results in ineffective quality improvement. Creating the vision, planning and leading the organisational change by top management ensures TQM success	Khanna, Sharma, and Laroiya (2011); Whalen and Rahim (1994); Talib et al. (2011b); Sebastianelli and Tamimi (2003); Mohanty (1997); Abdelkrim (2013);
B_5	Employee resistance to change	Employee resistance to adopt change is a common barrier faced by organisations while implementing any quality improvement programme	Jun et al. (2004); Soltani et al. (2008); Talib et al. (2011b); Raimona Zadry and Mohd Yusof (2006); Sohal and Terziovski (2000); Khan (2011)
B_6	Inadequate use of empowerment and teamwork	Employee empowerment and teamwork are vital for TQM success	Talib et al. (2011b); Rahman (2001); Mosadeghrad (2005)
B_7	Lack of continuous improvement culture	Continuous improvement is vital for TQM success	Talib et al. (2011b); Kumar, Kumar, Grosbois, and Choisne (2009)
B_8	Lack of communication	Proper communication between departments enables effective TQM implementation	Gunasekaran (1999); Abdelkrim (2013)
B_9	Non-usage of advanced TQM tools	Maximum benefits of TQM practices could be realised through comprehensive knowledge of several key elements such as system, tools and techniques	Talib et al. (2011b); Baidoun (2003); Gupta, Wali, and Deshmukh (2003)
B_{10}	Lack of customer involvement	Paying inadequate attention to customers or lack of customer focus will result in TQM failure. TQM initiatives are recognised as a failure if they fail to delight customers and do not add value from customers' viewpoint	Abdelkrim (2013); Thiagarajan and Zairi (1997); Raimona Zadry and Mohd Yusof (2006); Mosadeghrad (2005); Nizam and James (2005)

(*Continued*)

Table 1. Continued.

Barrier notation	Barrier	Description	Author(s)/references
B_{11}	Non-conduct of process capability and Six Sigma studies	Success of TQM initiatives depends on periodic conduct of process capability and Six Sigma studies. Industries need to continuously monitor sigma level of processes and to become zero-defect enterprises	Mohanty and Lakhe (1998); Gupta et al. (2003)
B_{12}	No proper motivation	TQM initiates a wholesome transformation in employee spirit, thinking, behaviour and job-related practices	Jun et al. (2004); Mosadeghrad (2005); Mohanty (1997); Nizam and James (2005)
B_{13}	Ineffective measures of quality improvement	TQM practices are positively associated with operational performance. TQM is centred on monitoring employees and processes. Effective measures need to be developed for measuring quality improvement	Mosadeghrad (2005); Khanna et al. (2011); Whalen and Rahim (1994)
B_{14}	No periodic benchmarking	Absence of benchmarking prevents continuous quality improvement culture and impacts competitiveness	Talib et al. (2011b); Bhat and Rajashekhar (2009); Catalin et al. (2014); Khanna et al. (2011)
B_{15}	Non-integration of voice of customer and supplier	Success of TQM initiatives depends on integrating the requirements of customers and suppliers Appropriate mechanisms need to be developed for the integration and subsequent processing for voice of customers and suppliers	Khanna et al. (2011); Sohal and Terziovski (2000); Nizam and James (2005); Samuel (1999)
B_{16}	Inadequate resources	Resource shortage or constraints affects TQM success Allocation of necessary resources is essential for TQM success	Mosadeghrad (2005); Nizam and James (2005); Whalen and Rahim (1994); Samuel (1999); Hafeez et al. (2006)
B_{17}	Short-term thinking	Lack of long-term objectives and targets leads to the loss of credibility of a quality improvement programme	Mosadeghrad (2005); Whalen and Rahim (1994)
B_{18}	High cost of implementing TQM outweigh the benefits	The primary obstacle identified in TQM implementation is the high expenditure. Expenditures on TQM implementation is to be considered as a strategic investment	Hafeez et al. (2006); Sohal and Terziovski (2000); Khan (2011); Samuel (1999)
B_{19}	Lack of incentives and human resource practices	Lack of effective and efficient employees and lack of non-monetary motivation mechanisms act as barriers to implement TQM concepts	Mosadeghrad (2005); Hafeez et al. (2006); Salegna and Fazel (2000)
B_{20}	Lack of quality practices and competent employees	Most organisations are not able to realise real benefits of TQM practices because of the implementation flaws and lack of competent employees	Mosadeghrad (2005); Awan, Bhatti, Bukhari, and Qureshi (2008); Salegna and Fazel (2000)
B_{21}	Lack of participative decision-making	Encouraging the employees to solve their problems and involving them in the decision-making process will increase their morale	Oakland (2011); Gupta et al. (2003)

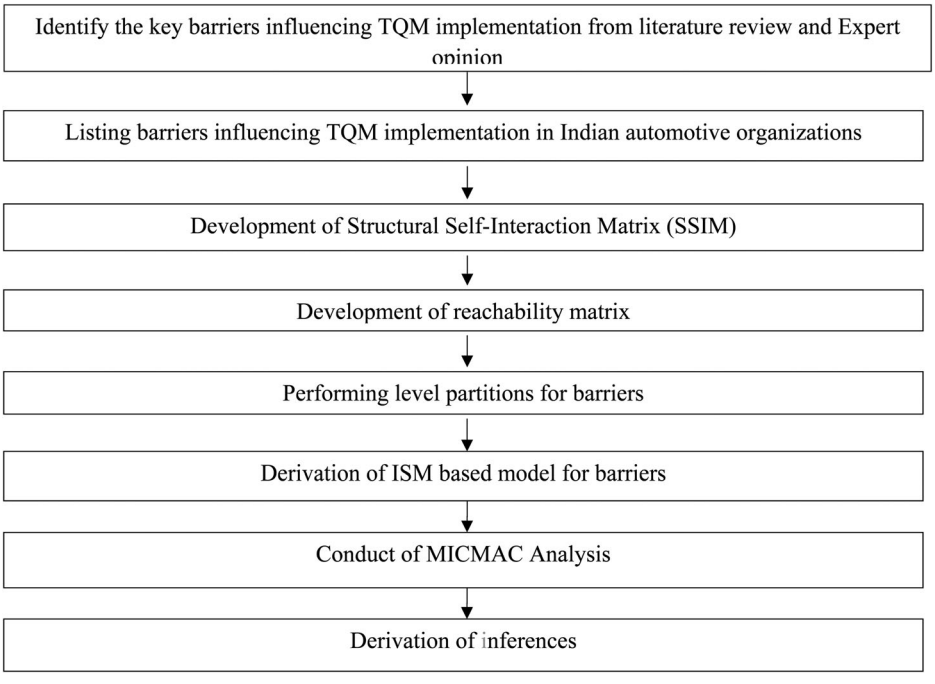

Figure 1. Methodology.

