School of the Built Environment

The use of a system dynamics approach for modelling maturity of Total Quality Management in Saudi construction firms

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Abstract

Managing quality in the construction industry is a challenge, especially in developing countries like the Kingdom of Saudi Arabia. The Saudi construction industry has been criticised for poor quality-related performance. Some Saudi construction firms achieved ISO-9001 certification, but failed to maintain it, suggesting that Saudi construction firms struggle to sustain their quality performance. Considering the importance of the Saudi construction sector to the national economy, it is imperative for Saudi construction firms to improve their quality performance. Saudi construction firms need to look at a long-term sustainable quality management strategy in order to improve their overall quality performance.

Total Quality Management (TQM) has been a subject of extensive academic and practical interest since the 1990s. However, most research focused on adopting a one-off and short-term strategy for managing quality. TQM maturity was used in the research; it refers to an organization's progression through incremental steps in quality improvement. System Dynamic modelling (SDM) was used to track firms' progress through quality levels over time. Such models can track firms' maturity towards higher TQM levels allowing them to make strategic decisions at different stages to speed up their progression towards a more mature TQM performance.

The assessment of the maturity level of TQM in construction firms would help to recognise the areas of improvement needed to improve quality, and achieve the main organizational goals. This research involves investigating the complexities in the dynamic interaction and causal relationships between the aspects that Saudi construction firms must focus on (enablers), and the organizational goals related to quality management. The SDM technique evaluates this dynamic interaction, based upon the European Foundation for Quality Management, EFQM Excellence quality model.

The EFQM model comprises five sets of enablers: Leadership, People, Policies & strategy, Partnership & Resources, and Processes. These five enablers affect the TQM performance (in terms of achieving TQM related goals) of the organisation. The components of the EFQM enablers were adapted to contextualise the EFQM model for the Saudi construction industry. Data was collected using two questionnaire surveys. The first survey was conducted with 43, ISO-9001 certified Saudi construction firms. This involved identifying the relationship between variables in the TQM maturity model. The second survey was conducted with 20 experienced individuals. The weighting for the enablers, specifically for the Saudi construction industry, was estimated in the second survey using AHP analysis. SDM investigated the dynamic interaction among variables in the model. Two case studies of the Saudi industry were selected to apply the simulation, and to investigate different policy decision interventions.

The findings show that leadership is one of the key factors that can help Saudi construction firms achieve high levels of TQM maturity. This may be explained by the high-power distance culture of Saudi Arabia, which is top driven and centralised. The second most critical factor is the people focus. Focusing on people aspects is critical because of high levels of diversity in the Saudi construction industry, and the collectivist nature of Saudi culture. Consideration of these two enablers is likely to improve other enablers, as well as leading to an overall rise in Saudi construction firms' ability to reach higher maturity levels. However, the impact of these two enablers only works to a certain extent; improving them beyond that level, shows no marked improvement in firms' progression towards higher TQM maturity levels. Improvement in the initial value of other enablers also provides significant improvement in the firms' ability to achieve higher TQM levels within shorter time spans.

This research supports the case for using a system-thinking perspective when considering implementation of TQM in organisations. A holistic organisation wide approach is required for implementation of TQM. The research recommends adopting a sustained long-term approach towards implementation of TQM, which is likely to generate long term benefits. Despite any kind of policy interventions, there is a gap between the time when enablers are activated and when firms begin to realise the benefits of its TQM strategy. Firms must persist with their TQM strategy and consider the long-term benefits when making decisions to pursue a quality-focused strategy.

Keywords: TQM, TQM Maturity, System Dynamics modelling, Saudi construction firms

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Author's declaration

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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Chapter 1 INTRODUCTION

1.1 Background

Managing quality in the construction industry is a challenge, especially in developing countries like the Kingdom of Saudi Arabia (Alotaibi *et al.* 2015). BS 4778 (British Standards Institution, 1987) defines quality as "the totality of characteristics and features of a service or a product that makes it able to meet the needs of the consumers and the standards it is stated that it meets". The American Society for Quality Control defines quality as, the total characteristics and product or service features tailored in a way that it works or performs based on the stated specifications to meet various customer and client needs (Campanella, 1999).

The construction industry is a key industry sector in the global economy. It provides infrastructure and housing for businesses and society and employment to millions of workers. World Market Intelligence (2016) reports the construction industry is the largest employer industry in the world. Global Construction Perspectives and Oxford Economics (2013), estimate annual construction output is likely to increase from $8.7 trillion in 2012 to $15 trillion in 2025. The construction industry undertakes a vast range of building, infrastructure, and heavy engineering projects. The size of construction projects ranges from small to large costing billions of dollars (Davies and Mackenzie, 2014; Barclay and Osei-Bryson, 2010). The complexity of the construction industry has increased creating management challenges (Li and Guo, 2011; Ponzini, 2011).

The construction industry is viewed generally as delivering poor quality, compared to other sectors like the manufacturing and services sectors (Idrus and Sodangi, 2010; Kerzner, 2009; Noble, 2009; Mahmood, 2008; Manuel *et al.* 2008; Levy, 2007; Khalid *et al.*, 2006). Poor quality in the construction industry is of significant concern for clients and for society worldwide because of projects that collapse, or defective projects that affect safety and health of citizens. Criticism has been directed towards the construction industry for its fragmentation within the supply chain, low productivity and poor quality and workmanship (Shibani *et al.*, 2010; Metri, 2005). A focus on quality could improve construction project performance in delivery, price, reliability, and customer satisfaction (Berssaneti and Carvalho, 2015; Gudiene *et al.*, 2014; Varajao *et al.*, 2014; Omran *et al.*, 2012; Oakland and Marosszeky, 2006).

Low profit margins put down ward pressure on quality (Fung *et al.* 2012; Manuel *et al*., 2008). However, the claim that quality has higher costs is faulty because costs associated with poor quality such as cost of reworking is quite high (Rumane, 2011). Quality focus provides higher results but in long term. One of the benefits of higher quality performance is improvement in a firm's reputation.

Quality is one of the key aspects of competitiveness for firms in all industry sectors; including construction (Harrington *et al.* 2012; Hoonakker *et al.* 2010). The primary focus of quality management is to meet customer requirements and to strive to exceed customer expectations. The quality of an organization's products and services is determined by the ability to satisfy customers and the intended and unintended impact on relevant interested parties. ISO9000:2015 suggests quality can:

- Increase customer satisfaction;
- Improve customer loyalty;
- Enhance repeat business;
- Enhance the reputation of the organization;
- Expand the customer base;
- Increase revenue and market share.

Demand from construction industry clients for higher levels of quality has grown since the 2008 financial crash; they want better value for money and improved quality. Oakland and Marosszeky (2006) reported that many construction contractor firms depend on their reputation for good quality to compete in the construction industry.in recent years, demand for higher levels of contractor quality have grown ever more pressing (Griffith, 2010). A focus on quality could greatly improve construction project performance in terms of delivery, price and reliability (Chung, 1999; Oakland and Marosszeky, 2006). Egan (1998) suggested that the entire industry would benefit from any process that makes construction sector performance more efficient and effective.

Construction project delivery, unlike manufacturing processes, lacks product integration and involves interdependent complex processes undertaken in a harsh environment on a job site by temporary project teams. Each project is unique, with the separation between design and production and a long supply chain that creates special challenges in the management of quality (Harrington *et al.* 2012). The construction process is fundamentally an iterative, rather than a linear process with multiple stakeholders who are interdependent.

This has significant implications when managing quality; failure of one part of the process can affect all the other items in the system. In complex systems, managers should focus more on interactions of system variables than actions (Sterman, 2000). The research recognises this system complexity as being important for the management of quality in construction firms.

Whilst quality management systems have been hailed as the key evolutionary step for the construction industry, it has been difficult for construction companies to generate the full range of benefits from implementing quality management such as Total Quality Management (TQM) (Harrington *et al*., 2012). The problem can be understood by looking at two issues: first is the failure to adopt an approach that includes continuous improvement to achieve higher maturity in quality management, and; second is the failure to look at the implementation of quality initiatives holistically such as from a system perspective. The management of quality is an equally complex process with the multitude of stakeholders and their interdependence. Outcomes are determined not by single causes, but by multiple causes, and these causes may, and usually do, interact in a non-additive fashion. Adopting a holistic quality improvement approach aimed at gradual and sustained improvement in quality has potential of offering a workable solution to the aforementioned problems.

1.2 Quality Management Systems

Quality management system is the managing structure, processes, procedures, responsibilities and management resources to implement the principles and direct organisation's activities to achieve the quality objectives of an organisation (Dale *et al*, 2007). A quality management system is a dynamic system that evolves over time through periods of improvement (Khanna *et al.* 2004; Conti, 2010). Quality management systems such as TQM, Kaizen, Six Sigma and ISO-9000 have been promulgated as possible solutions to the quality issues that many industries face (Georgiev and Ohtaki, 2016). Total Quality Management (TQM) has been widely discussed as a solution to the quality assurance and quality management issues in industries such as manufacturing (Bigliardi and Galati, 2014; Bahri *et al*., 2012), and construction (Kheni and Ackon, 2015; Harrington *et al*., 2012). The next section provides an overview of relevance of TQM to the construction industry.

1.3 Total Quality Management (TQM)

W. Edwards Deming defined good quality as meaning a predictable degree of uniformity and dependability with a quality standard suited to the customer (Othman and Rashed, 2016). When defining quality, many researchers argue that it should be explained in the context of customer satisfaction (Luu *et al.* 2008). However, the success of construction firms depends not only on customer satisfaction, but on the satisfaction of other influential stakeholders who have sufficient power to affect the success of construction firms, such as the design team consultants, the specialty contractors and organisations in the supply chain. Construction firms must aim for stakeholder satisfaction, rather than only customer satisfaction.

TQM is one of the quality management frameworks, which defines quality in terms of stakeholder satisfaction. Many researchers have described the benefits of adopting TQM principles within construction organisation (Bardoel and Sohal, 1999; Willar *et al.* 2011; Harrington *et al.*, 2012; Bani, 2012). Some potential benefits are:

- Work being carried out correctly right from the start.
- Reduction in costs, time, waste, rework and improve quality outputs.
- Improving Productivity and efficiency of quality systems.
- Closer relationships with subcontractors and suppliers.
- Reduced cross-functional barriers.
- Better employee satisfaction.
- Client recognition.
- Improving performance and competitiveness.

TQM has the potential to improve business results, greater customer orientation and satisfaction, worker involvement and fulfilment, team working and better management of workers within companies. However, it has been criticised as a management fad by its opponents (Dahlgaard and Dahlgaard-Park 2006; Green, 2006; Douglas, 2006; Byrne, 1997). Kearney (1992) estimated that around 80 percent of TQM initiatives fail. Failure is a subjective term; it is difficult to find substantive evidence about failure. In some cases, the organisations may have had unrealistic expectations from TQM implementation. The failure in such cases could be attributed to failure of companies to set realistic expectations, and not the failure of the TQM system. Explaining the high rate of failure of TQM initiatives, Kolesar (1995) and Neogy (cited by Antony, 2007) argue that the problem is not with TQM, but with organisations which fail to implement it adequately. Bergquist *et al.* (2005) and Van DerWiele *et al.* (2002) point towards a large number of quality award winners using TQM, proving TQM can benefit organisations if they implement it properly. Andersson *et al.* (2006) argues that firms which successfully implement TQM, financially outperform organisations that do not adopt TQM or fail to implement it adequately.

Firms that adopt TQM look at each process and function through the TQM/quality lens. This means that quality takes precedence over any other aspect of process/function. The construction industry is complex and many quality management approaches do not cover all aspects (e.g. resources, culture, functions, processes and policies) (Cheng, 2008; Andersson *et al.* 2006; Antony, 2004, 2007). TQM is flexible (Ehigie and McAndrew 2005) hence, applicable to the construction industry.

TQM can help construction companies to address many of the issues they face about quality (Harrington *et al.*, 2012). Oakland and Aldridge (1995, p. 32) assert that "if ever an industry needed to take up the concept of TQM, it is the construction industry." TQM has been a key to business improvement since 1974, and is fundamental in improving efficiency and competitiveness across many industries. Quality improvement practices like TQM, requires quality consciousness, teamwork and cooperation, moulded into construction industry practices.

The different perspectives of TQM have led to differences in understanding of what it is, and how it is to be implemented. Lau and Anderson (1998) reviewed 13 articles and found 12 different definitions of TQM. Oakland and Marosszeky (2006) considered it a philosophy, Dahlgaard *et al.* (1998) considered it a culture, and Bohan (1998) considered it a strategy. This lack of consensus has resulted in misconception and confusion about the measurable benefits of TQM. Organisations have varied in their adoption of TQM, with consequently different outcomes. Bergquist *et al.* (2005) recommends developing consensus on what TQM is and how it should be treated and adopted. This will help in identifying the goals which can be realistically targeted by the adoption of TQM.

TQM comprises three words:

- Total: Complete/ holistic approach.
- Quality: Ability to meet and exceed stakeholder expectations.

- Management: continuous improvement of resources and processes.

Combining these three words give a simple definition of TQM as follows: TQM is a holistic approach of managing continuous improvement of organisational resources, activities and processes in order to meet and exceed stakeholder expectations.

This definition highlights two key issues that this research aims to address; firstly, "holistic," and secondly "continuous improvement." These words suggest that any TQM initiative should seek to develop continuously an organisation's resources and activities towards achieving its quality-related objectives. This development should be considered holistically, which means the interaction between the organisational resources and activities is quite critical.

A major issue is the selective implementation of TQM, which means that the implementation of TQM is not holistic. Holistic perspective is one of the primary principles of TQM, it is doomed to fail unless implemented holistically (Harrington *et al.* 2012; Conti, 2010). This can be resolved using a system thinking approach in TQM implementation as discussed below. Holistic consideration requires system thinking, while continuous development requires considering development over time and reaching to a high maturity level. TQM does not yield rapid results, those expecting fast results from TQM are mistaken (Douglas, 2006). Black and Revere (2006) argue that one of the reasons why organisations have not implemented TQM was because the benefits are long-term and deeply embedded, which does not show short-term success. This highlights a serious flaw in the approach that organisations take when adopting TQM, which is a journey and not a destination (Burati and Oswald, 1993). Many organisations look at it as a destination and try to link it with concrete objectives. Attainment of higher maturity level of TQM must be achieved by putting quality at the heart of everything, every resource, every activity, and every function and by adopting a continuous improvement approach. Section [1.4] discusses the concept of continuous improvement under the TQM maturity model, while section [1.5] discusses the holistic perspective in TQM under system thinking.

1.4 TQM maturity concept

TQM maturity proposes the view that the firm's TQM performance improves over time. The measurement of TQM performance helps to identify how firms both mature and improve their quality management. Continuous improvement is core to the TQM philosophy, it highlights that TQM is not aimed at providing instant results, but rather advocates small incremental improvement over time. Firms that look to implement TQM must be long-term focused. TQM is never ending; when the firms stop complying with the TQM philosophy, it is possible to reverse the gains made by its adoption. Black and Revere (2006) suggested this reversal as one of the reasons for the comparative lack of popularity of TQM. Lemak and Reed (1997) found that firms that exhibit long-term commitment to TQM financially outperform other organisations. Dahlgaard and Dahlgaard-Park (2006) argue that TQM is not a quick fix solution, but is aimed at long-term gains.

This research is based on the premise that TQM is a journey in which the organisation continuously improves its quality performance while institutionalising past changes. In order to achieve this, all the components of the system (i.e. organisation) need to interact and work together in order to achieve desired goals of the organisation. By doing so, the firm gradually improves its quality performance, improving its TQM maturity.

TQM maturity therefore refers to an organisation's progression from lower quality performance to higher quality performance. Different TQM maturity levels indicate whether one firm has better TQM performance than another. These levels are tracked according to a TQM index score, which is a measure of a firm's TQM performance. It provides a way of checking changes (improvement or decline) in a firm's TQM performance. This research is concerned with proposing policies that can help Saudi construction firms to achieve higher TQM maturity levels. A system dynamic modelling technique is adopted to understand how Saudi construction firms can continuously improve their TQM performance level.

Models such as European Foundation for Quality Management (EFQM) and MBNQA identify the enablers that will help the firm gain maturity in its TQM performance. EFQM provides a theoretical framework for understanding the parts of a system that can lead to improved results. Specifically, EFQM is used as the primary model for the implementation to determine the enablers that will lead Saudi construction firms towards higher TQM maturity levels. The underlying reasons for the selection of EFQM are discussed in chapter two.

1.5 TQM and system thinking

Organisations have often implemented TQM selectively, ignoring the systemic nature of TQM (Conti, 2010). TQM must be implemented across the organisation and all its systemic components in order to yield desirable benefits (Kheni and Ackon, 2015). A system is a set of interdependent parts, which interact together in a complex manner to create a whole. Although a system is comprised of several components, none of the components on their own can represent the whole system (Ackoff, 2006). Therefore, any quality management program/policy should target the system as a whole and not its individual components. The interaction between the components should be taken into consideration. The relevance of systems thinking in organisational research can be understood from the fact that all organisations act as systems; although they all comprise similar sets of components, they are all different for each other.

A system comprises of two or more elements, so that each element interacts with each other, their interaction affects the system (Ackoff, 2006). Since any one element alone is not capable of performing what the system does, a system cannot be replicated by its components. An organisation can be considered as a socio-technical system, which functions as a result of the interaction of humans and technology, with humans utilising technology to accomplish organisational tasks. With a system thinking approach, it is evident that neither human resources nor technology alone can influence the system. In this respect, the quality improvement can only be achieved through a systematic and synchronised improvement in quality performance of both human and technological aspects of business.

Unless considered holistically, i.e. across all resources, processes, policies, practices and functions, TQM is unlikely to generate desired benefits. What TQM requires is an evolution of the organisation as a ‘whole’ across the quality awareness scale; for example, from quality conscious to quality focused. Saudi construction firms can be considered as subsystems, which are part of a larger system i.e. the construction industry. Since the industry is fragmented, none of the organisation is complete in itself, but is rather a component of the large industry network. The organisation system will thus include not only its internal components, but also the external components that it interacts with i.e. its partners, stakeholders etc. The high-power distance culture of Saudi Arabia can be a challenge in implementing TQM, which requires participation of all relevant stakeholders as the Saudi Arabian management style, is top driven and centralised. A people perspective is important; it is people that will eventually implement the TQM organisation policy.

TQM is about continuously improving customer satisfaction by quality-led company-wide management systems (Forbes and Ahmed, 2011). This goes beyond the mere application of total quality as a management requirement (Kaur and Sharma, 2014). The problem is that different people may have different perceptions of quality, such as what it is, how is to be measured, and who it should benefit. The differing perception means there is no consistency in how quality is treated by different components of the system.

The following important TQM characteristics emerge from the discussion in sections 1.3, 1.4 and 1.5:

- TQM implementation requires long-term focus and sometimes even short-term sacrifices.
- TQM requires continuous development and a firm must ensure that past gains made by adoption of TQM are not lost. Firms should continuously improve their TQM performance and ensure that the philosophy is enshrined in each one of its components including its resources, policies and processes.
- TQM should be adopted at a system level i.e. in each and every component of the organisational system.
- TQM should be adopted according to the context of the organisation. TQM is flexible and can be adapted to an organisational context (Ehigie and McAndrew 2005).
- Firms must set realistic expectations with TQM.

1.6 Statement of the problem

The challenge of implementing TQM is that TQM is not a programme, nor a tool, nor a slogan; it is an organizational paradigm (Harrington *et al.*, 2012). TQM implementation requires the creation of an organizational culture that fosters continuous improvement in everything, by everyone at all times, and requires changes in organizational processes, strategic priorities, individual belief, attitudes and behaviours (Dale *et al.*,1997a).

TQM as an organizational paradigm aiming toward continuous improvement, it is not a linear system. It requires an understanding of how TQM principles can be achieved in a complex system like construction work. Van der Wiele *et al.* (1997, p. 237) stated “TQM is dynamic in nature, based on continuous improvement and change, it aims to achieve complete customer satisfaction by identifying and building on best practice in processes, products and services.” The construction process is fundamentally an iterative rather than a linear process with multiple stakeholders. This has significant implications when managing quality, failure of one part of the process can affect all the other items in the system. This research recognises this complexity and fragmentation as being important for the management of quality.

The research aims to propose a TQM implementation policy, which will help Saudi construction contractor firms[1] to speed up their achievement of TQM-related goals. This could be achieved by understanding the complexities in the dynamic interaction among system's variables that play a significant role in embedding TQM in construction firms. It involves building a system dynamic model representing the dynamic interaction and causal relationships between the enablers (i.e. factors that must be focused upon in order to improve quality) and quality related goals (goals that targeted to be achieved). Simulating the model over a time period will show how the dynamic interactions of variables affect organisation's TQM maturity level. Therefore, the following questions need to be answered.

1.7 Research questions:

1) What is the appropriate assessment framework of TQM for the Saudi construction firms that include enablers (efforts) and goals (achievements)?
2) What are the dynamics interactions and causal relationships between the enablers of TQM and their impact over time on the attainment of higher TQM maturity levels?
3) What kind of policies can help Saudi construction firms in achieving higher TQM maturity levels?

1.8 Aim and objectives

This research proposes a TQM implementation policy that will help Saudi construction firms attaining of higher TQM maturity levels in a timely fashion using a system dynamics approach.

Objectives

The following objectives have been established to achieve this aim:

1. To investigate the characteristics of the Saudi construction environment and how this influence quality management in construction firms.

[1]Hereby referred to as Saudi construction firms.

2. To find an appropriate assessment framework for TQM and identify the enablers and goals of TQM and how they relate to Saudi construction firms.
3. To identify the causal relationships between enablers and goals and their interdependencies.
4. To build a system dynamics model to understand the complexity of dynamic interactions among enablers and goals on a long-term basis.
5. To identify the policy implications through the application of TQM maturity model for Saudi construction firms.

1.9 Significance of research

The construction sector is seen as difficult, complex, and fragmented, with the multiple layers of specialist contractors in the supply chain, and the separation of design from production. It requires an understanding of how TQM principles can be implemented in a complex system like construction work.

The Saudi construction industry has been criticised for poor performance, in particular poor focus on quality (Assaf and Al-Hejji 2006; Arain *et al.* 2006; Al-Kharashi and Skitmore, 2009; Alghonamy *et al*. 2014). The Saudi government has emphasized the need for improvements in productivity, quality, safety, and management approaches (Saudi Standards, Metrology and Quality Org. 2015). This is important because the government is the largest sponsor of construction projects in Saudi Arabia. It has strived to improve the performance and quality of construction projects through its 9th Development Plan for 2010-2014 (MEP, 2015).

The Saudi Arabian construction industry is undergoing transition with the demand for improved quality, exerting pressure on construction industry players to review their strategy on quality. The result has been a rise in Saudi construction firms achieving ISO9001 certification. However, many Saudi construction firms are not maintaining their ISO9001 certification because of failure to sustain the standards. This suggests a shortcoming in their approach towards quality improvement.

TQM systems are used in the manufacturing industry, but have not been widely used in the Saudi construction sector. Construction organisations in the Kingdom of Saudi Arabia have been slow to embrace fully a holistic approach to the TQM philosophy (Al-Otaibi *et al.*, 2015; Al-Ghonamy *et al.*, 2014; Albayoudh, 2003). Sharma and Kodali (2008) reported that many organisations are not in a position to understand clearly the concept of

TQM, knowing what has to be implemented and in which areas to focus to achieve quality improvement. Although different TQM enablers are identified and used in the literature, organisations must identify how these enablers interact over time, with each other, and with the goals of quality improvement, in order to achieve higher maturity levels of total quality management in the construction sector.

One of the reasons why TQM may have been not been successful in the construction industry is its structure and composition, especially in a developing country like Saudi Arabia (Al-Otaibi *et al.* 2015). The Saudi construction sector has many unique characteristics, such as the Arab management culture, high reliance upon foreign and unskilled labour, high levels of cultural diversity, the contractor registration system, and the fragmented nature of Saudi companies operating as contractors in the construction sector. This means that knowledge of TQM implementation cannot be applied to the Saudi context by copying from the literature; implementation of TQM has to be studied from the perspective of within Saudi construction firms. It is important, initially, to understand the context of these firms as no previous research was identified which considers this aspect. This is a process which determines factors that influence the organisation's purpose, objectives and sustainability. It considers internal factors such as values, culture, resources and performance of the organization. It also considers external factors such as cultural, social, customers/clients and economic environments.

It is imperative to understand the complexity of the dynamic interactions among the main variables that drive total quality management (TQM) and their impact over time. System dynamics was used to consider when and how the Saudi construction firms can achieve and sustain higher TQM maturity levels. This would help in developing policies for achieving higher TQM maturity levels for Saudi construction firms. Consequently, this would help Saudi construction firms to recognise the areas of improvement to improve quality, alongside an effective quality management system and achieve higher TQM maturity level.

1.10 Thesis outline

Chapter 1 is the background of the research, the problem statement and why the problem is critical. It includes the aim and objectives, and rationale for the research.

Chapter 2 is a critique of the relevant literature. The first section discusses quality definition in construction, the evolution of quality, quality in construction, TQM in construction. The second section of the literature review chapter discusses assessment framework of TQM and comparing different frameworks that have been discussed in past researches including their advantages and limitations.

Chapter 3 presents the development of assessment framework of TQM; the constructs of the dynamics system and total quality maturity models.

Chapter 4 contains a discussion on the Saudi construction industry including its key aspects which may affect its drive for quality. The economic environment which is fuelling demand for better quality is discussed along with consideration of institutional and industrial factors such as labour issues, regulations etc. and social-culture aspects.

Chapter 5 presents the methodology for the research. It investigates the different tools and methods that could be used and then discusses the specific methods and tools used. It also gives the reasoning behind the selection of particular research design and methods.

Chapter 6 presents statistical analysis of quantitative data. Partial Least Squares (PLS) Regression analysis is conducted to identify the causal relationship between the different variables in the EFQM framework. This helps to understand which factors have a cause-and-effect relationship with other variables and what is the nature of this relationship i.e. is it direct or inverse. The next step was to identify the weight of each enabler i.e. the intensity of impact of the variables on TQM maturity levels. The data was analysed using Analytical Hierarchy Process (AHP). The results are the inputs in the system dynamic modelling.

Chapter 7 presents a system dynamics approach. Casual loop relationships and a Stock flow diagram are presented to understand the complexity of dynamic interactions among Enablers and Goals on a long-term basis. Following this, the base model is run to estimate the TQM maturity cycle for Saudi construction firms in general. Sensitivity analysis is conducted to validate the model and see how changing the initial values of the enablers will affect firms' ability to reach higher TQM maturity levels.

Chapter 8 presents the applications of the dynamics model using a case study approach. In the case study analysis of different sets of enabler values are used to understand the impact of changing initial values of the enabler on attainment of higher TQM maturity levels.

Chapter 9 presents the findings and a discussion of the research.

Chapter 10 presents the conclusions, with the limitations of the research.

Chapter 2 LITERATURE REVIEW ON QUALITY MANAGEMENT

2.1 Introduction

Quality has been defined in many different contexts. The literature suggests that the concept of understanding quality in construction has matured over time. Two key aspects of the implementation of TQM are considered: applying it holistically, and continuous improvement. The implementation of system thinking in TQM is discussed. Reasoning is given why system thinking is critical for understanding the implementation of TQM. The different TQM assessment frameworks/models are critiqued. Evaluation of the advantages and limitations of different frameworks/models are made in order to select the applicable assessment framework for TQM in construction firms. Their relevance to TQM implementation in the Saudi construction industry is discussed, with and, justification for the adoption of a European Foundation for Quality Management (EFQM) model in this research.

2.2 Movement of Quality

The perceptions of quality have changed significantly over the last century, evolving through four distinguishable eras focused on: inspection; statistical quality control; quality assurance; and total quality management (Dale *et al.,* 2007) – see Figure 2.1. Inspection involves activities like measurement, examination and testing a single or more characteristics of a product/process and comparing the results against a set of specified requirements to ensure conformance of the product (Dale *et al.,* 2007).As a result, supervisors were controlling large number of workers leading to reduction of control over the workforce. To cope with this problem, companies adopted fulltime quality inspectors, yet there was a huge disconnect in the product uniformity, therefore, an assumption of quality control was the answer to ensure quality assurance. This assumption may be correct in a manufacturing and assembly environment for mass produced products, it is more difficult to manage in a site environment or in the delivery of professional services.

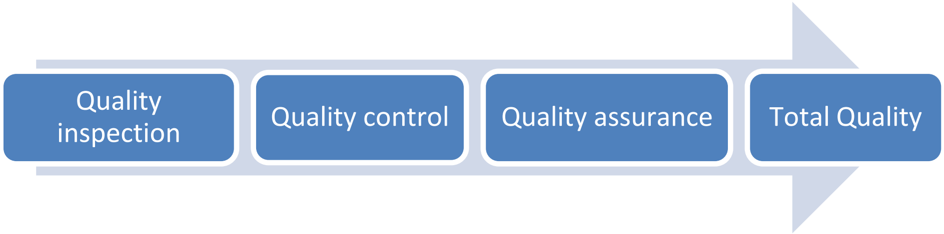

Figure 2-1: Movement of quality

Juran (1988) suggests quality control is a managerial process where quality performance of the production process could be analysed while comparing it against set requirements about goals and faults that could be corrected. Every stage of a construction project should be subject to quality control procedures through various systems with tools, control charts, checklists, detailed inspection, and testing. These tools can be used for various purposes like generating ideas, planning, analysing, evaluating and creating scope for continuous quality improvement in different stages of construction projects. Dale *et al.* (2007) describes those organizations that rely on inspection and quality control to manage quality as operating in a detection-type mode. Detection relies on finding and correcting mistakes. Rather than just identifying the sub-standard products/services, it would be ideal if emphasis is focused on preventing the manufacture/delivery of such products/services.

Quality assurance is a prevention system, which works at improving the quality of the product and service in addition to increasing productivity by emphasising the design of the product, service, and the production process (Rumane, 2011). Through focusing on the source activities and working on integrating quality into the design and planning stage, products that do not meet the set standards is prevented, especially when such defects are discovered early in the process. The organizational management must encourage the various departments to work in unison and identify and eliminate the root cause of problems. Synchronised efforts by every team member results in continuous overall organizational quality improvement leading to the next level in quality known as total quality management.