2009). ISM is a structured approach, which converts industrial and academic expert subjective data into quantitative values and provides a simple structured model for a complex system (Thakkar, Deshmuk, Gupta, & Shankar, 2005). This methodology is interpretative as the relationship of each variable with others is identified and represented in a matrix form. Using this matrix, driving and dependence powers of individual barriers have been identified, and barriers have been prioritised and represented in a levelled model. ISM methodology is more suitable for analysing barriers in a structured way. It organises barriers at different levels based on their importance and interconnections are also indicated.

Steps involved in the ISM technique (Raj, Shankar, & Suhaib, 2008) include the following:

(1) Obtain various barriers that influence TQM implementation from the literature review and expert opinion.
(2) From the barriers identified, contextual relationship for each barrier with others is analysed and depicted in a structural self-interaction matrix (SSIM) which indicates pair-wise relationship between barriers.
(3) Reachability matrix is derived from the SSIM matrix and transitivity is examined. Reachability matrix converts subjective data into quantitative values.
(4) The obtained reachability matrix is partitioned into different levels.
(5) Barriers are categorised into four quadrants by applying MICMAC analysis.
(6) The model is reviewed to examine inconsistency and necessitate appropriate modifications (if necessary).

Application of ISM methodology

Based on expert opinion and literature analysis, 21 major barriers influencing TQM implementation have been identified and analysed using the ISM approach. A survey has been conducted among 50 experts working in automotive component manufacturing organisations and who are responsible for TQM implementation in their organisations. A total of 35 responses were received. The response rate is 70%, which is acceptable based on research studies (Barlett, Kotrlik, & Higgins, 2001).

Structural self-interaction matrix

The SSIM includes pairwise analysis among barriers and relationship is depicted using standard symbols based on a survey among experts. This survey was performed through online and electronic mail. The experts provided their opinion based on a comprehensive understanding of barriers and their interrelationships. The consensus opinion of experts has been used as inputs. The format used to gather input is:

'Kindly assign the relation between Lack of top management commitment and Attitude of employees towards advanced quality practices in your organisation (using V/A/X/O)'.

Four symbols (V, A, X and O) have been used in this study to denote the interrelationship between two barriers i and j (Kannan et al., 2009; Vinodh, Ramesh, & Arun, 2016):

V : Barrier i will lead to barrier j;
A : Barrier j will lead to barrier i;
X : Barriers i and j are interrelated; and
O : Barriers i and j are unrelated.

Using the contextual relationship, SSIM has been developed. Based on expert opinion, the relationship between barriers has been identified and SSIM is shown in Table 2.

Reachability matrix

SSIM is transformed into a reachability matrix by translating the symbols into binary numbers 0s and 1s. The substitution of 1s and 0s is as per the following rules (Govindan, Azevedo, Carvalho, & Cruz-Machado, 2015; Kannan et al., 2009; Raj et al., 2008):

(1) If (i, j) entry in SSIM is V, then (i, j) entry in the Reachability matrix becomes 1 and (j, i) entry becomes 0.
(2) If (i, j) entry in SSIM is A, then (i, j) entry in the matrix becomes 0 and (j, i) entry becomes 1.
(3) If (i, j) entry in SSIM is X, then (i, j) entry in the matrix becomes 1 and (j, i) entry also becomes 1.
(4) If (i, j) entry in SSIM is O, then (i, j) entry in the matrix becomes 0 and (j, i) entry also becomes 0.
(5) Diagonal elements will be assigned 1 as both i and j are the same.

Based on these relationships, the initial reachability matrix shown in Table 3 is formed which shows that the presence of entry 1 in the cell denotes the existence of a relation between the two barriers. Final reachability matrix shown in Table 4 is iterated based on a transitivity condition. It states that if barrier A is related to barrier B and barrier B

is related to barrier C, then necessarily barrier A is related to barrier C. Barriers with no relationships are checked for transitivity and related using the above condition. This indirect relationship of each barrier provides a more accurate result to build the ISM model. Table 5 shows the formulation of driving and dependence power matrix by summing up values both row- and column-wise. Each row-wise addition represents the driving power of that barrier, which implies that these barriers drive the barriers with which it has a relation, and column-wise addition represents the dependence power of that barrier, which means that these barriers depend on the barriers with which it has a relation. Also, this metric is used as a base to build the level partition shown in Table 6.

Level partitions

Level partition table is derived from the reachability matrix, in which reachability and antecedent sets are derived for individual barriers. The reachability set is one which represents barriers that have an influence on it and the antecedent set represents barriers that it has an influence over. The intersection of these two sets represents interdependence. Levels are assigned based on driving power computed in the SSIM.

This level partition is used as a basis for developing the ISM model. Barriers with the same reachability level and intersection level are positioned at the same level in this matrix and also represented in ISM hierarchy.

Developing the ISM model

The barriers prioritised using the above process are represented in Figure 2. The model is based on bottom to top approach. Lack of top management commitment, poor planning, lack of proper training and education, inadequate resources and high cost of implementing TQM are positioned at the bottom level of the model, indicating significant driving power. These barriers are root causes for other barriers at higher levels within the ISM model. These lower level barriers must be prioritised as major areas of concern for managers aspiring to implement TQM practices. Barriers at the top level include lack of continuous improvement culture, ineffective measures of quality improvement, non-integration of voice of consumer and supplier, attitude of employees towards advanced quality practices and non-usage of TQM tools, which have high dependence and are not driving any other factor. Any action on this factor will not affect any other factor; however, any action on any other factor will have an impact on these barriers due to strong dependence.