The view of quality has changed significantly over time. The responsibility of quality has moved from quality departments and direct labour employees, to the responsibility of everyone, including senior managers. Kerzner (2009) outlines these changes with the view of quality in the past and present as shown in Table 2.1.

Table 2-1: Changing views of quality, adapted from (Kerzner, 2009)

Past	Present
• Quality is the responsibility of blue-collar workers and direct labour employees working on the shop floor	• Quality is everyone's responsibility, including white-collar workers, the indirect labour force, and all staff
• Quality defects should be hidden from the customers (and possibly management)	• Defects should be highlighted and brought to the surface for corrective action without allocating blame
• Quality problems lead to blame, faults, justification, and excuses	• Quality problems lead to cooperative solutions
• Corrections-to-quality problems should be accomplished with minimum documentation	• Documentation is essential for "lessons learned" so that mistakes are not repeated
• Increased quality will increase project costs	• Improved quality saves money and increases business
• Quality is internally focused	• Quality is customer focused
• Quality will not occur without close supervision of people	• People want to produce quality products and should be trusted to produce them, they need an environment of trust and delegation of responsibility
• Quality occurs during project execution	• Quality occurs at project initiation and must be planned for within the whole project from inception through design and production and into use

Kerzner's analysis was based on the assumption about uniformity of skills and competencies. Not all construction processes are like a production line, they involve multi-cultural work force, who, even with training do not have a cultural understanding of good quality. The concept of quality is not uniform across all the functions and participants within a construction project. Any quality system must recognise the diversity of competencies and skills of the workforce, and the interdependence of the tasks. For example, installing a burglar alarm system requires many specialists, not just the skills of the alarm installer. There are three types of interdependence (Thompson, 1967).

a) Pooled interdependence, where there is a low level of interdependence.
b) Sequential/workflow interdependence. Workflow interdependence is the term used when multiple work processes, functions or personnel rely on or collaborate with each other to accomplish duties or output a product, where there is reliance upon ensuring quality is maintained through the sequence of assembly.

c) Reciprocal/task interdependence, which is the highest intensity of interdependence where the workforce needs to ensure they have close communication between tasks. The construction sector is very reliant upon reciprocal/task interdependence.

TQM procedures applicable for the construction sector must recognise the fragmentation and interdependence of the tasks, and the differences between workflow and task interdependence.

2.3 The concept of quality

There are many definitions that describe quality, most relate to knowledge of services, products and the satisfaction of customers and clients. However, there is no consensus among the scholars about the definition; each scholar focuses on a particular aspect of quality (Pyzdek, 1999).

According to the ISO (the International Organization for Standardization, 1994a), quality is "the totality of characteristics of an entity that bears on its ability to satisfy stated or implied needs." Garvin (1984, p.26) reports five main approaches to defining quality:

Transcendent—"Quality cannot be defined, you know what it is." (Pirsig, 1999, p. 185). This approach claims that quality is hard to define; however, it is absolute and is recognizable anywhere in the world through experience.

User-based—"Quality consists of the ability to satisfy wants" Edwards (1968, cited in Rumane, 2011, p. 7). Kuehn and Day (1962, p. 101) assess quality from the end product point of view and suggest what is expected finally in the market place. They state that the quality of a product depends on "how well it fits patterns of consumer preference.", While, Juran (1988) focuses on "fitness for use."

Product-based— "Differences in quality amount to differences in the quantity of some desired ingredient or attribute" (Abbott, 1955, pp. 126–127). According to Leifler (1982, cited in Rumane, 2011, p. 7), quality means "the amounts of the unpriced attributes contained in each unit of the priced attribute."

Manufacturing-based— Gilmore (1974, cited in Garvin, 1984, p.26) describes it as "the degree to which a specific product conforms to a design or specification." Crosby (1980, p. 15) being part of quality team defined quality as "conformance to requirements".

Value-based— Looking at quality from a value perspective, Broh (1982, p. 3) explained it as "the degree of excellence at an acceptable price and the control of variability at an acceptable cost." From a customer's perspective, Feigenbaum (1951, p. 1) called it something "best for certain customer conditions", which, (a) can be based on the actual use, and (b) the selling price of the product". Rumane (2011) described value as quality divided by cost, which means value increases when better quality is provided to the client with lower price.

Quality has been defined in many ways by scholars who were the pioneers of the quality movement, ideologies, philosophies, methodologies, and tools. Deming, Ishikawa, Feigenbaum, Crosby and Juran are known as the "quality gurus" and the big five. However, their approach and views on quality varies. Oakland (2003) stated that the big five focused on the fundamental principles of total quality, though they have varying solutions to the requirements of quality management. Table 2.2 presents the definitions of the quality according to quality experts. The consistent theme that emerges from the table is the importance of customers' satisfaction, by meeting their needs and ensuring the fitness for purpose.

Table 2-2: Definition of quality (Experts of Quality)

Quality definition	**References**
Quality is the total composite service and product characteristics that are enhanced by marketing, manufacturing, engineering in a way that they will meet what the customers expect.	Armand V. Feigenbaum
Quality should aim at meeting customer needs not only in the present, but in the future.	W. Edward Deming
Conformance to requirements.	Philip B. Crosby
Quality is fitness for use.	Joseph M. Juran
"Quality and customer satisfaction is one and the same thing." Further, quality goes beyond quality of a product as it also encompasses quality of process, individuals and the rest of the parts making up an organization.	Kaoru Ishikawa
Quality is meeting customer's requirements.	John S. Oakland

In the above definitions, quality is that which meets customer and clients' needs and expectations through provisioning of better products and services that can meet organizational goals and objectives. The problem is that sometimes the two can be competing and, in such cases, determining the optimum solution is a challenge and may affect perception of quality for different stakeholders.

Most of the definitions have been formulated from a manufacturing perspective. The definition that suits manufacturing may not necessarily meet the requirements of the construction industry. In manufacturing, there is significant variation in expected quality and customers are often willing to pay the right price for desired level of product quality. Lower than expected quality in manufacturing would result in devaluation of a brand name, loss of customers, and low sales. In the construction industry, poor quality results in dissatisfied customers, additional cost and time for re-work to remedy defects, excessive repair and maintenance, potentially unsafe buildings, loss of reputation and loss of business. Construction projects are unique with a specific set of requirements. In construction projects, quality does not only refer to the product quality or equipment quality used in the construction projects, but to the overall management of the processes in completing the project. Thus, it mainly depends on controlling the quality in construction that is the crucial responsibility of the contractor.

Achieving quality in manufacturing involves different processes that include various stages of inspection and testing of both material and labour. A non-conforming product is reworked or repaired to ensure compliance of the requirements, or it is eliminated from the system. In contrast, in the construction industry, rework or rectification may be difficult to achieve and makes the remedial process a challenge that may be both problematic and costly because of all the different parties involved.

The concept of customer focus is more complex in the construction industry. Manufacturing produces mass products for a broad range of unknown customers; a construction project is procured by a single client. The construction industry has multiple end users. For example, infrastructure projects are funded by the government, but used by members of public. In addition, the scale of construction projects and their impact on the society and economy means that construction industry players need to focus on the client and other stakeholders/end users. The focus on quality should be to satisfy all these stakeholders.

The stakeholders have a different view of their client. The specialty contractor may view the principal contractor as the client, rather than the project sponsor, because the principal contractor can provide further work. The personnel on the job site view their employer as the client, because they pay the wages.

From a construction industry perspective, Hart (1994) observed that quality has three meanings:

i. It is about getting the work done on time;
ii. Making sure that the fundamental characteristics of the eventual project is within a given specification;
iii. It should involve working within the budget.

However, clients are very concerned that quality now embraces a more modern all-embracing meaning. Simply meeting specification is a very basic minimum requirement. Quality of service delivery is equally important, responding to requests in a timely way. Hart (1994) failed to mention the importance of health and safety, environmental sustainability, and corporate social responsibility as an aspect of quality.

According to Kanji and Wong (1998), construction firms face several problems due to the complexity of their operations. The construction sector is made up of a diverse range of organizations, which work together to complete projects. Unless all these have a similar understanding of the term "quality" and focus on it, it is difficult to achieve perceived quality in a construction project.

There seems to be no consensus on what "quality" means in the context of construction firms (Hoonakker *et al.*, 2010). Quality has been defined as the completion of a project on time and within budget (Kiwus and Williams, 2001); reducing repairs and defects (Love *et al.*, 2004); or conformance to ISO 9001 criteria (Bubshait and Al-Atiq, 1999), all of which are manufacturing-based definitions. Definitions of quality focus on customer satisfaction and expectations (Chase, 1993; Torbica and Stroh, 1999). The American Society of Civil Engineers (ASCE) has defined quality as the fulfilment of project responsibilities in the delivery of products and services in a manner that meets or exceeds the stated requirements and expectations of the owner, design professional, and constructor (Campanella, 1999). This is especially relevant today because of the large scale of projects in which multiple unrelated entities work together to complete the projects. If these entities have different perspectives of quality, it will be impossible to achieve the overall project goals. It is essential to synchronise the efforts of all the involved entities so that they all work towards achieving a common quality goal; this uniformity of focus is critical.

Quality is not just about satisfying the client, but also fulfilling the community's expectations (Chung*et al.*, 2008). The impact of the construction industry on society in general, in terms of sustainability, health and safety, disruption caused by construction activities and the resulting influence of the society on the construction industry, makes it imperative for the industry to adopt a wider stakeholder perspective rather than a narrow customer perspective. Dissatisfied people can raise objections on such issues as noise pollution, making it difficult for construction firms to obtain planning permissions for a project.

Definition provided by professional bodies such as the ISO may be too simple or general. The different definitions of the term ‘quality’ highlight the fact that quality is often perceptual, those looking to achieve quality goals need to ensure that there are no differences/gaps in the quality perceptions of different stakeholders.

Quality is not stationary; perception of quality may evolve and change with time, hence a dynamic perceptive is required to achieve quality objectives. Researchers argue that since quality is a dynamic concept, the achievement of quality should be a continuous process. An effective way of continuous quality improvement would be to employ the organizational efforts in identifying the root cause of problems and in providing solutions. A long-standing controversy about the high costs of quality and the impacts of poor quality significantly hinder the effort for improving quality in construction. The next section wills discuss the misconception of cost of quality in construction.

2.4 Misconception of the Cost of quality in construction

Juran (1988) claims quality is free. He adds what costs money is ‘un-quality’; un-quality represents all consequences of not doing the job right the first time. It can be argued that the cost of un-quality can be high in construction projects, because the cost of reworking or the costs incurred due to failure can be significant.

Research has focused on the operational perspective of the cost of quality. The cost attributed to quality is in two main areas: costs relating to doing things wrong, and costs related to attempting to prevent them from being done incorrectly. Crosby (1979) sets a formula for Cost of Quality (COQ):

COQ = Cost of conformance + Cost of Non-conformance.

Cost of conformance is providing a product or service in a fully effective manner according to specification. Non-conformance cost is made up of both direct and indirect costs, coming from the internal and external failure of not doing things in the right way the first time. An example might be onsite accidents, errors made at work, poor workmanship; these can all lead to penalties, increased costs of insurance. Campanella (1999) have postulated that quality costs can be as high as 20% of total construction costs. It is difficult to challenge such a percentage, but research is needed to understand the cost of quality failure.

In industrial construction, the direct costs of rework (termed deviations) can be as high as 12% of total costs (Burati and Farrington, 1987). Direct cost estimates from rework on commercial building construction are more conservative, averaging about 5% (CII, 2005). Based on this more conservative estimate, a simple calculation based on the U.S. construction industry annual output of US$1,116 in 2016 (Bureau of Economic Analysis, 2017), reveals that over $50 billion is wasted on the direct cost of rework alone. Considering that rework is only one aspect of non-conformance cost of quality, the cost of poor quality in construction is significant (Oakland and Marosszeky, 2006).Factors that contribute to poor quality, such as redoing defective work; interruptions due to repairs or obtaining replacement parts; replacement material purchases; staff time and money spent on handling of customer complaints; remedial work after project delivery, decreasing effectiveness of marketing efforts; and lawsuits, court costs and compensation payments (Ashford, 2002, p.185)

The cost of un-quality is rarely recorded in the construction industry because of the lack of clarity on what costs can be attributed to poor quality and which of the project participants these costs should be attributed (Moatazed-Keivani *et al.*, 1999). This means that in many markets it is difficult to push for quality initiatives, as there are no verifiable economic grounds or business case to do so. The costs of poor quality are not simply about spending time and money on rectifying work, they can significantly impact a firm’s reputation. The problem is that the cost of un-quality is so diverse and wide ranging that it is almost impossible to account for all the costs. This should not deter construction firms from accounting for the un-quality costs they could identify. In addition, business managers can make intelligent guesses about the costs incurred due to quality-related issues such as a reputation for poor quality (Oakland and Marosszeky, 2006).Companies that have measured the costs of poor quality have arrived at figures ranging from 10%–40% of the turnover of the organization (Ashford, 2002). These include all cumulative cost factors, such as lost man-hours and delays as a consequence of non-conformance activities, rework, and rescheduling to speed up or adjust the construction schedule. In addition, Thomas *et al.* (2003) stated that the costs of rectifying faulty construction issues during and after contract completion—such as leaking buildings and premature deterioration of exterior finishes—are in the same cost order as the profitability of many construction firms in the sector. By contrast, companies typically spend only a fraction of this cost (around 1% of their turnover) on quality improvement systems (Ashford, 2002).

Measuring the cost of poor quality is important for several reasons:

a) it exposes waste and the need to rework for all to see;
b) it serves as a driving force to improve company operations;
c) determines the progress of a company in reducing the cost of quality.

Eliminating or correcting poor quality within organizations has become an essential process undertaken each day in construction projects. The costs of carrying out repairs are high and time consuming; this underlines the importance of attaining quality. The value of improving quality can be diverse and powerful.

The costs of conformance involve working professionally from the outset, self-checking, creating procedures and training (Sullivan, 2010). This requires firms to invest additional effort and money; the rewards can be significant, with creased customer satisfaction and repeat business; more consistent and standardised procedures; improved approaches to public and private sector contracts; streamlined and more efficient operations; better management and employee understanding of an organization and more effective contributions; and improved organization reputation (Griffith, 2011).

2.5 Total Quality Management (TQM)

The evolution of TQM into an all-pervasive management philosophy took shape through the works of Crosby (1979), Deming (1982, 1986), Feigenbaum (1983), Ishikawa (1985), Juran (1988), and Taguchi (1982). Whilst popularized in the mid-1980s, the basic elements were established between the 1950s and 1970s. Although the bulk of theoretical development of TQM was in the United States of America, it was the Japanese who first applied the concepts (Martínez-Lorente*et al.*, 1998). In BS 5750: British Standard (BSI, 1992) TQM is a philosophy of management; it involves company practices which aim at harnessing the material and human resources of an organization in ways that will help in achieving the goals and objectives of that organization.

The Asian Institute of Technology (AIT), defines TQM as a philosophy in a systematic, consistent and integrated way, which incorporates every organizational resource, it focuses on ensuring the full satisfaction of customers inside and outside of the organization. The critical issue is not only the employees under direct control of the management, but also entities, which are part of a loosely integrated supply chain who contribute to the project.

A project manager needs to manage not only the employees but also other stakeholders, ensuring they all work as a team, owning the production process and, with committed top management acting as their guide; they are able to participate proactively Pheng and Teo (2004).

The Latham Report (1994) cited the definition of TQM adopted by the Henderson Committee (1992), which led to the formation of the British Quality Foundation:

> "*Total quality management is a way of managing an organization to ensure the satisfaction at every stage of the needs and expectation of both internal and external customers, that is shareholders, consumers of its goods and services, employees and the community in which it operates, by means of every job, every process being carried out right, first time and every time*." (Henderson Committee, 1992.Cited by Griffith and Watson, 2003, p. 268).

In Wessel and Burcher (2004), TQM is defined by the British Quality Association as being an all-embracing philosophy of business management that focuses on meeting the customer's needs with enhanced efficiency and effectiveness. According to Dale *et al* (2007, p. 9) "TQM is the mutual cooperation of everyone in the organization and associated business processes to produce products and services, which meet and, hopefully, exceed the needs and expectations of customers."

The definitions above define TQM as being a philosophy, but with varying viewpoints. From the British Standard viewpoint, it is described as a philosophy of management focused on achieving the objectives of the organization. On the other hand, the Asian Institute of Technology defines it as the philosophy aimed at ensuring customer satisfaction. In both definitions, what is common is the term "philosophy".

Based on the aforementioned definitions the definition of TQM as conceptualised, for the purpose of this research TQM is as a holistic approach of managing continuous improvement of organizational resources, activities and processes in order to meet and exceed stakeholder expectations.

2.5.1 **Benefits of TQM in construction**

Many researchers in the field of total quality management have described the benefits of adopting TQM principles within an organization. Arora (1996) and Huarng (1998) say that TQM could help reduce costs, time, waste, and rework and improve quality outputs. The positive correlation between TQM adoption and improving performance and competitiveness have been emphasised in the literature (Gunasekaran, 1999; Salegna and Fazel, 2000; Bani, 2012). The implementation of TQM could improve productivity and efficiency with quality systems that reduce customer complaints (Sun, 2000).

The benefits achieved through adopting TQM in seven Australian construction organizations based on case study research have been reported by Bardoel and Sohal (1999). The reported benefits are:

- reduced the quantity of goods damaged in transit and construction; reduced construction cycle time; reduced delivery time to the site;
- better control of processes resulting in consistency from design through to delivery;
- increased measurement of performance; decreased fallout of chemicals;
- improvement in customer perceptions of the company.

Vukomanovic *et al*. (2014) conducted a survey of 34 different construction companies in South-Eastern Europe using the EFQM model. There was a strong relationship between TQM enablers in the model, and the results/goals of construction firms. Bani (2012) found, in a study among UK and Jordanian construction firms, that reducing operation defects, improving customer relations, meeting customer requirements, increasing service quality, and increasing company market share are the most benefits of adopting a TQM approach.

By embodying TQM spirit in all aspects of the organization, construction firms would gain the benefits of this approach, which represents the management goals/objectives, such as customer satisfaction, employee morale, higher productivity zero defects, less rework, meeting specifications, completion on time, reduce cost, increase in sales, larger market share and increase competitiveness. An organization must implement TQM effectively and overcome possible challenges.

2.5.2 **Challenges in implementing TQM in construction**

TQM begins with the primary assumption that employees in organizations must cooperate with each other in order to achieve quality for the needs of the customer. The concept of quality has migrated from being considered as a non-price factor on which imperfect competition in the markets is based, to being considered as a strategic resource of firms. Quality went from being a one-dimensional attribute of the product to being a multidimensional construct which has to be managed and the implementation of which leads to a dynamic capability of firms.

TQM is a long-term approach and firms need to improve performance in an iterative manner. It is a continuous improvement process - firms cannot achieve the highest levels of TQM quickly, but must go through a number of iterative steps of incremental improvement. Each increment improves on the previous level of quality performance that must include feedback received (regarding improvement of quality) on past stages. One problem with TQM implementation has been that organizations have often implemented it selectively, ignoring the systemic nature of TQM (Conti, 2010). True TQM must be implemented across the organization and all its systemic components, in order to yield desirable benefits (Kheni and Ackon, 2015).

TQM has been utilized efficiently in manufacturing and other industries, while the successful implementation of TQM in the construction industry has different challenges (Hoonakker *et al.*, 2010). The temporary nature of relationships in the construction industry, its fragmentation, contractual and transactional nature of relationships, and long supply chains makes it difficult to implement TQM (Harrington, *et al.*, 2012). Temporary project teams formed especially to carry out a TQM project may be disbanded on completion of the contract (Pheng and Teo 2004). In the Saudi construction industry, a large proportion of the workforce is unskilled and poorly educated, with a high level of cultural diversity, poor perception of quality, and poor enforcement of regulations. These make it difficult for managers to implement a consistent quality policy across the organization.

In the construction industry, the owner is involved in all the project stages. Owners tend to provide greater inputs from the inception of the product, design specifications and production processes. The inputs for service or manufacturing sectors are restricted to quality standards, demand and the market price. Being able to know what customers need is integral part of satisfying customers.

Owner/customers in construction define their expectations and influence the quality requirements. For example, in the design project brief, the client will emphasise the main requirements, which can be aesthetic quality, design quality, workmanship quality, service quality, or a multitude of different items, such as the safety, quality, reliability of the components, and maintainability of the facility. The problem occurs when the customers want lower costs, rather than quality, with the expectation that the quality is not affected by the low price. One of the reasons put forward why firms do not invest in TQM as a long-term strategy is because of the belief that contractor selection at the tender stage is based upon lowest price. This is particularly true for the Saudi public sector procurement. Public sector managers may have no knowledge of quality in construction; the customer-led demand for quality may not be there, making it uneconomical for construction industry players to invest in quality systems that will improve quality standards.

The construction industry adopts many quality improvement initiatives such as quality control (QC), quality assurance (QA) and TQ. However, there is often confusion between the concepts of these initiatives, believing that compliance with QA standards such as ISO 9001 and 9002 is all that there is to the application of TQM on construction projects (Jaafari, 2001). Harrington *et al.* (2012) states QA and QC may be considered in construction industry as separate and sub-elements of total quality (TQ), but QA and QC do not represent the only elements of TQM. The difference between the TQM and the rest of the quality improvement initiatives (e.g. QA and QC) is that TQM is a continuous and lasting concept being embedded at the root of a firm to improve the quality, regardless of whether it working on a project or waiting for the next project.

The quality culture in TQM is not only following quality instructions and guidelines; it is about an environment in which the employees see that quality-focused actions are undertaken at every level of the organization. Total Quality Management aims to ensure quality is achieved across the organization and all its systemic components, in order to yield desirable benefits rather than in selective areas. System thinking perspective could help construction firms to overcome challenges of TQM implementation.

2.6 System thinking

A system is a set of interdependent parts, which interact together in a complex manner to create a whole (Sterman, 2000).

Cusins (1994) identified five key aspects that characterise a system:

- A system’s environment is defined by arbitrary boundaries.
- Inputs from the external environment enter the system through this boundary.
- Within the system the inputs are transformed by actors through some process.

- These transformed inputs are the output of the system, which cross over to external environment.
- Processes involve a flow of resources, energy, material and information.

Based on Cusins' view, construction companies can be defined as systems especially from a quality perspective. Quality in construction is built around processes, which are linked to projects. These projects have fuzzy boundaries as they contain many participants who join and leave the system from time to time. External entities such as customers, government, regulators, society etc. provide the necessary inputs to the system. The natural law of systems states that "if the output of the system does not satisfy the environment, the inputs will cease" (Cusins, 1994, p. 20). This would mean that if the output of a construction firm does not satisfy its stakeholders, especially its customers, its inputs such as capital, will cease to flow.

A system essentially comprises of two or more elements so that each element interacts with each other, their interaction affects the system and none of the components on their own, can represent the whole system (Ackoff, 2006). Therefore, any quality management program/policy has to target the system as a whole and not its individual components. Since any one element alone is not capable of performing what the system does, a system cannot be replicated by its components. An organization can be considered as a socio-technical system, which functions because of the interaction of humans and technology, with humans utilising technology to accomplish organizational tasks. With a system thinking approach, neither human resources nor technology alone can influence the system. The quality improvement can only be achieved through a systematic and synchronised improvement in quality performance of both human and technological aspects of business.

2.7 Gap in research

Issues such as reworks, wastage, poor efficiency and poor customer satisfaction have affected efficiency, productivity and profitability of construction industry (Harrington *et al*. 2012) especially in countries like Saudi Arabia (Al-Otaibi *et al*. 2015). The focus on cost rather than on quality has affected both the industry players and their customers. However, the focus is mainly on short-term goals (Hoonakker *et al.* 2010). One of the key failures in this regard is to achieve and sustain high quality standards.

Al-Otaibi *et al.* (2015) research on quality management in Saudi construction industry found that poor quality management is one of the key factors threatening the competitiveness of Saudi construction firms. TQM factors can explain up to 37 percent variances in competitiveness and 68 percent variance in quality culture. At the same time, quality culture can explain up to 12.5 percent variance in competitiveness of Saudi construction firms. Thus, adopting TQM practices is likely to have significant impact on the competitiveness of Saudi construction firms. Kheni and Ackon's (2015) quantitative research found that adequate implementation of TQM can help construction firms not only avoid wastag, but also improve their productivity, efficiency and profitability which, in turn, is likely to boost their reputation with different stakeholders (Kheni and Ackon, 2015).

TQM is useful for quality management in construction because it talks about continuous improvement (Kheni and Ackon, 2015; Harrington *et al*. 2012). TQM can help the construction industry overcome many of these challenges. Researchers argue that TQM has failed in the construction industry, because of the difficulty in implementation in a non-manufacturing context. Harrington *et al*. (2012) found that construction firms have been slow to move over from quality control to TQM. TQM is essential for long-term survival of construction industry players because it tackles many of the inefficiency issues that threaten the sustainability of the construction organisations.

In their mixed methods research, Hoonakker *et al.* (2010) found that poor people management especially lack of skilled workers and poor team building skills followed by cost focus are to blame for poor implementation of quality in construction industry. They found that construction industry acknowledges the significance of leadership, human resources, customer focus and satisfaction as key factors in implementation of quality in construction. However, there is a poor focus on managing processes and planning a long-term strategy. The literature review confirmed that the complexity and scale of construction projects, with the fragmentation of industry makes it challenging to implement TQM (Harrington *et al*. 2012). However, the failure is not necessarily because of the nature of the industry, but a failure of the companies to understand fully the long-term nature of TQM implementation, and a failure to devise a way to measure TQM performance (Harrington *et al.* 2012; Hoonakker *et al.* 2010).

Conti (2010) listed several factors that focus on short term results, changing organisational goals; focus on financial performance over sustainable customer/stakeholder value generation capability, poor leadership involvement, poor understanding of the alignment between company context and adopted quality management approach as some of the key factors contribute to the poor implementation of quality management. He argues that organisations should be considered as socio-cultural systems rather than as technical systems. In his opinion, modern organisations are complex systems and system thinking approach is useful in modelling complex systems. Using the relations between different components, it is possible to improve efficiency, innovation and creativity within the system. Conti argues that System Thinking is useful for quality management application because the latter often requires rethinking of the organisation and this can only be achieved through a system perspective. System perspective also puts within an imaginary boundary, the components and relationships that affect quality management. This enhances focus and improvement implementation of quality management.

Extending this perspective it can be argued that TQM implementation should take socio-cultural nature of the organisational system into consideration. However, Conti (2010) merely argues for using the system thinking approach for implementation of TQM, but does not carry out any empirical research to test whether it can be applied for quality management. This research aims to overcome this gap. The gap in the research is the recognition of the need for a holistic, organization-wide approach to TQM, which requires consideration of an organization as a system in which various diverse entities interact together to accomplish a common goal (Conti, 2010). Research has not considered the organization as a system, where all components rooted in TQM, continuously interact and influence each other, which leads to a change in the overall state of the system.

The short-term approach taken by managers, leads to a lack of interest in TQM. TQM-related goals are outcome of continuous improvement efforts. Research has mainly considered it as static target, achieved through a range of enablers such as top management commitments, training, empowerment, rewards, processes improvement and quality policies etc. **(**e.g. Shibani *et al.*, 2010, Hoonakker *et al.*, 2010, Harrington *et al.*, 2012). These studies were dealing with the relationship between enablers and common goals of the organization as linear relationship. When firms implement a set of TQM enablers it will achieve desired goals, whilst ignoring the interaction between these enablers over time. In reality, these enablers interact dynamically leading to incremental improvements in quality, eventually leading to TQM- related goals. This dynamic interaction of enablers and their consequences over time is currently missing from the TQM literature.

The literature review has revealed that this problem has not been considered before. Studies have not identified the complexity of the dynamic interactions among the main elements that enable TQM in construction firms, nor identifying the consequences of quality initiatives undertaken over time. This research identifies the need to consider TQM maturity as an outcome of dynamic interaction of its enablers and can only be achieved when all entities, processes and policies, are quality focused; nobody has looked at this interaction in a construction industry context. This meets the aim of the research to look at how firms can achieve higher TQM maturity levels.

2.8 TQM maturity

Maturity can be defined differently in different contexts. Merriam-Webster (2013) has defined maturity as a "complete state of development". Maturity models can depict the distinctive organizational conduct and growth at various levels, develop encoding criteria, and formulate ways of transiting to the next level. Identification of a rational and liberal path for organizational development can be enabled by maturity models (Fraser et al., 2007). In terms of quality, quality maturity grid proposed by Crosby (1979) defined five successive phases for quality maturation:

1. Uncertainty:
2. Awakening,
3. Enlightenment,
4. Wisdom and
5. Certainty.

These levels depend on changing on quality's view and reduction in cost of quality throughout the transition from low level to high level. Dale *et al.* (2007) identified six levels of adoption of quality management. These levels are "uncommitted", "drifters", "tool pushers", "improvers", "award winners" and "world class". The authors suggest that in addition to these levels, organisational behaviour and attitude towards total quality improvement plays a vital role in the transition of the quality management procedures. However, time required for organisation to transit throughout maturity journey is missing in these quality maturity models. TQM is an organizational paradigm aiming toward continuous improvement. It requires an understanding of how TQM principles can be achieved in a complex system like construction work. With the help of a TQM maturity model, management can formulate a quality initiative and track organisation's progress towards its quality goals.

The TQM maturity model aims to improve and prioritise areas of organizational quality, and assist senior managers to interpret the vital aspects of organizational behaviour for quality. A maturity model is useful because of its incremental progression through dynamic interaction of the enablers. By looking at a timewise interaction of these enablers, it is possible to determine the policy interventions that the organization needs to adopt in order to achieve the desired results.

TQM implementation is best top-driven in construction firms due to the level of fragmentation and the nature of site production work. This means that a leadership enabler may be critical at the beginning of implementation of TQM. Not all enablers can be implemented all the time, an understanding of their significance and impact over the TQM maturity cycle is critical. TQM maturity therefore refers to an organization's progression from lower quality performance to higher quality performance. TQM maturity levels indicate whether one firm has better TQM performance than another.