MICMAC analysis

Matrice d'impacts croises-multiplication appliqué a un classement (cross-impact matrix multiplication applied to classification) is known as MICMAC (Talib et al., 2011b). The main objective of MICMAC is to cluster the barriers based on their driving and dependence power.

A graph is plotted with dependence power on *X*-axis and driving power on *Y*-axis and is shown in Figure 3.

The first quadrant represents linkage barriers; the second quadrant indicates independent barriers; the third quadrant represents autonomous barriers and the fourth quadrant indicates dependent barriers.

Managerial implications based on the findings from the MICMAC analysis are as follows:

Table 2. Structural self-interaction matrix.

	B_{21}	B_{20}	B_{19}	B_{18}	B_{17}	B_{16}	B_{15}	B_{14}	B_{13}	B_{12}	B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
B_1	V	V	V	V	V	V	V	V	V	V	V	V	X	X	V	V	V	V	X	V	X
B_2	A	A	A	A	A	A	V	A	V	A	A	A	A	X	A	A	X	A	A	X	
B_3	V	V	A	A	V	A	V	V	V	V	V	V	V	V	V	V	V	V	X		
B_4	X	V	V	V	A	V	V	V	V	V	V	V	V	V	V	X	X	X			
B_5	V	V	A	A	V	A	V	A	V	V	V	O	V	V	V	V	X				
B_6	X	X	X	O	V	A	V	V	V	V	V	A	V	V	V	X					
B_7	X	A	A	X	A	A	V	X	A	A	X	A	X	A	X						
B_8	A	A	O	X	V	A	V	O	A	O	A	X	V	X							
B_9	A	A	A	X	A	X	V	A	A	X	X	A	X								
B_{10}	A	A	O	V	X	A	X	A	A	X	A	X									
B_{11}	X	A	A	A	X	A	V	X	V	A	X										
B_{12}	X	X	A	A	A	A	A	X	V	X											
B_{13}	A	X	A	A	A	A	X	V	X												
B_{14}	X	V	A	A	X	A	X	X													
B_{15}	A	A	A	A	X	A	X														
B_{16}	A	V	V	V	V	X															
B_{17}	A	A	A	A	X																
B_{18}	X	X	V	X																	
B_{19}	V	V	X																		
B_{20}	A	X																			
B_{21}	X																				

Table 3. Initial Reachability Matrix.

	B_{21}	B_{20}	B_{19}	B_{18}	B_{17}	B_{16}	B_{15}	B_{14}	B_{13}	B_{12}	B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
B_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
B_2	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	0	1	0	0	1	0
B_3	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
B_4	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
B_5	1	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	1	0	1	0
B_6	0	0	1	0	0	0	0	1	1	1	1	0	1	1	1	1	0	1	0	1	0
B_7	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0
B_8	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1	0	0	0	0	1	0
B_9	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0
B_{10}	0	0	0	0	1	0	1	0	0	1	0	1	1	1	1	1	0	0	0	1	0
B_{11}	0	0	0	0	0	0	1	1	1	0	1	1	1	0	1	0	0	0	0	1	0
B_{12}	1	1	0	0	0	0	0	1	1	1	1	1	1	0	1	0	1	0	0	1	0
B_{13}	0	1	0	0	1	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0	0
B_{14}	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0
B_{15}	0	0	0	0	1	0	1	1	1	1	0	1	1	0	1	1	1	0	0	0	0
B_{16}	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0
B_{17}	0	0	0	0	1	0	1	0	1	1	1	1	1	0	1	1	0	1	0	1	0
B_{18}	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0
B_{19}	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
B_{20}	0	1	0	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0
B_{21}	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0

Table 4. Final Reachability Matrix.

	B_{21}	B_{20}	B_{19}	B_{18}	B_{17}	B_{16}	B_{15}	B_{14}	B_{13}	B_{12}	B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
B_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
B_2	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1*	1	1*	0	1	0
B_3	1	1	0	1*	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
B_4	1	1	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	0
B_5	1	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	1	0	1	0
B_6	0	0	1	0	1*	0	0	1	1	1	1	1*	1	1	1	1	0	1	0	1	0
B_7	1	1	0	1	0	0	1*	0	1*	0	0	0	1	1*	1	1	1	1*	0	1*	0
B_8	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1	0	0	0	0	1	0
B_9	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0
B_{10}	0	0	1*	0	1	0	1	0	1*	1	1*	1	1	1	1	1	0	0	0	1	0
B_{11}	0	0	0	0	1*	0	1	1	1	1*	1	1	1	0	1	1*	1*	1*	0	1	0
B_{12}	1	1	0	0	1*	0	1*	1	1	1	1	1	1	0	1	1*	1	0	0	1	0
B_{13}	0	1	0	1*	1	0	1	0	1	1*	1*	1	1*	0	1	0	1	0	0	1*	0
B_{14}	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1*	0	0	0	1	0
B_{15}	0	0	0	0	1	0	1	1	1	1	0	1	1	0	1	1	1	0	0	0	0
B_{16}	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0
B_{17}	0	0	0	0	1	0	1	0	1	1	1	1	1	0	1	1	0	1	0	1	0
B_{18}	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0
B_{19}	1	1	1	1*	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
B_{20}	0	1	0	1	1	0	1	1*	1	1	1	1	1	1	1	1	0	0	0	1	0
B_{21}	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1*	1	0

1* entries are included to incorporate transitivity.

Table 5. Driving and dependence power.

	B_{21}	B_{20}	B_{19}	B_{18}	B_{17}	B_{16}	B_{15}	B_{14}	B_{13}	B_{12}	B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1	Driving power
B_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	21
B_2	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1*	1	1*	0	1	0	9
B_3	1	1	0	1*	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	19
B_4	1	1	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	0	20
B_5	1	1	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	1	0	1	0	14
B_6	0	0	1	0	1*	0	0	1	1	1	1	1*	1	1	1	1	0	1	0	1	0	13
B_7	1	1	0	1	0	0	1*	0	1*	0	0	0	1	1*	1	1	1	1*	0	1*	0	12
B_8	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1	0	0	0	0	1	0	12
B_9	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	5
B_{10}	0	0	1*	0	1	0	1	0	1*	1	1*	1	1	1	1	1	0	0	0	1	0	12
B_{11}	0	0	0	0	1*	0	1	1	1	1*	1	1	1	0	1	1*	1*	1*	0	1	0	13
B_{12}	1	1	0	0	1*	0	1*	1	1	1	1	1	1	0	1	1*	1	0	0	1	0	14
B_{13}	0	1	0	1*	1	0	1	0	1	1*	1*	1	1*	0	1	0	1	0	0	1*	0	13
B_{14}	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1*	0	0	0	1	0	14
B_{15}	0	0	0	0	1	0	1	1	1	1	0	1	1	0	1	1	1	0	0	0	0	10
B_{16}	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0	17
B_{17}	0	0	0	0	1	0	1	0	1	1	1	1	1	0	1	1	0	1	0	1	0	11
B_{18}	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	17
B_{19}	1	1	1	1*	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	18
B_{20}	0	1	0	1	1	0	1	1*	1	1	1	1	1	1	1	1	0	0	0	1	0	14
B_{21}	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1*	1	0	19
Dependence Power	11	14	8	11	18	5	20	13	21	18	17	17	20	15	21	16	13	10	7	19	1	

Table 6. Level partitions table.

Variables	Reachability set	Antecedent set	Intersection	Level
B_1	$B_1,B_2,B_3,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	B_1,B_4	B_1,	10
B_2	$B_2,B_4,B_5,B_6,B_7,B_8,B_9,B_{13},B_{15}$	$B_1,B_2,B3,B_4,B_5,B_6,B_7,B_8,B_{10},B_{11},B_{12},B_{13},B_{15},B_{14},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_2,B_4,B_5,B_6,B_7,B_8,B_{13},B_{15}$	2
B_3	$B_2,B_3,B_4,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{20},B_{21}$	$B_1,B_3,B_4,B_{16},B_{18},B_{19},B_{21}$	$B_3,B_4,B_{16},B_{18},B_{21}$	8
B_4	$B_2,B_3,B_4,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_2,B_3,B_4,B_5,B_6,B_7,B_{11},B_{16},B_{17},B_{21}$	$B_2,B_3,B_4,B_5,B_6,B_7,B_{11},B_{16},B_{17},B_{21}$	9
B_5	$B_2,B_4,B_5,B_6,B_7,B_8,B_9,B_{11},B_{12},B_{13},B_{15},B_{17},B_{20},B_{21}$	$B_1,B_2,B_3,B_4,B_5,B_7,B_{11},B_{12},B_{13},B_{15},B_{16},B_{18},B_{19},B_{21}$	$B_2,B_4,B_5,B_7,B_{11},B_{12},B_{13},B_{15},B_{21}$	7
B_6	$B_2,B_4,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{17},B_{19}$	$B_1,B_2,B_3,B_4,B_5,B_6,B_7,B_{10},B_{11},B_{12},B_{14},B_{15},B_{17},B_{19},B_{20},B_{21}$	$B_2,B_4,B_6,B_7,B_{10},B_{11},B_{12},B_{14},B_{17},B_{19}$	4
B_7	$B_2,B_4,B_5,B_6,B_7,B_8,B_9,B_{13},B_{15},B_{18},B_{20},B_{21}$	$B_1,B_2,B_3,B_4,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_2,B_4,B_5,B_6,B_7,B_8,B_9,B_{13},B_{15},B_{18},B_{20},B_{21}$	3
B_8	$B_2,B_7,B_8,B_9,B_{10},B_{12},B_{13},B_{15},B_{17},B_{18},B_{20},B_{21}$	$B_1,B_2,B_3,B_4,B_5,B_6,B_7,B_8,B_{10},B_{14},B_{16},B_{18},B_{19},B_{20},B_{21}$	$B_2,B_7,B_8,B_{10},B_{18},B_{20},B_{21}$	5
B_9	$B_7,B_9,B_{11},B_{13},B_{15}$	$B_1,B_2,B_3,B_4,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_7,B_9,B_{11},B_{13},B_{15}$	1
B_{10}	$B_2,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{15},B_{17},B_{19}$	$B_1,B_3,B_4,B_6,B_8,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_6,B_8,B_{10},B_{11},B_{12},B_{13},B_{15},B_{17},B_{19}$	4
B_{11}	$B_2,B_4,B_5,B_6,B_7,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17}$	$B_1,B_3,B_4,B_5,B_6,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_4,B_5,B_6,B_{10},B_9,B_{11},B_{12},B_{13},B_{14},B_{17}$	4
B_{12}	$B_2,B_5,B_6,B_7,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17},B_{20},B_{21}$	$B_1,B_3,B_4,B_5,B_6,B_8,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_5,B_6,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17},B_{20},B_{21}$	4
B_{13}	$B_2,B_5,B_7,B_9,B_{10},B_{11},B_{12},B_{13},B_{15},B_{17},B_{18},B_{20}$	$B_1,B_2,B_3,B_4,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_2,B_5,B_7,B_9,B_{10},B_{11},B_{12},B_{13},B_{15},B_{17},B_{18},B_{20}$	3
B_{14}	$B_2,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17},B_{20},B_{21}$	$B_1,B_3,B_4,B_6,B_{11},B_{12},B_{14},B_{15},B_{16},B_{18},B_{19},B_{20},B_{21}$	$B_6,B_{11},B_{12},B_{14},B_{15},B_{20},B_{21}$	6
B_{15}	$B_5,B_6,B_7,B_9,B_{10},B_{12},B_{13},B_{14},B_{15},B_{17}$	$B_1,B_2,B_3,B_4,B_5,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_5,B_7,B_9,B_{10},B_{12},B_{13},B_{14},B_{15},B_{17}$	3
B_{16}		B_1, $B_3,B_4,B_{16},B_{18},B_{21}$	B_3,B_4,B_{16},B_{18}	8