Continuous improvement is core to TQM philosophy, it highlights that TQM is not aimed at providing instant results, but rather advocates small incremental improvements over time. Firms that look to implement TQM must be long-term focused. It also highlights that it is never ending; when the firms stop complying with TQM it is possible to lose rapidly the gains made by its adoption. Black and Revere (2006) suggested this reversal as one of the key reasons for the comparative lack of popularity of TQM. Lemak and Reed (1997) found that firms that exhibit long-term commitment to TQM outperform other organizations financially. Dahlgaard and Dahlgaard-Park (2006) argue that TQM is not a quick fix solution but is aimed at long-term gains.

One of the objectives of the research is to understand the dynamic interaction of what construction firms do to improve quality, and the results that are attained. This requires a measurement of the performance of the two constructs to identify the interaction over time. Research from the 1990s supports the viewpoint that a relationship exists between TQM principles in practice and the increase in an organization's performance (Hendricks and Singhal, 1997; Easton and Jarrell, 2000; Samson and Terziovski, 1999; Lemak and Reed, 1997). TQM can help in improving organizational performance (Feigenbaum, 2005; Curkovic *et al.*, 2000; Hewitt, 1994). It is important to identify the links between the two because organizations may not consider investing in an initiative that does not fulfil any of its objectives.

For any model, framework, or strategy to be adopted, it must have some purpose or solve some problem, which the organization considers valuable. The performance results are an important part of the feedback to decision makers, whether good or bad, to highlight weaknesses and strengths, and motivation for further improvement. It is crucial for the assessment of TQM in construction firms to find out the model that constitutes both enablers and results.

2.9 TQM Assessment Models/Frameworks

There are number of TQM assessment Models/frameworks. Albayoudh (2003) categorised these models under two categories: "academic and construction institute-based models, and quality-based awards models." Examples of these models are:

- Academic and construction institutes based models:
  Oakland and Marosszeky (2006), ECI (1996).
- Quality-based Awards models:
  The European Foundation for Quality Management (EFQM), Malcolm Baldrige National Quality Award (MBNQA), the International Organization for Standardisation (ISO), the Australian Quality Award (EQA), and Singapore Quality Award etc.

Quality-based award models are used for this research because they recognise how firms aim achieve the higher level of quality in all systematic components of the organization. These models help top management to understand the relationships between what their organization does and the results it achieves. To be excellent, organizations cannot focus their efforts in just one area. They have to optimise the use and effectiveness of all of their resources within the overall organization. Quality-based awards models are considered suitable for this research as an assessment framework for total quality management in Saudi construction firms.

Quality awards are aimed at encouraging organizations to excel in quality achievement. The awards can be helpful recognising organizations that have implemented the successful quality programs (Evans and Lindsay, 2002). According to Ghobadian and Woo (1996), the main goal of quality awards is to utilise the ability to enhance the nature of organizational competitiveness, increasing quality awareness, and its successful deployment. The awards encourage organizations to continuously improve their products and services, promote understanding of the requirements for ensuring quality and meeting customer needs, in addition to encouraging the use of self-assessment methods benchmarking techniques for performance improvement. The awards provide a framework for identifying a range of processes which influence an organization's total quality and its business results. There are many quality-based models. Including all available frameworks would enrich the theoretical framework this study. However, the focus on limited number of the most valid existing frameworks would make the evaluation of assessments frameworks more meaningful and feasible.

The research focused on the most well-established frameworks to provide confidence in their validity. These are: the Japan Deming Prize, the Malcolm Baldrige National Quality Award (MBNQA), the European Quality Award (EQA) and the International Organization for Standardisation (ISO). The King Abdul-Aziz Quality Award (KAQA) has been selected as it is the national quality award in Saudi Arabia.

The main themes considered for the evaluation of these frameworks are:

- holistic framework which includes all potential enablers (efforts) of TQM and goals (achievements),
- applicability and empirical validity for construction,
- clarity in assumption of the causal/ relationship between the criteria in the framework for building interaction between variables on system dynamics.

2.9.1 **Japan Deming Prize**

The Japanese Union of Science and Engineering in 1951 recognized the contribution of Dr W. Edwards Deming in the development of the quality practice in the country. The prize is awarded to organizations that have put efforts into improving quality, and have achieved worthwhile improvement in their performance.

According to the Deming Prize Committee (2014), there are more than 232 organizations that are among the winners of the Deming Prize. The key benefits and effects of this prize include helping in stabilising and enhancing quality, reducing costs and improving productivity, expanding sales, increasing profits by implementing management and business plans, enhancing participation and improving skills, and motivating employees and raising their morale (The Deming Prize Guide, 2014).

The criteria used in determining quality in this prize are (Pfeifer, 2002):

1. Policy
2. Organization and its Management
3. Education and dissemination
4. Collection, dissemination and use of information of quality
5. Analysis
6. Standardization
7. Control
8. Quality assurance
9. Results
10. Planning for the future

The Deming Prize model is not considered suitable for this research because it focuses mainly on "conformance to specifications" and on statistical quality control. The Saudi construction industry regulatory framework is still under development, focusing on compliance, is unlikely to result in total quality improvement. All the factors in the Deming prize have equal weighting making them equally significant in achieving improved quality. This contradicts the findings of the literature review, which indicates that the cultural dimensions as well as the structure of the industry could affect the different factors.

2.9.2 **Malcolm Baldrige National Quality Award (MBNQA)**

This award recognises organizations that have substantially improved their products, competitiveness and services, in addition to fostering the sharing of best practices (Goetsch and Davis, 2010). The main aim of the award is to promote quality and excellence in performance, as well as to ensure organizations' competitiveness (NIST, 2014). The criteria for the awards have seven categories and the maximum score of all criteria is 1000 points. Table 2-3 shows the seven categories with the weighting:

Table 2-3: Performance criteria in MBNQA

Award criteria	**Points**
Leadership	120
Strategic planning	85
Customer focus	85
Measurement, analysis, and knowledge management	90
Workforce focus	85
Operations focus	85
Results	450
Total score	1000

Source: National Institute of Standards and Technology (NIST) (2014).

The award system connects and integrates categories as shown below in (Figure 2-2). The figure shows how the operations in an organization take place at the top. At the centre of the figure, operations show results that can be achieved, and the analysis of information that is used to measure the performance of the management system. The top management is critical to any organization because it creates the values, the goals, and guides the drive towards quality and performance of the organization.

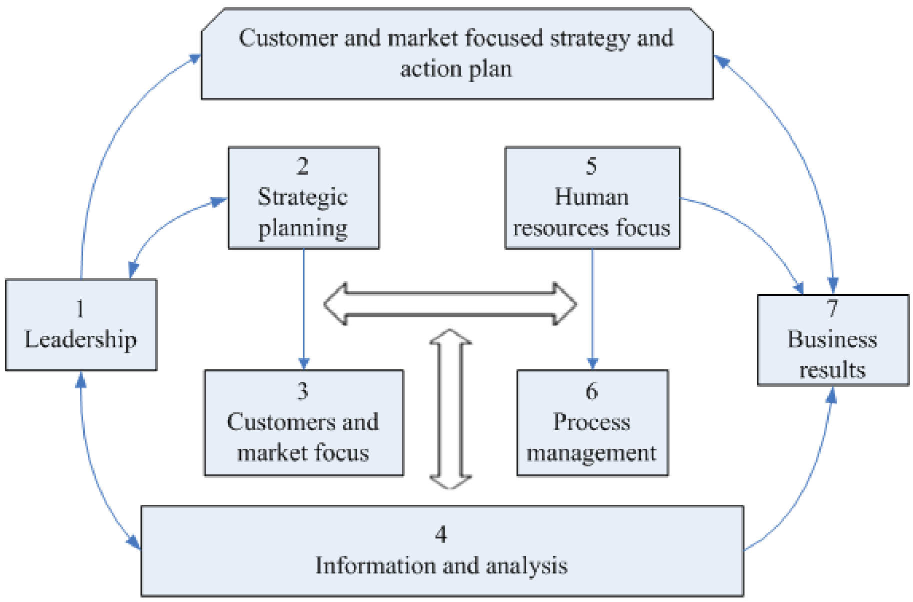

Figure 2-2: Malcolm Baldrige National Quality Award (MBNQA), (NIST) (2014).

For an organization to be a premier organization and win the Malcom Baldrige award, it needs a well-defined plan with processes and procedures.

With the emphasis on customer satisfaction, this model could be considered for this research. However, it focuses mainly on manufacturing, services and small business. There are aspects of the construction industry, which makes this award unsuitable with the project driven approach, where each project team and location is temporary and unique with different regulatory constraints, and reliance upon the supplier network. Projects represent a form of temporary organization having specific contexts. The construction industry is very dependent upon temporary project teams. Mainstream organization theory is based upon the assumption that organizations are or should be permanent; theories on temporary organizational settings, such as projects, are much less prevalent. The role of "time" in the firm is different as compared to its role in the temporary organization. The project as a temporary organization is viewed as a production function, as an agency for assigning resources to the management of change within the functional organization, and as an agency for managing uncertainty. Within the construction industry, the temporary organization operates within an environment of overlapping organizational boundaries, where multiple organizations simultaneously make representation on a single endeavour. Hence, whilst the MBNQA model has many merits, it is considered unsuitable for this research.

2.9.3 **European Quality Award**

The European Foundation for Quality Management (EFQM) is a not-for-profit membership foundation in Brussels, established in 1989 to increase the competitiveness of the European economy. Whilst there are numerous management tools and techniques commonly used, the EFQM Excellence Model provides a holistic view of the organization that can be used to determine how these different methods fit together and complement each other (EFQM, 2014). The model can be used in conjunction with any number of these tools, based on the needs and function of the organization, as an overarching framework for developing sustainable excellence.

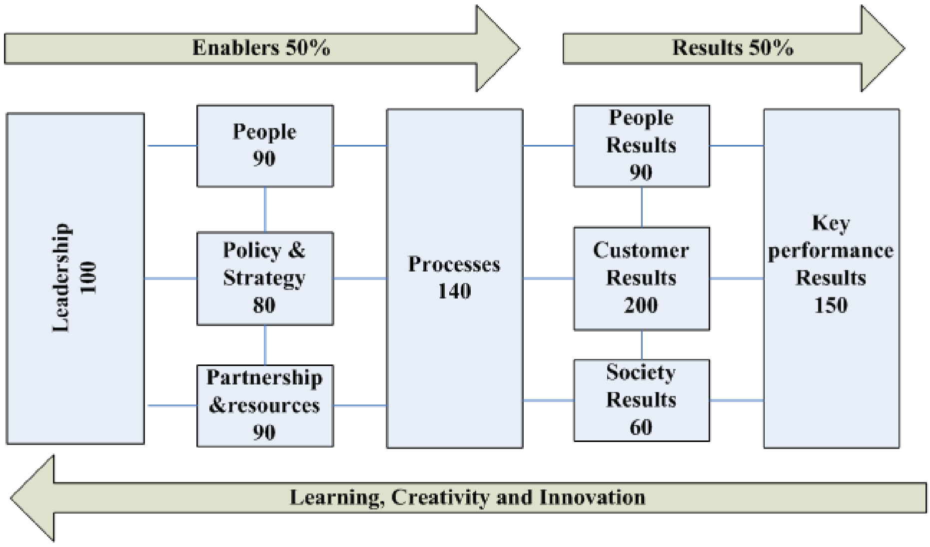

Figure 2-3: The EFQM Excellence Model (EFQM, 2014)

The EFQM excellence model has nine criteria; five are enablers, while the remaining four are results. Figure 2-3 shows the EFQM criteria. Each element in the model can help to assess the progress of the organization towards achieving TQM. The enablers are used to describe leadership, policy and strategy, partnerships and resources, whereas people management and processes contribute to achievement of results. Four results criteria are used to measure results, satisfaction of all stakeholders, society and customer, performance of employees (who are accountable to the organisation's achievements) and business performance. The enablers are made up of activities that require optimization to achieve set goals and objectives of the organizations. The results criteria consists of analysis of the achievements of the company from the past to the present (EFQM, 2014). According to Hillman (1994) the enablers are those processes and systems that need to be in place and managed to deliver total quality while the results provide the measure of actual achievement of improvement.

EFQM is one of the most comprehensive accepted performance measurement frameworks, which focus not only on customer satisfaction, but on stakeholder satisfaction. Construction projects have a significant and long-term impact on society, hence quality in construction should not be considered from a narrow 'customer perspective' but a broader 'stakeholder perspective.' EFQM also recognises the disparity in organizations, with temporary project teams being able to benefit from the EFQM structure through the processes approach.

Since EFQM has a customer and stakeholder perspective, it was considered most suitable for this research.

2.9.4 **King Abdul-Aziz Quality Award (KAQA)**

King Abdul-Aziz Quality Award (KAQA), launched in 2000, is a National Quality Award in Saudi Arabia with the main goal of maximizing efficiency, quality, and productivity in various industrial sectors within the country (KAQA, 2015). The award encourages Saudi firms to implement the models of quality management, to take advantage of their quality level to create an ability to compete internationally (KAQA, 2015). The framework for KAQA uses the European Foundation for Quality Management (EFQM) to meet the Saudi context. Mohammad and Mann (2010) show that more than half of the awards use the criteria of MBNQA and EFQM, and awards based on EFQM are more numerous than other awards.

The criteria of KAQA are leadership, strategic planning, human resources, partnership and resource, operation and processes, customer results, human resources result and KPI (Figure 2.4). KAQA has 16 objectives that include the responsibilities associated with quality management; encouraging the theory of quality, educating the employees of the organizations to take full advantage of quality (KAQA, 2015). The KAQA creates awareness among the institutions and prepares them for treating quality programmes as a supreme indicator for global competitiveness.

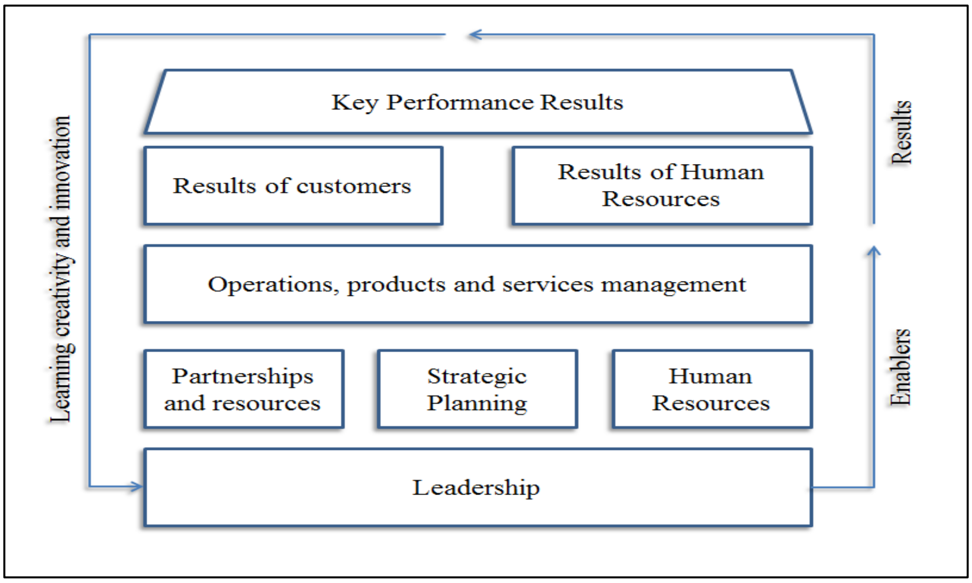

Figure 2-4: King Abdullah Quality Award, (KAQA, 2015)

While this model has been developed for the Saudi context, there are reasons why this was found not to be suitable for this research. Firstly, this model has not been validated in the construction sector; no Saudi construction firm has won this award. The possibility is that items stipulated in the award do not resonate with construction firms. Secondly, there is no clear causal linkage between the various factors in the model. The causality assumption between the model's criteria is important for the system dynamics simulation. This makes it difficult to simulate the model. This model was not considered suitable for this research for these reasons.