	$B_2,B_3,B_4,B_5,B_7,B_8,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20}$			
B_{17}	$B_2,B_4,B_6,B_7,B_9,B_{10},B_{11},B_{12},B_{13},B_{15},B_{17}$	$B_1,B_3,B_4,B_6,B_5,B_8,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_4,B_6,B_{10},B_{11},B_{12},B_{13},B_{15},B_{17}$	4
B_{18}	$B_2,B_3,B_5,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_1,B_3,B_4,B_7,B_8,B_{13},B_{16},B_{18}, B_{19},B_{20},B_{21}$	$B_3,B_7,B_8,B_{13},B_{18},B_{19},B_{20},B_{21}$	8
B_{19}	$B_2,B_3,B_5,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{17},B_{18},B_{19},B_{20},B_{21}$	$B_1,B_4,B_6,B_{10},B_{16},B_{18},B_{19},B_{21}$	$B_6,B_{10},B_{18},B_{19},B_{21}$	8
B_{20}	$B_2,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13}, B_{14},B_{15},B_{17},B_{18},B_{20}$	$B_1,B_3,B_4,B_5,B_7,B_8,B_{12},B_{13},B_{14},B_{16},B_{18},B_{19},B_{20},B_{21}$	$B_7,B_8,B_{12},B_{13},B_{14},B_{18},B_{20}$	6
B_{21}	$B_2,B_3,B_4,B_6,B_7,B_8,B_9,B_{10},B_{11},B_{12},B_{13},B_{14},B_{15},B_{16},B_{17},B_{18}\ B_{19},B_{20},B_{21}$	$B_1,B_3,B_4,B_5,B_7,B_8,B_{12},B_{14},B_{18},B_{19},B_{21}$	$B_3,B_4,B_7,B_8,B_{12},B_{14},B_{18}, B_{19},B_{21}$	8

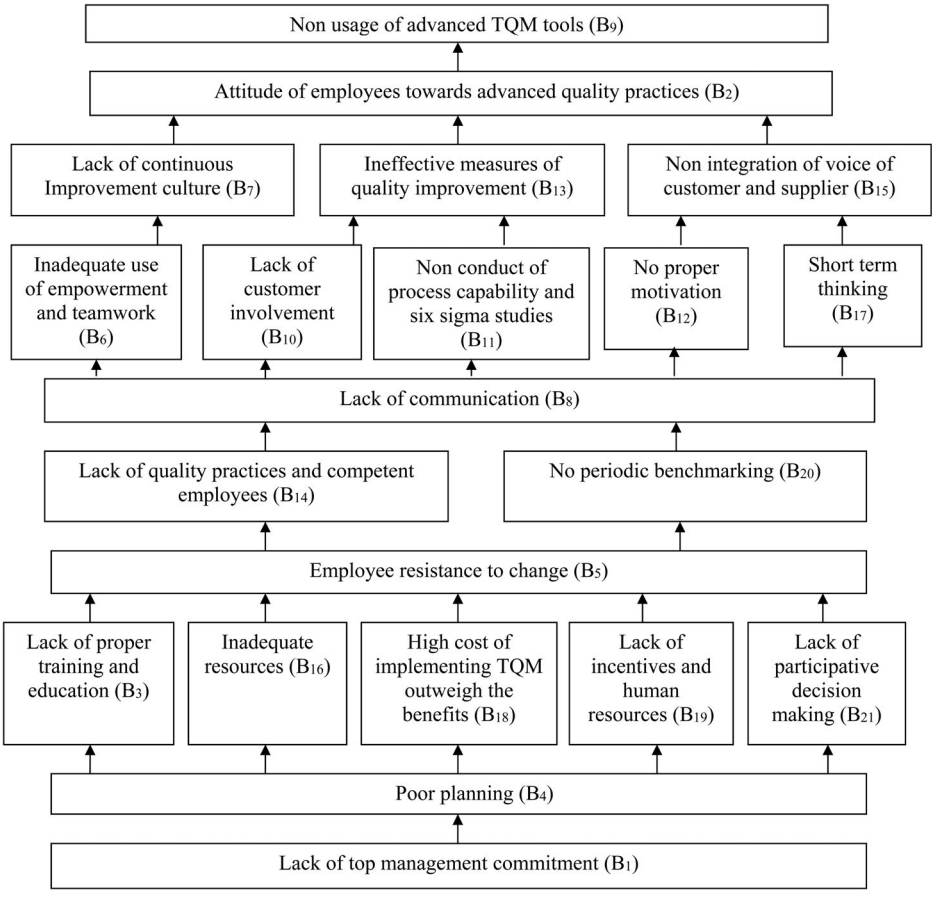

Figure 2. Developed the ISM model.

(1) Linkage barriers: These barriers have a strong driving as well as dependence power, implying a careful consideration of these barriers, as any action on these barriers will have an effect on others and also a feedback influence on each other. They are represented in Quadrant I. Lack of communication, lack of customer involvement, non-conduct of process capability and Six Sigma studies, no proper motivation, no periodic benchmarking, short-term thinking and lack of participative decision-making are found to be linkage barriers. These barriers are very important and should be highly concentrated. These barriers must be eliminated carefully since they have higher control of other barriers. Elimination of these barriers will greatly enable the implementation of a newer system.

(2) Dependent barriers: These barriers have a weak driving power but strong dependence power. They are represented in Quadrant IV. They are greatly affected by many barriers. Lack of continuous improvement culture, ineffective measures of quality improvement, non-integration of voice of consumer and supplier, attitude of employees towards advanced quality practices and non-usage of advanced TQM tools are found to be dependant barriers. Less importance is given to these barriers as they are controlled by other barriers.