2.9.5 **The International Organization for Standardisation (ISO)**

The ISO is a non-governmental organization established in 1947. ISO 9001 is standard that outlines the requirements an organization must maintain in their quality system for ISO 9001 certification. The number of ISO 9001 certificates issued globally by the ISO increased by more than 1% in 2014, with total certificates issued by ISO 9001 to more than 1,564,448in 187 nations (ISO, 2015). The numbers of ISO 9001 certificates in construction organization globally has grown from 2004; however, the drop in growth in the recent years as shown in Figure 2-5 according to ISO, was caused by the reduction in construction workload following the 2008 financial crisis.

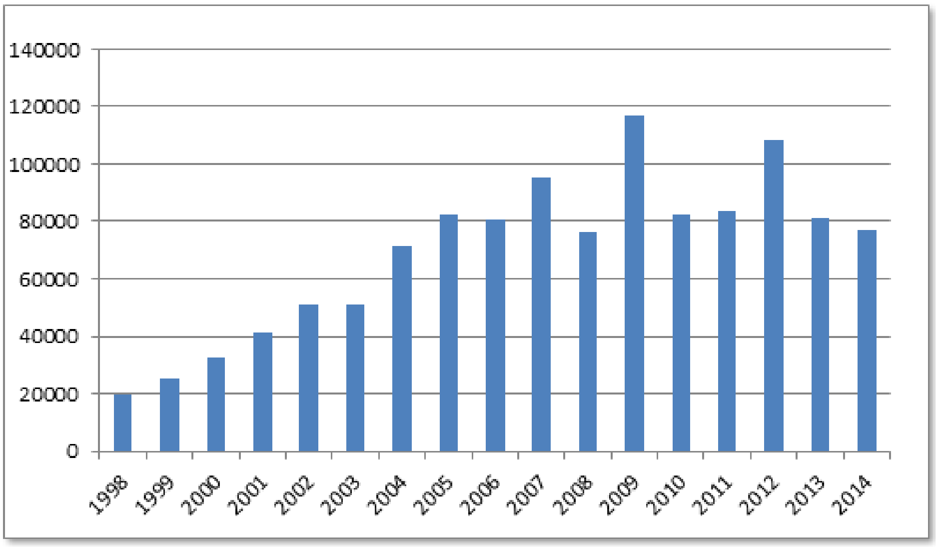

Figure 2-5 ISO 9001 - Certification in construction globally, (ISO, 2015)

ISO 9001 comprises four parts. The ability of an organization for production, servicing and development is endorsed by ISO 9001 certification.

a) ISO 9002 is used as a gauge to measure the conformance of a product by installation and production.
b) ISO 9003 is used as a tool in quality assurance at the final stages of testing as well as inspection, to support the detection of errors/flaws in the product, which do not conform to the specifications.

c) ISO 9004 is used to steer the advancement and implementation of quality management framework for an organization.

The ISO 9001: 2008 standards are based on eight quality management principles:

1. Customer focus: Organizations depend on their customers and therefore should understand current and future customer needs, meet customer requirements and strive to exceed customer expectations.
2. Leadership: Leaders must establish the unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.
3. Involvement of people: People at all levels are the essence of an organization and their full involvement enables the use of their abilities for the organization's benefit.
4. Process approach: A desired result is achieved more efficiently when activities and related resources are managed as a process.
5. System approach: Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.
6. Continual improvement: Continual improvement of the organization's overall performance should be a permanent objective of the organization.
7. Factual approach to decision making: Effective decisions are based on the analysis of data and information.
8. Mutually beneficial supplier relationships: An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

Figure 2-6 illustrates the use of the process approach to achieve continual improvement as suggested by the ISO 9001: 2008 standards. The biggest challenge for the construction sector is continual improvement, as a project-based industry with temporary project teams working primarily on unique projects. ISO 9001 series has grown into a globally accepted standard for standardization of quality; its presence in many developing countries like Saudi Arabia is still new.

Sun (1999) considered the pattern of TQM implementation versus ISO 9001 from the early 1990s to 1999. The ISO 9001 quality management system forms the basis for achieving TQM (Taylor, 1995 in Sun, 1999). However, doubts have been raised about the effectiveness of ISO 9000 standards for infusing quality within organizations. ISO 9000 is as a step towards TQM and not the end of the quality journey. Although many small businesses are benefiting from ISO 9000, many small ISO businesses in Saudi Arabia are not progressing towards TQM.

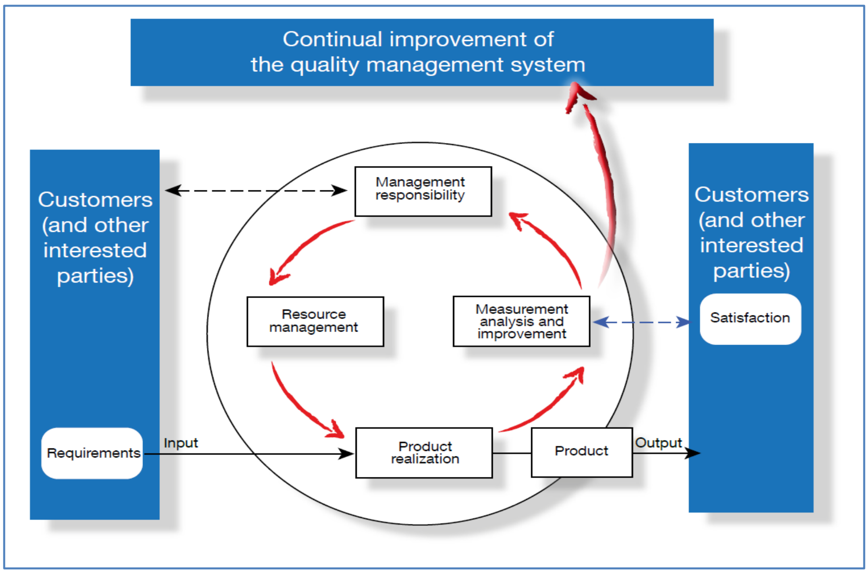

Figure 2-6: The ISO 9001 process approach *Source*: ISO (2015)

ISO 9001 structures the requirements for a quality management system that emphasises the writing of instructions and procedures, used to offer guidance to the employees of an organization. Construction companies tend to be technical in nature in addition to portraying some social nature. The social and technical aspects of construction companies can be integrated through TQM, by adopting managerial processes, which are focused on meeting the needs of the employees, customers and the stakeholders of the organization.

In the quest to improve quality and satisfy customers, many construction firms have implemented a quality management system such as quality control and quality assurance (ISO 9001). However, these systems failed due to the absence of a total quality culture in the construction firms (Lam *et al.*, 2008). Many cultural changes are required to meet a TQM environment in the organization. Rumane (2011) illustrates some of these cultural changes as shown in Table 2-4 using from-to approach.

Table 2-4: Cultural Changes Required to meet TQM; Adapted from Rumane (2011)

From	To
Inspection orientation	Defect prevention
Meet the specification	Continuous improvement
Get the product out	Customer satisfaction, exceed customer expectations
Individual input	Cooperative efforts by collaboration
Sequential engineering	Team approach
Quality control department	Organizational involvement, removing the silo thinking
Departmental responsibility	Management commitment
Short-term objective	Long-term vision
People as cost burden	Human resources as an asset to be encouraged
Purchase of products or services on price-alone basis	Purchase on total cost minimization basis
Minimum cost suppliers	Mutual beneficial supplier relationship with long-term relationship and respect for the suppliers

Table 2.4 assumes a simplistic industry, whereas the construction sector has multi-layers of specialty contractors, and in the case of Saudi Arabia, many foreign workers who may not fully understand the importance of good quality. Any system used must recognise the complexity of the construction sector and its processes.

ISO 9001 is the first step in the TQM journey. The spirit of continuous improvement in TQM would help construction firms to improve quality, alongside an effective quality management system, with higher maturity level in terms of quality. This requires continuous improvement with the dynamic interaction of enablers over time.

ISO-9001 requirements have been compared with other models in terms of representing TQM. According to Tari (2005), the comparison of some these models (EFQM, ISO-9001, MBNQA, and the Deming Application prize) shows that the TQM philosophy is best represented by the excellence model – EFQM. Causal assumption of the relationship between the variables is very important for the build of system dynamics simulation; it does not exist in this ISO 9001 framework. The ISO framework was considered to be unsuitable for the assessment of TQM in construction firms.

2.10 Synopsis of evaluation of TQM assessments frameworks

Table 2-5 summarises and shows the evaluation and critical review of all frameworks.

Table 2-5 : Comparative analysis of the frameworks

Comparative themes		EFQM	MBNQA	Deming	KAQA	ISO
Criteria	Leadership	√	√		√	√
	Policy and strategy	√	√	√	√	
	People management	√	√	√	√	√
	Suppliers and resources	√			√	√
	Processes	√	√	√	√	√
	Information and analysis		√	√		√
	Customer focus/satisfaction	√	√	√	√	√
	Employees satisfaction	√			√	
	Society satisfaction	√				
	Business results	√	√	√	√	
	Project results					
Clear Principle of Causal relation between criteria		√				
Valid and applicable for construction		√	√			

The EFQM excellence model is selected as the most suitable for the construction industry. The EFQM model is based on the premise that excellent results with respect to performance, customers, people, and society are achieved through leadership driving policy and strategy, delivered through people, partnerships and resources, and processes. It presents a comprehensive view of the link between efforts (enablers) and achievements (goals) (Mohamed and Chinda, 2011).

The reasons given below further substantiate this selection of EFQM.

- The rapport built up with suppliers and sub-contractors is crucial in the construction industry; the EFQM excellence model includes resources and partnerships that serve the purpose of TQM.
- The EFQM excellence model pays attention to the local community and environment. Such attention to societal perceptions helps in several ways, such as reduction of potential risks to society and environment (Little, 2002) and enhancement of societal perceptions of organizational competence (Wright *et al.*, 1999).

Some studies evaluate empirically the internal structure of the EFQM. Watson (2001) undertook a survey of fifty companies using a structured questionnaire to test the advantages of the EFQM Excellence Model. The results demonstrate that the EFQM Model was simple, holistic, dynamic, and flexible. Respondents were of the view that it empowered organizations to achieve a higher level of quality through the application of the model with TQM. Almusleh (2011) argues that the principles of TQM have been successfully incorporated into the EFQM model. EFQM is less difficult to apply than other performance measurements, such as the balanced scorecard (Mohamed and Chinda, 2011; Robinson *et al.*2005).

Wilkinson and Dale, (1999, p. 294) argue that an examination of the assessment criteria used by the EFQM Model for Business Excellence demonstrates the extent of the involvement in shaping total quality culture. For example:

(a) Assessing a leadership's commitment to quality, especially the efforts towards development of a quality-focused culture through raising awareness on the importance of quality management. It focuses on management's direct involvement in quality management, allocating resources and auditing the progress of a quality management strategy.

(b) Policy and strategy criterion focuses on the strategic issues such as mission, vision, corporate strategy etc. It focuses on whether the organization is focusing on quality in its strategy because strategy is what guides the operations.

(c) Assessment of satisfaction of all relevant stakeholders such as customers, employees and society in general, by gathering evidence on how the perception of different stakeholders is measured, and how projects are designed to meet these perceptual expectations.

The EFQM model is generic and applicable across many industries; it originated within manufacturing and is used in the services sector. There are many underlying differences between the construction industry and other industries; hence, the EFQM model may be suitable for the construction industry following adaptation. Bassioni *et al.* (2004) emphasised the adaptations to the founding quality models needed for the construction industry. The typical performance factors of cost, time and quality constitute the 'project' performance that defines the adaptation of the EFQM model.

It is postulated that EFQM is concerned with the shaping and assessing of TQM in construction firms. The model was validated in the construction industry by the study conducted by Vukomanovic et *al.* (2014), where the scores from 34 different construction companies were evaluated in regions in South-Eastern Europe. The study concludes that the most suitable model for a construction contractor organization is the EFQM model. However, the weightings of EFQM criteria are arbitrary, changing over time (Vukomanovic et *al.*, 2014). While EFQM is relevant for construction industry, the weights may not correspond to the construction industry and hence reassessment of weights is needed before applying EFQM to construction industry context.

Having selected the EFQM model and criteria to represent the TQM assessment framework, the process now considers adapting EFQM to the construction sector and identifying the principles and constructs of TQM in construction firms under each criterion of EFQM (Enablers and Results).

Chapter 3 THE DEVELOPMENT OF TQM ASSESSMENT FRAMEWORK

3.1 Introduction

This chapter provides an explanation of the various criteria of the TQM assessment framework and the sub-criteria comprising. The five criteria of the EFQM model (known as enablers) and sub-criteria comprising the enablers are described, with the different TQM related goals. Modifications were made to contextualise the EFQM model for the Saudi construction industry. TQM index score and TQM maturity levels are discussed.

3.2 TQM criteria and sub-criteria

Having selected the EFQM criteria to represent the assessment criteria of the TQM maturity model, the process is focused on identifying the sub-criteria of TQM under each criterion of EFQM through an extensive literature review.

The management initiatives required to achieve quality objectives in the construction industry are different from manufacturing, because of the dynamics of the industry and the quality goals driving the industry. Figure 3-1 shows the components of the EFQM model:

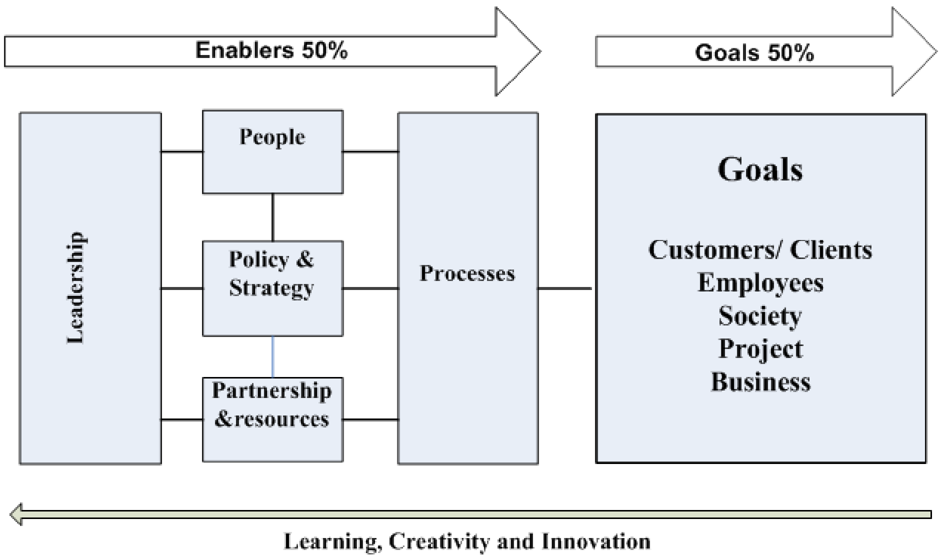

Figure 3-1: Components of EFQM model.