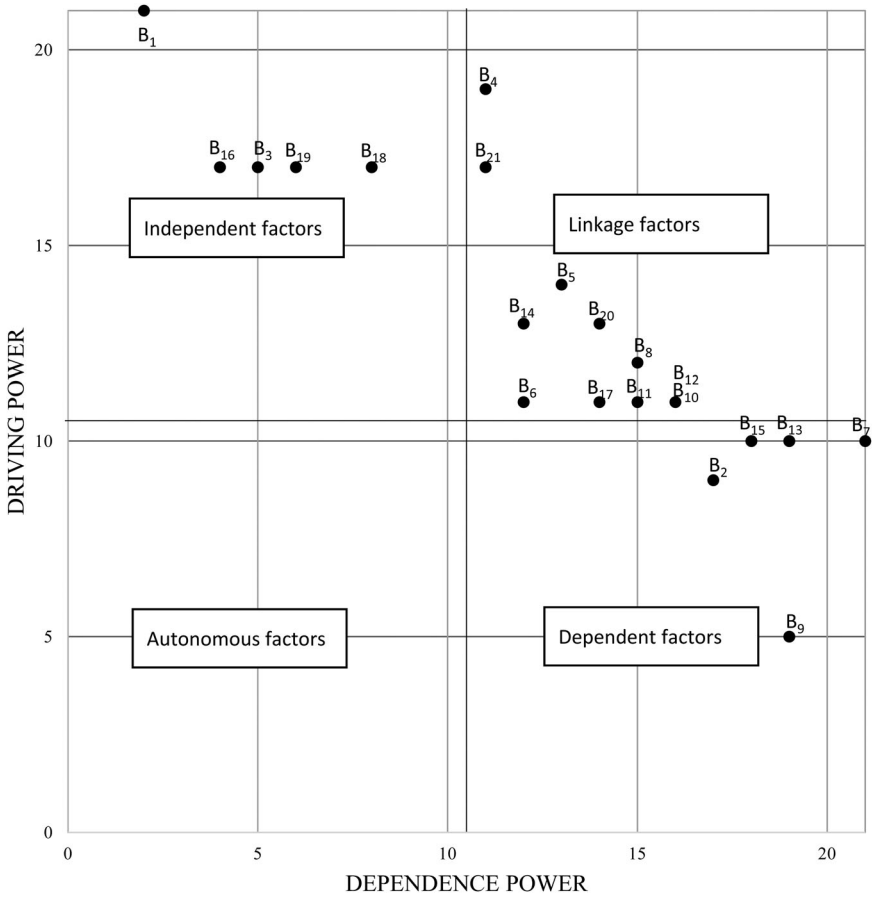

Figure 3. Results of MICMAC analysis.

(3) Driving barriers: They have a strong driving power but weak dependence power. They are represented in Quadrant II. These barriers are the cause for various other barriers. Lack of top management commitment, poor planning, lack of proper training and education, inadequate resources and high cost of implementing TQM practices are identified as the main driving barriers. Elimination of these barriers will provide greater support in implementation as they drive various other barriers.
(4) Autonomous barriers: These barriers have less driving and less dependence power. They are represented in Quadrant III. They are relatively disconnected with few links. There are no autonomous barriers in this study.

Results and discussions

By analysing the dominant barriers from the ISM model, the difficulty involved in implementing TQM practices in automotive industries can be identified. The model provides a framework for analysing the barriers and helps in understanding the problems in the implementation of a newer system. The ISM model shows the order in which barriers

need to be analysed. Reachability matrix shows the driving values of each barrier; barriers that have higher driving values are shown at the bottom of the ISM model. Barriers at the lower level have to be concentrated more and require immediate action as they drive all other barriers.

It can be inferred from the ISM model that lack of top management commitment, poor planning, lack of proper training and education, inadequate resources, high cost of implementing TQM outweighing the benefits, lack of incentives and human resources and lack of participative decision-making are at the bottom of the ISM model with higher driving power. These are the most dominant barriers for which an organisation has to concentrate and take additional efforts to eliminate them. These barriers are source causes for barriers located at top levels within the ISM model. For implementing any newer system, management commitment is most significant. Without management commitment, bringing any cultural change will not be possible. Implementation of TQM involves compliance with standard Quality Procedures, which requires proper planning and training.

The barriers not considered in prior studies and addressed in the present study are described as follows: non-usage of advanced TQM tools such as modified forms of Quality Function Deployment and Failure Mode and Effect Analysis which enable organisations to attain higher quality performance; lack of customer involvement in product design and process execution; non-conduct of process capability and Six Sigma studies as organisations need to monitor process capability and sigma level for attaining zero-defect practices; no proper motivation for employees on adopting quality practices; ineffective measures for quality improvement as quality performance could be ensured using appropriate measures in the absence of which quality improvement could not be guaranteed; no periodic benchmarking with reference to quality performance; non-integration of voice of customer and supplier with reference to design and manufacturing processes; inadequate resources as without adequate resources, implementation of quality practices may be difficult; short-term thinking as quality concepts are long-term oriented; high cost of implementing TQM outweigh the benefits; lack of incentives and human resource practices; the organisation should encourage employees by providing appropriate incentives and supports, which creates a positive work culture; lack of quality practices and competent employees and lack of participative decision-making as quality initiatives involve decision-making at different levels. The organisation should always consider suggestions from all levels of the organisation, which also creates a responsibility among employees.

The barriers located at the middle of the ISM model having both driving and dependence show the interdependency of each barrier in the system. Action taken on barriers at the bottom of the ISM model helps to reduce the effort required for removing these middle-level barriers.

The barriers at the top level include lack of continuous improvement culture, ineffective measures of quality improvement, non-integration of voice of consumer and supplier and attitude of employees towards advanced quality practices. These barriers are dependent type. Hence, concentration of bottom-level barriers enables to cope with top-level barriers.

Planning decides the success of any project that consumes resources. To plan perfectly, it becomes necessary to analyse and understand the influential barriers influencing the system. The present study focuses on the identification and prioritisation of barriers influencing the implementation of TQM practices in the automotive sector, which provides guidelines to top management, practicing managers and decision-makers of the automotive sectors. The results of this study are presented to the practicing managers and their

Table 7. Comparison of results of the present study with prior studies in the literature.