The enablers in the EFQM model refer to the efforts that the organization input in order to achieve its quality objectives (Vukomanovic *et al.*, 2014). The leadership enabler affects three other enablers: people, partnerships and resources, policy and strategy. These affect the processes, which lead to better quality management (Gómez *et al.*, 2011). The goals aspect in the model captures the quality-related goals that the organization is aiming to achieve. The EFQM model is based on the view that excellent results with respect to Performance, Customers, People and Society are achieved through Leadership driving Policy and Strategy, People, Partnership and Resources, and Processes (Dale *et al.*, 2007). The importance of this leads to the development of the underlying principle for this research.

"That goals are achieved through processes linked to people, policies and strategy, partnership and resource, driven by leadership".

Four categories of results comprise (people results, customer results, society results, and business results); collectively they are the Goals. In view of the importance of the stakeholders in the supply chain, the stakeholders are embedded in Goals category. This research is aimed at identifying the system as a whole; it assumes that the TQM implementation system is aimed at achieving one set of goals. Separating these goals in category will require a tracking system progression along five different paths rather (one corresponding to each category of goals). Hence, instead of considering the goals as distinct categories, these have been combined together under one goals category.

3.3 Enablers

3.3.1 **Leadership**

Leadership is the most important criterion in most quality and excellence awards (e. g. EFQM, MBNQA, KAQA). Quality specialists have emphasised the role of Leadership in creating value and goals for quality in their organization (Kanji and Yui, 1998; Kaplan and Norton, 2001; Oakland and Marosszeky, 2006). The leadership enabler refers to how the organization's leaders develop and mediate the achievement of quality-related vision and values (EFQM, 2014). These vision and values may lead to the development of a quality-focused culture based on quality-driven values. Leaders' efforts involve their direct engagement as well as through the setting of policy and strategy which drives organizational efforts towards the achievement of quality goals (Yukl, 2012).

Chin and Choi (2003) emphasised that in the construction industry, one of the most substantial predictors of the successful implementation of TQM principles was the commitment of top management. Haupt and Whiteman (2004) concluded that commitment by top management in any organization was a requirement for successful implementation of quality management. Pheng and Teo (2004) argued that common problems concerning TQM implementation could be reduced on construction sites if it were compulsory for management to take more concerted action towards raising quality standards.

The relationship between leadership and commitment is crucial. The leader's sensitivity to the needs of improving quality is part of organizational commitment; having a clear well-articulated vision, communicating the commitment to the organization. Managers must be clear about the goals and values of the organization. Leadership is important in any construction project; the behaviour of leadership is the crucial element, directly linked with success in project management-related parameters (Gharehbaghi and McManus, 2003).

Management can instil trust and confidence among followers by expressing their commitment to quality goals. This signals to the followers that management values quality objectives and that future policies of the organization will be quality-driven (Calvo-Mora *et al*. 2005). Employees who wish to make themselves more valuable to the organization will have to follow quality objectives as deciphered through the management commitment and vision.

Excellent organizations have leaders who shape the future and make it happen, acting as role models for its values and ethics, and inspiring trust at all times. They are flexible, enabling the organization to anticipate and reach in a timely manner to ensure the on-going success of the organization (EFQM, 2014). The role of leadership is critical in achieving higher TQM levels because of the strategic nature of a TQM-pursuing policy. The ultimate objectives, both short-term and long-term are decided at the top and then operationalised at lower levels (Lewis, Pun and Lalla, 2006a).

Quality management is not a one-off activity, but a continuous process in which an organization continues to improve in an iterative manner. This requires top management to audit past performance and continuously update organizational strategy to steer the company in the right direction; it may include reallocation of resources or removing some constraints, which may be affecting employees' ability to achieve the desired results. This ensures that management exhibits a continuous commitment to achieving the quality goals. This will result in sustained efforts (Lewis, Pun and Lalla, 2006b).

Achieving better quality performance can only be achieved through concerted efforts to change the culture within the organization making it more quality-focused. Attitudes and behaviours of individuals must be altered through any means, including rewards management, training and management (Jacobs and Suckling, 2007). The common perception of the site workforce in the construction industry is that they are poorly skilled and mainly concerned with financial rewards. Hence, monetary compensation may be required as an incentive to improve. This is a perception, not necessarily fact. The theory of international labour mobility suggests that workers will move from their home countries to foreign countries searching for higher wages. In Saudi Arabia many of the site operatives are poorly educated, with unskilled foreign workers who migrated to Saudi Arabia in search of a job and money (Mazher *et al.* 2015). The foreign workers must have a work permit, but they have little guarantee of permanent employment. It is very challenging for the management to alter the culture of the organization. It is not possible for the organization to achieve higher levels of TQM without changing workers' behaviour and attitudes.

Attempts to integrate quality improvement initiatives have not always been successful, owing to the top management being either uncommitted or deficient in leadership qualities. Top management must exhibit commitment to quality, while middle management should contribute to operationalising the quality strategy. Middle managers play a crucial rule because they bridge the gap between strategic planning and execution of a quality strategy (Oakland and Marosszeky, 2006). Involvement at a personal level is required from the leaders in the deployment of quality-related values, which are clear and consistent with the goals and objectives of the organization. The management creates and deploys well-defined systems necessary for the achievement of these goals (McCarthy and Greatbanks, 2006). The methods and systems, guide the activities related to quality, and encourage employee participation.

According to Oakland and Marosszeky (2006; p. 42) there are five requirements for effective leadership:

1. Development and publishing of clear documented corporate beliefs and purpose – a mission statement.

2. Development of effective and clear strategies and supporting plans for achieving the mission.

3. Identification of varied levels of success factors and the different critical process that are involved.

4. A review of the management structure and its appropriateness.

5. Encouragement of participation by employees (empowerment).

The list is too general and generic in nature; it does not recognise the complex and nature of companies in the construction supply chain, nor the interdependence of companies and the workforce, or the fragmented composition of the site workforce. The measurement of quality improvement is important, particularly for clients: the contractor may be happy with the quality, but the client is disappointed, that will fail to offer a quality solution. The relationship, whether it is contractual, or personal, plays an important role.

Many site managers use confrontational styles of leadership, which can be inappropriate when dealing with subordinates (McCarthy and Greatbanks, 2006). They have competencies that may not fit with the nature of the work and the leadership style required. The highly-culturally diverse nature of the Saudi construction industry requires a culturally sensitive management approach. The confrontational and discriminatory structure of the industry makes it difficult for the managers to adopt a participative approach. Many site workers are poorly educated, and unskilled coming from Africa and South East Asia, they are focused on financial rewards and continuity of employment to maintain their work permits. They only speak their native language. Most of the project managers and senior managers are either Saudi nationals or from western countries. This results in a complex arrangement of management at the highest level being disconnected from the site production workforce.

Such cultural disparities among workers at different levels leads to communication and other cultural gaps, which makes it difficult for managers to promote the quality agenda. The large proportion of migrant workers means the site employees and employers do not perceive their relationship as long-term (Lewis, Pun and Lalla, 2006b). A combination of a transactional and people-centred management approach is required, in which the firm invests in the employees and harnesses their improved skills and capabilities for mutual benefit (Bencsik and Nagy, 2007).

3.3.2 **People**

The People enabler refers to an organization’s strategy towards management of its human resources. It involves developing, and releasing, the knowledge and full potential of its human resources at an individual, team-based, and organization-wide level (Oakland, 2014). The Resource Based View (RBV) of the organization suggests that an organization can achieve competitive advantage through effective utilisation of unique resources and one of the most critical resources in this regard are the human resources (Ruiz-Carrillo and Fernandez-Ortiz, 2005).It is argued that TQM is about developing a quality culture within the organization (Lou, 2008). Quality culture development within organization means developing standards, norms, practices and behaviour for quality management. It is the people who exhibit these norms and behaviour; human resources are at the core of quality management.

The full potential of people working as individuals or as teams in any organization is managed, developed and released by successful organizations. The organization's activities entail the empowerment and involvement of people, allowing them to utilise effectively their knowledge and skills. According to Bencsik and Nagy (2007) employee empowerment leads to enhanced productivity as well as customer and employee satisfaction. Blanchard *et al.* (1996) explains that employee empowerment includes allocation of power, delegation of authority, and motivation to innovate.

The involvement of employees in decision-making and planning ensures better implementation, which is essential for continuous and comprehensive improvement (Gatchalian, 1997). Employees can identify several possible implementation issues as they have tacit knowledge of operational activities by virtue of their experience (McCarthy and Greatbanks, 2006).Gufreda and Maynard (1992) showed that employee involvement involves a process of transformation of the organizational culture to utilise the energies of the entire workforce in working with the organization towards solving problems and making necessary improvements. Employees working in their respective positions should increasingly possess the skills required to provide appropriate responses, which are both effective and efficient in achieving what they are supposed to achieve (Hansemark and Albinsson, 2004).

Quality improvement cannot be achieved through a single process or activity, but through small incremental improvements across all processes and activities. Failure of one of the links can break the quality chain in the organization. Therefore, synchronised and coordinated efforts of all those involved is required. Whilst top management can develop a strategy to improve quality, implementation of TQM has to be done through the employees. Since the employees know their role and tasks better than any other employee or manager, they can best contribute in identifying ways to improve. It is essential to empower employees (Bencsik and Nagy, 2007). Leaders can develop a policy of employee empowerment to improve quality; this is likely to lead to better and improved processes, which is likely to improve quality-related goals (McCarthy and Greatbanks, 2006).

Tsang and Antony *et al*. (2002 p. 39), define employee training “in terms of the basic practices provided by the organization to enhance the specific skill set required of employees so as to boost the performance, quality and customer satisfaction of the organization and at the same time reduce cost and time-related constraints.” For TQM implementation, it is essential to train and educate employees to make sure that they have the knowledge and skills to implement quality.

Quality-related attributes are not limited to a single person, but rather it is everybody’s responsibility (Harrington *et al.*, 2012; Phan *et al.* 2011; Goetsch and Davis, 2010). Training enables workers to be up-to-date with the latest concepts of working and fully aware of the necessary techniques required to ensure that their skills did not become obsolete over time, especially in situations where there were dynamic changes in the environment. Training of employees takes place after orientation takes place. Training is the process of enhancing the skills, capabilities and knowledge of employees for doing a particular job. Training process moulds the thinking of employees and leads to quality performance of employees. It is continuous and never ending in nature.

Crosby (1979) posits that it is essential to generate quality awareness by training among people in order to achieve quality goals. Awareness refers to knowing the management’s policy on quality, and understanding how they can contribute to the organization’s quality objectives.

Goetsch and Davis (2010) show that rewards and recognition are the most important enablers. They go a long way in maximising the potential of employees and give a sense of involvement within the company, thus serving as the main contributors towards the development of organizations. Research shows that productivity and performance are linked directly with rewards and recognition of the employees (McCabe, 2014).

3.3.3 **Policy and Strategies**

Policy and strategy refers to how an organization implements its quality vision and mission via clear stakeholder-focused strategies, supported by relevant policies, plans, objectives, targets, and processes(Oakland, 2006).. The focus is on improving quality in every aspect and at every stage of the project, it is essential to generate the cooperation of all internal and external project partners (McCabe, 2014). The policy and strategy of the organization is driven by factors such as business environment, customer expectations, and customer behaviour (Martín-Castilla and Rodríguez-Ruiz, 2008). The Saudi construction industry is reliant on public sector projects, which are dependent on the volatile and fluctuating oil price. Organizations should plan and manage their strategy in order to deal with likely risks within and outside of the construction domain.

Quality policies ensure consistency in an organization's efforts towards TQM implementation (Phan *et al.* 2011). Firms must clarify not only their quality policy but also how they wish to implement it. Furthermore, all the employees should be able to decipher the quality policy in the context of their roles (Bou-Llusar *et al.* 2009, 2005). Every division, function and level has its own quality policy and strategy, which addresses the key aspects within it. If the different divisions and groups pursue their own quality strategy there could be discrepancies. It guides the different divisions and groups towards a single objective and explains to them what strategy they should pursue.

The quality policy and strategy stems from the quality-related vision provided by the management, operationalised by different divisions and functions. Following the same quality vision ensures synchronisation between quality related efforts of different divisions. A strategy is a unique plan made to reach the organizational goals and objectives, but Policy refers to a set of rules made by the organization for rational decision making (Fuentes *et al.* 2006). Quality strategy is critical because this is what the organization is pursuing through TQM adoption. Management sets the strategy, which acts as a guide for the rest of the organization. Thus, management needs to push for adoption of quality as a strategy (Fuentes *et al.*, 2006).

Once quality is embedded in the strategy, it will ensure that quality is prioritised over other objectives. Management needs to show commitment for continuous improvement, not just a one-off plan. It is also essential that steps are taken to raise employees' and partners' knowledge and awareness of the quality strategy and its objectives (Hides, Davies and Jackson, 2004).

Setting quality policy and strategy ensures that adequate resources are provided for quality management practices. Like the people enabler, the policy and strategy enabler is critical because it ensures that the organization takes a holistic approach towards quality management, making sure that all required resources are allocated to achieve the desired level of quality standards within the organization (Bou-Llusar *et al.* 2009).

Policy and strategy is particularly relevant in the Saudi construction industry because Saudi Arabian culture is mostly top-driven due to high power distance culture (Hofstede, 2011). The country is heavily policy and regulation driven as people tend to focus on abiding by laws, rather than making decisions themselves. In such an environment, management can achieve a lot by placing a heavy emphasis on quality in their policy and strategy.

One of the key aspects in quality policy and strategy, especially in context of TQM, is that it cannot be both static and effective; quality policy and strategy needs to be dynamic. Firms need to incorporate lessons from the past in the policy and strategy for the future (Aichouni *et al.* 2014). This can be done through quality audits in which the managers evaluate what the firm has managed to achieve, what the firm has failed to achieve, and why. Feedback to employees is a useful contributor in effective quality audit, highlighting any reasons for failure (Bou-Llusar *et al.* 2005). Management should be flexible to review and upgrade the policy overtime. However, management should be careful to only make changes to its quality policy and strategy when absolutely necessary and not make radical changes or change without a reason. Frequent radical changes to quality policy and strategy will affect employee confidence.

3.3.4 **Partnerships and Resources**

Partnerships and resources refer to how an organization plans and manages its external partnerships with project participants and other stakeholders and resources to support its quality polices and strategies (Oakland, 2014). Use of resources is critical for achievement of quality goals. For example, the use of technological resources helps in the facilitation of information exchange, knowledge creation and communication.

All stakeholders need to work together to achieve the organization’s quality objectives. Clients should develop a shared knowledge base of quality with the contractors, to identify and remove the constraints to achieving higher quality goals. Partnership management can be a useful strategy in this regard (Bou-Llusar *et al.* 2005).

In order to support quality policies and strategies, and to ensure effective operation of processes, construction firms should plan and manage:
a) internal resources such as equipment materials, technology, buildings,
b) external partnerships and suppliers.

Allocation of resources is shows commitment of top management towards quality improvement. The different sub-criteria levels for resources and partnerships in the EFQM model are:

- Management of external partnerships

- Management of finances
- Management of buildings, equipment and materials
- Management of technology
- Management of information & knowledge.