Research Studies	Focus of Study	Number of factors/ barriers	Dominant factors/barriers	Methodology used
Present Study	Barriers to TQM practice in the automotive sector	21	Lack of top management commitment and Poor planning	ISM
Talib et al. (2011a)	TQM practices in the service sector	17	Top management commitment and Communication	ISM
Talib et al. (2011b)	Barriers to TQM implementation	12	Lack of top management commitment and lack of coordination between departments	ISM

opinion is that the modelling approach helped them to implement the TQM system in a systematic manner with less hurdles. The developed model acts as a rational approach through which barriers and their interrelationships are characterised to prioritise and implement the system in an effective way to deliver high-quality products and increase organisation efficiency.

As mentioned in Table 7, Talib, Rahman, and Qureshi (2011a) developed a hierarchy model of TQM practices that will help practicing managers and experts pertaining to the service sector in implementing TQM. They identified a list of 17 practices from the literature and used ISM methodology to develop a hierarchy model. They found top management commitment and communication as dominant practice which an organisation has to assign higher priority over others. Talib et al. (2011b) developed a structural model to analyse the barriers to TQM implementation in organisations. They used an ISM tool to analyse the relationship among the 12 barriers which are derived from the literature review and expert opinion. They identified that lack of top management commitment and lack of coordination between departments as the dominant barriers having high driving power and low dependency power. Their study mainly focused on the service sector. In the present scenario, the growth of the automotive sector contributes significantly to the country's GDP. Hence, it becomes necessary to concentrate on the automotive sector and to identify the influential barriers of TQM implementation in the automotive sector. In the present study, 21 barriers influencing the implementation of TQM practices in the automotive sector have been identified based on literature analysis and expert opinion. Certain key influential barriers missed in the past studies are also taken into consideration and analysed in the present study. The barriers are comprehensive to reflect the managerial and technological advancements in the present trend of the Indian automotive sector. The present study results show that lack of top management commitment and poor planning are identified as the most dominant barriers.

Conclusions

For effective implementation of TQM practices in the automobile industry, barriers needs to be identified and analysed. The barriers, if not eliminated, affect the performance of TQM practices, which in turn will affect the quality performance of organisations. In this context, this study presents an ISM-based approach to analyse the interaction

among barriers of TQM practices in the automotive sector. Based on the study, 21 barriers have been identified as dominant barriers. The driver power-dependence matrix provides insight into the top management to understand the relative importance and interdependencies among TQM barriers. The most influential barriers are lack of top management commitment, poor planning, lack of proper training and education, inadequate resources, high cost of implementing TQM outweighing the benefits, lack of incentives and human resources and lack of participative decision-making. The developed model provides a clear understanding on the key influential barriers, which enables managers to understand the interaction among barriers to minimise or eliminate the barriers.

Limitations and future scope

The present study focuses on the adoption of TQM practices in the Indian automotive component manufacturing sector. In the future, the scope for the implementation of TQM practices can be examined in other sectors. Also, additional factors also could be examined in line with developments in quality management practices. And the model could also be validated using a structural equation modelling approach.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abdelkrim, Y. B. (2013). Barriers to implementing total quality management in Algerian manufacturing organizations. *Valahian Journal of Economic Studies*, *4*(18), 61–66.

Awan, H. M., Bhatti, M., Bukhari, K., & Qureshi, M. (2008). Critical success factors of TQM: Impact on business performance of manufacturing sector in Pakistan. *International Journal of Business and Management Science*, *1*(2), 187–203.

Baidoun, S. (2003). An empirical study of critical factors of TQM in Palestinian organizations. *Logistics Information Management*, *16*(2), 156–171.

Baladhandayutham, R., Devadasan, S. R., Selladurai, V., & Senthil, V. (2001). Integration of BPR and TQM: Past, present and future trends. *Production Planning Control: The Management of Operations*, *12*(7), 680–688.

Barlett, J. E., Kotrlik, J. W., & Higgins, C. C. (2001). Organizational research: Determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal*, *19*(1), 43–50.

Bhadauriya, V. S., & Gupta, S. (2015). Automobile industry in India: An analysis. *Journal of Management Value and Ethics*, *5*(2), 50–57.

Bhat, K. S., & Rajashekhar, J. (2009). An empirical study of barriers to TQM implementation in Indian industries. *The TQM Journal*, *21*(3), 261–272.

Catalin, S. H., Bogdan, B., & Dimitrie, G. R. (2014). The existing barriers in implementing total quality management. *Annals of the University of Oradea, Economic Science Series*, *23*(1), 1234–1240.

Govindan, K., Azevedo, S. G., Carvalho, H., & Cruz-Machado, V. (2015). Lean, Green and resilient practices influence on supply chain performance: Interpretive structural modeling approach. *International Journal of Environmental Science and Technology*, *12*(1), 15–34.

Gunasekaran, A. (1999). Enablers of total quality management implementation in manufacturing: A case study. *Total Quality Management*, *10*(7), 987–996.

Gupta, A. D., Wali, Ayoob A., & Deshmukh, S. G. (2003). Critical success factors of TQM: A select study of Indian organizations. *Production Planning and Control: The Management of Operations*, *14*(1), 3–14.

Hafeez, K., Malak, N., & Abdelmeguid, H. (2006). A framework for TQM to achieve business excellence. *Total Quality Management & Business Excellence*, *17*(9), 1213–1229.

Jun, M., Shaohan, C., & Peterson, R. (2004). Obstacles to TQM implementation in Mexico's Maquiladora industry. *Total Quality Management & Business Excellence*, *15*(1), 59–72.
Kannan, G., Pokharel, S., & Kumar, S. P. (2009). A hybrid approaches using ISM and fuzzy TOPSIS for selection of reverse logistics provider. *Journal of Resources, Conservation and Recycling*, *54*(1), 28–36.
Khan, M. A. (2011). An empirical study of barriers in implementing total quality management in service organizations in Pakistan. *Asian Journal of Business Management Studies*, *2*(4), 155–161.
Khanna, H. K., Sharma, D. D., & Laroiya, S. C. (2011). Identifying and ranking critical success factors for implementation of total quality management in the Indian manufacturing industry using TOPSIS. *Asian Journal on Quality*, *12*(1), 124–138.
Kumar, R., Garg, D., & Garg, T. K. (2011). TQM success factors in north Indian manufacturing and service industries. *The TQM Journal*, *23*(1), 36–46.
Kumar, U., Kumar, V., Grosbois, D., & Choisne, F. (2009). Continuous improvement of performance measurement by TQM adopters. *Total Quality Management & Business Excellence*, *20*(6), 603–616.
Lin, C., & Chang, S. (2006). Exploring TQM's impact on the causal linkage between manufacturing objective and organizational performance. *Total Quality Management & Business Excellence*, *17*(4), 465–484.
Ljungstrom, M., & Klefsjo, B. (2002). Implementation obstacles for a work-development-oriented TQM strategy. *Total Quality Management*, *13*, 621–634.
Mahapatra, S. S., & Sekhar, S. (2004). Competitiveness of service sector through TQM principles. *Productivity*, *45*(3), 434–443.
Mohanty, R. P. (1997). TQM: Some issues for deliberation. *Production Planning and Control: The Management of Operations*, *8*(1), 10–13.
Mohanty, R. P., & Lakhe, R. R. (1998). Factors affecting TQM implementation: Empirical study in Indian industry. *Production Planning and Control: The Management of Operations*, *9*(5), 511–520.
Mosadeghrad, A. M. (2005). A survey of total quality management in Iran: Barriers to successful implementation in health care organizations. *International Journal of Health Care Quality Assurance Incorporating Leadership in Health Services*, *18*(3), 12–34.
Nizam, A., & James, D. T. (2005). TQM best practices: Experiences of Malaysian SMEs. *Total Quality Management & Business Excellence*, *16*(4), 491–450.
Oakland, J. (2011). Leadership and policy deployment: The backbone of TQM. *Total Quality Management & Business Excellence*, *22*(5), 517–534.
Rahman, S. U. (2001). A comparative study of TQM practice and organizational performance of SMEs with and without ISO 9000 certification. *International Journal of Quality and Reliability Journal*, *18*(1), 35–49.
Raimona Zadry, H., & Mohd Yusof, S. R. (2006). Total quality management and theory of constraints implementation in Malaysian automotive suppliers: A survey result. *Total Quality Management*, *17*(8), 999–1020.
Raj, T., Shankar, R., & Suhaib, M. (2008). An ISM approach for modelling the enablers of flexible manufacturing system: The case study in India. *International Journal of Production Research*, *46*(24), 6883–6912.
Salegna, G., & Fazel, F. (2000). Obstacles to implementing quality. *Quality Progress*, *33*(7), 53–57.
Samuel, K. M. H. (1999). From TQM to business excellence, production planning and control. *The Management of Operations*, *10*(1), 87–96.
Saravanan, R., & Rao, K. S. P. (2006). Development and validation of an instrument for measuring total quality service. *Total Quality Management*, *17*(6), 733–749.
Sarkis, J., Hasan, M. A., & Shankar, R. (2006). Evaluating environmentally conscious manufacturing barriers with interpretive structural modeling. In Surendra M. Gupta (Ed.), *Optics east 2006* (pp. 638508–638508). Boston, MA: International Society for Optics and Photonics.
Sebastianelli, R., & Tamimi, N. (2003). Understanding the obstacles to TQM. *The Quality Management Journal*, *10*(3), 45–48.
Sinha, N., Garg, A. K., Dhingra, S., & Dhall, N. (2016). Mapping the linkage between organizational culture and TQM: The case of Indian auto component industry. *Benchmarking: An International Journal*, *23*(1), 208–235.

Sohal, A. S., & Terziovski, M. (2000). TQM in Australian manufacturing: Factors critical to success. *International Journal of Quality and Reliability Management*, *17*(2), 158–168.

Soltani, E. (2005). Top management: A threat or an opportunity to TQM? *Total Quality Management & Business Excellence*, *16*(4), 463–476.

Soltani, E., Lai, P. C., & Gharneh, N. S. (2005). Breaking through barriers to TQM effectiveness: Lack of commitment of upper-level management. *Total Quality Management & Business Excellence*, *16*(8–9), 1009–1021.

Soltani, E., Lai, P. C., Sayed Javadeen, S. R., & Hassan Gholipour, T. (2008). A review of the theory and practice of managing TQM: An integrative framework. *Total Quality Management & Business Excellence*, *19*(5), 461–479.

Talib, F., Rahman, Z., & Qureshi, M. N. (2011a). An interpretive structural modelling approach for modelling the practices of total quality management in service sector. *International Journal of Modelling in Operations Management*, *1*(3), 223–250.

Talib, F., Rahman, Z., & Qureshi, M. N. (2011b). Analysis of interaction among the barriers to total quality management implementation using interpretive structural modelling approach. *Benchmarking: An International Journal*, *18*(4), 563–587.

Thakkar, J., Deshmuk, S. G., Gupta, A. D., & Shankar, R. (2005). Selection of third-party logistics (3PL): A hybrid approach using interpretive structural modelling (ISM) and analytic network process (ANP). *Supply Chain Forum*, *6*(1), 32–46.

Thiagarajan, T., & Zairi, M. (1997). A review of total quality management in practice: Understanding the fundamentals through examples of best practices applications-part III. *The TQM Magazine*, *9*(6), 414–417.

Vinodh, S., Ramesh, K., & Arun, C. S. (2016). Application of interpretive structural modelling for analysing the factors influencing integrated lean sustainable system. *Clean Techn Environ Policy*, *18*, 413–428.

Whalen, M. J., & Rahim, M. A. (1994). Common barriers to implementation and development of a TQM program. *Industrial Management*, *36*(2), 19–24.