The challenge in construction is how to ensure all the stakeholders in the value chain understand the requirement for quality; this is particularly relevant in Saudi Arabia, where there is extensive outsourcing to SMEs that do not necessarily have a culture of providing high quality. The workers do not have continuity of employment, often hired on short-term arrangements. Oakland and Marosszeky (2006) suggest that firms' suppliers should have a thorough understanding of the work that is to be delivered by the process of partnership. This includes understanding the concept of quality in the project and requires firms to involve partners in the decision-making process.

Procurers must adopt a quality-based selection process for subcontractors, rather than based on other short-term measures such as low price. Quality-based classification eliminates a lot of uncertainty from the procurement process. This does not stop at procurement stage; once selected, the contractor needs to work with the subcontractor(s) to ensure that agreed principles of quality are followed. The procurer needs to carry out an inspection of quality standards at various stages of the project. This will help in timely corrections but, most importantly, to create a quality profile of the subcontractor that can act as a benchmark for subcontractors to improve their performance.

There are different forms of resources; financial resources, technological resources, material resources and information resources (Abu Bakar *et al.* 2011; ReVelle and Margetts, 2010). Organizations deliver the required resources to their projects in order to enhance their operational process, thereby achieving their targets through a planned strategy. Investment in resources is vital for the potential growth of a business (Oakland and Marosszeky, 2006). However, the benefits reaped from improved strategies and changes in construction processes are difficult to identify, due to the dynamic nature of construction and the changes in teams from one project to another. The comparison between investment in high quality and the cost of low quality could guide the organization to take the right decision. The management of human resources is critical for the achievement of quality goals (ReVelle and Margetts, 2010).

3.3.5 **Processes**

Processes refer to "how an organization designs, manages, and improves its processes to support its policies and strategies, and fully satisfy and generate increasing value for its customers, employees, and other stakeholders" (Oakland, 2014; p.134). Quality management requires processes improvement, which is how the firm manages its processes to ensure they operate as expected, without any breakdowns or slowdowns.

Construction projects are outcomes of a sequence of processes, disruption to any one of the process will cause major disruption and delay to the project (Rumane, 2011).Errors in processes may lead to defects, which increases wastage due to rework. Defect-free processes ensure that the firm does not have to rely on inspection for quality management. Excellent organizations are generally designed and maintained in a systematic manner, thus improving their overall process to satisfy stakeholders, as well as increase the company's value (Jacobs and Suckling, 2007).

TQM is built around a firm's knowledge of customer expectations and needs. It is largely a customer-focused framework. Customer focus is one of the key success criteria for construction firms; hence all process improvements with a customer focus should be prioritised (Martín-Castilla and Rodríguez-Ruiz, 2008).Every process improvement should directly or indirectly add value to the customer, or it is not a worthwhile investment

Organizations looking to improve their quality performance need to undertake performance measurement and identify areas for improving performance through process improvement. Firms can use both internal and external benchmarks for measuring performance and identify any possibilities for process improvement (Castka *et al*. 2004). There are several quality tools available for organizations to evaluate their performance and to identify areas for improvement.

According to Aichouni *et al.* (2014), the philosophy of quality management ensures that if the right process is selected, the final project should also fall into place. Therefore, it is vitally important for organizations to maintain these processes and improve them for the success of the final project. Quality performance and customer satisfaction are strongly dependent on the ability of an organization to plan and manage its own processes and its supply chain processes (Haponava and Al-Jibouri, 2010).

Oakland (2006) summarised the research on award-winning companies, which led to the identification of best practices of process management:

- Key business processes followed by their identification have prioritised the value chain, significance, strategies and process models
- Systematic management of the various processes, utilising ownership models, as well as meetings to solve interface issues of process.
- Setting improvement targets and reviewing processes.
- Improvement of processes through innovation and creativity as well as adopting business process improvement, self-managed teams and idea schemes.

According to Idris and Zairi (2006), systematic and effective implementation is the key to success of the improvement process. Dale *et al.* (1997b) showed that evaluation of process improvement should be periodic and continuous to identify the problem areas and weaknesses and to address them with specific solution-based remedies.

Process improvement ensures dissemination of quality improvement across the organization and its network. It provides the consistency required to achieve the quality goals, by ensuring that processes are designed to achieve the same goals, and that processes are optimised to achieve these objectives.

3.4 Goals

The goals refer to the main goals and objectives of the organization that the organization is aiming to achieve by implementing TQM. Competitiveness of firms depends on their ability to adopt a holistic perspective to improvement, looking at competitiveness across all dimensions (Flanagan *et al.* 2007). This means that firms need to target more than goals to transform their quality strategy into a winning formula. The goals based on the EFQM model embrace four constructs namely; people, customers, society and business goals. Researchers have argued that these need to be adopted in a construction industry context (Gudiene *et al.* 2014; Haponava and Al-Jibouri, 2009). For example, meeting project goals as well as stakeholder expectations in areas such as sustainability are some of the key goals for the construction industry. The constructs of goals in the EFQM model are discussed below.

3.4.1 **People related goals**

People and organizations work in a two-way relationship, where each has certain duties and expectations (Sadikoglu and Zehir, 2010). An organization expects employees to implement its strategy, while employees expect to be rewarded adequately for their work.

The role of people in implementation TQM is especially critical in the construction industry because construction work depends significantly on manual labour and human decision-making, unlike manufacturing with processes automation. Individuals need to be intrinsically motivated to implement an organization’s quality policy and strategy. This is only possible when the organization links its objectives to employee satisfaction (Sadikoglu and Zehir, 2010). Satisfied employees are likely to put in extra efforts to achieve an organization’s quality objectives. Motivated employees are more likely to contribute through feedback, which helps management to review their quality and strategy policy making to become more effective. For example, an employee would know how they can reduce waste in the processes in which they are involved.

People work not only for monetary rewards, but need to be compensated in other forms as well such as effort recognition, skill development etc. An issue is the disconnection between office and project managers, and the site construction workforce. Managers need to use their leadership skills to change this perspective.

3.4.2 **Customer related goals**

Customers are the primary stakeholders in a project; they risk their capital to fund the project. Customer satisfaction is the focus of a quality strategy, unless the firm achieves high levels of customer satisfaction, the business is unlikely to be competitive (Jacobs and Suckling, 2007). Poor implementation of quality initiatives such as TQM may be attributed to a misunderstanding of customers’ needs (Kim *et al.* 2010). It is important to look at quality from the customer perspective. Goetsch and Davis (2010) suggest that improvements in customer retention and competitiveness, as well as profits, are attributed to customer satisfaction.

Customer satisfaction can be estimated using feedback mechanisms such as customer complaints. For firms to achieve higher levels of customer satisfaction, it is essential to have a two-way communication channel for the customers to provide timely feedback, which will help the firm better shape its quality policy and strategy (Jacobs and Suckling, 2007).Customer results in the elements of the EFQM model include customer perceptions, measured in terms of customer surveys, focus groups, potential compliments, as well as rating of external resources. The measures are dependent upon the aims, which include the end users’ perceptions (Mccabe, 2014).

In the construction industry, client satisfaction is a complex phenomenon; it can be defined as how well a contractor's performance meets or exceeds the client's expectations (Cheng*et al.*, 2005; Kärnä*et al.*, 2009).A contractor should have a thorough understanding of the client's expectation (Maloney, 2002). Firms can increase market share and increase profits in the short run but the real benefit of a quality policy and strategy is quality image/reputation. Building quality image reputation is quite useful for firms; it helps them generate a positive brand image that helps in winning bids. Building quality image/reputation requires a long-term sustained effort towards quality management; it yields strong benefits to the organization (Ehrlich, 2006). Building quality image/reputation is one of the key goals of pursuing higher levels of TQM.

3.4.3 **Project related goals**

The term construction project is defined as a 'temporary endeavour to achieve some specific objectives in a defined time" (Young, 2000, p.8). Barclay and Osei-Bryson (2010) state that construction project success can be estimated on the following criteria:

- Did the project meet all client specifications?
- Was the project completed within time and budget constraints?
- Did the project meet any additional pre-stated objectives, such as phased completion?
- Does the project satisfy the needs of the key stakeholders?

Project quality can be viewed from several perspectives such as adhering to client specifications, minimisation of defects and rework *etc*. One of the reasons why this measure is used as a quality criterion is the ease of measurement. Freeman and Beale (1992, cited in Prabhakar, 2008) identified the following seven main criteria used to measure project success: technical performance; efficiency of execution; managerial implications; organizational implications; personal growth; manufacturer's ability, and; business performance. Kumaraswamy and Thorpe (1996) recommend the following criteria for project evaluation: meeting budget; schedule; quality of workmanship; client and project manager's satisfaction; transfer of technology; friendliness of the environment, and; health and safety.

A focus on quality could greatly improve construction project performance in terms of delivery, price and reliability. Quality performance has been defined in construction variously as completion of a project on time and within budget; reducing repairs and defects; meeting the customer’s expectations; repeat business (Ika *et al.* 2012; Prabhakar, 2008). Quality appears on the lists, it is a laudable aim, and measurement is more difficult.

Health and safety of people is a key requirement for project success. Most work-related injuries in Saudi Arabia occur in the construction and manufacturing sectors, according to the General Organization for Social Insurance (GOSI). A staggering 355,000 injuries were reported in these sectors since 2012, accounting for almost 88% of the total number of accidents in all sectors. This has caused a lot of concern for the industry. Health and safety incidents are a significant impediment to performance, hence improving health and safety is one of the key goals of the TQM strategy of the organization.

3.4.4 **Society related goals**

Society is one of the key stakeholders in every construction project, which is even more relevant in Saudi Arabia where much of the construction work is procured by the government. However, society has not been considered one of the primary stakeholders by the construction industry; it never had a direct influence on project-related goals. Since 2008 following the financial crash, issues such as sustainability, health and safety, corporate social responsibility, and localisation have gained prominence in both academic and policy circles. With government policy changes enforcing corporate social responsibility, society has become a key influencer of organizational goals.

For a firm to develop its reputation, it must consider issues that build its quality image in society. Managing public perception is critical because they often decide whether the project will go ahead or not. Perception pertains to the performance of the organization in terms of economics, environment and society. Giving wider representation to the representative members of society can help firms learn about society’s grievances and expectations, which can be incorporated into the project to achieve society’s approval.

3.4.5 **Business related goals**

The EFQM Excellence Model has measurement involving tangible and economic measures, and less tangible measures, which analyse the motivation of the employee and the customer’s perspective (Joiner, 2007). To achieve a balanced strategy and appropriate trade-off between the main stakeholders, the organization should apply a combination of these measures (tangible and less tangible).

The success, market position and financial performance of an organization can be evaluated by analysing their market share. Improving the quality of goods and services may result in a three-pronged advantage of enhanced market share, augmented profit and retention of loyal customers. Nevertheless, many companies regard profitability as an administrative objective and hence the performance or market share does not necessarily reveal profitability (Chong and Rundus, 2004).

With low profit margins and high levels of risks, improving sustainable financial performance is one of the key objectives of construction industry. In manufacturing, it may be able to pass on the costs to the buyers, but in construction, the project budget is decided at the tender stage of the project, hence cannot be transferred to the customers. Financial performance can be improved by decreasing costs and increasing revenues. Similarly, a company's efficiency can be improved by refining the internal quality. Firms improve financial performance by catering to the client's needs, resulting in customer loyalty and retention, thereby reducing customer acquisition costs as well as increasing business earnings. A greater return on investment can be attained by enhancing sales resulting from quality improvement strategies (Al-Qudah, 2012).

3.5 Summary of constructs and items of measurement

Table 3-1and 3-2 summarise the construct and items of measurement of the TQM enablers and goals that will be used as an instrument to assess TQM in Saudi construction firms. The items of measurement have been produced from analysis of the discussion in this Chapter 3, using the EFQM as an important part of the analysis.

The scores of the enablers and goals will be used to calculate the TQM index score. This index score is a summation of the scores achieved across all five enablers and goals using system dynamics approach for this purpose. Index score will then be used to determine firm's TQM maturity level as explained in the next section.

Table 3-1: Items of measurement of dynamics model for Enablers

Enablers	***Items of measurement***
Leadership	Management commitment
	Clear vision
	Communication
	Auditing
	Role model
	Continues development
Policy and Strategy	Quality vision
	Reviewing and upgrade policy
	Quality as strategy
	Priority of quality
	Customer satisfaction strategy
People	Empowerment
	Involvement
	Training
	Accessibility to Information
	Cross-functional team
	Feedback survey
	Rewards and recognition
Partnership and resources	Quality-based classification
	Inspection of quality standards
	Financial resources
	Skilled human resources
	Material and equipment
Processes	Processes improvement
	Customer focus
	Performance measurement
	Benchmarking
	Innovation and creativity
	Quality tools
	dissemination of quality improvement

Table 3-2 Items of measurement of dynamics model for Goals

Goals	*Items of measurement*
Customer-related goals	Customer satisfaction Customer complaints
People-related goals	Employee satisfaction Employee involvement
Society-related goals	Quality image/ reputation
Business-related goals	Market share Improved competitiveness Profitability and financial performance
Project-related goals	Construction time Construction cost Defects and rework Safety on the job site

3.6 System dynamic modelling

TQM implementation is a complex and dynamic because it requires every component of the organization to implement TQM, yet perspectives of what TQM implementation means differs from component to component. Furthermore, higher levels of TQM can only be achieved if it is implemented adequately by all system components. Hester and Adams (2014) suggest that dynamic systems solve complex problems through mass decomposition and reconstruction. In the decomposition stage all components defer the meaning of TQM to the context of their role in the system. In the reconstruction stage their responses are brought together by the system to create a holistic change in TQM status of the system. In systems as complex as the construction industry, the interaction between the components is not sequential but rather continuous; for example, the people component is continuously implementing quality policies, and strategy components are being continuously reviewed and developed by the leadership component. This means that the system may be in a continuous and flux state. The most suitable method to understand the development/progression of such systems is through system dynamic modelling.

System dynamic modelling (SDM) methodology assumes that the system, including the strength of relationship between the components and their relative influence on each other, change with time as the system edges closer to its objectives. SDM methodology is useful in modelling and simulating complex social systems whereby the different variables have interdependent relationships (Sterman, 2000). By analysing how the interconnectedness of the variables will affect the evolution of the system the decision makers can decide on policy interventions which will help them drive the whole system towards a desired state. Researchers have used SDM methodology to holistically model and analyse complex systems in a construction industry context (Boateng *et al.* 2012; Mohamed and Chinda, 2011; Nasirzadeh *et al.* 2008).

The model embraces three main components namely Enablers of TQM, Goals, and the TQM maturity Index. The proposed model has used the EFQM criteria, it is well-defined and the most suitable model because of it is tried and tested across many industries (Watson and Seng, 2001; Bassioni et *al.* 2004; Vukomanovic et *al.* 2014). Detailed discussion of the system dynamic model is presented in section 5.7.

For this research, the TQM maturity score is organised on a scale of 0 to 1000 points with five TQM maturity levels, each comprising a TQM maturity score interval of 200points. The highest TQM index score is 1000 (500 points for Enablers and 500 points for goals) for which adopted from the highest score in EFQM model. It is divided into five categories indicating the different stages of TQM maturity level as shown in Table 3-3. More stages of transition allow identification of sensitive analysis related to changes in the five enablers. This is useful because of the high number of sub-factors (see Table 3-1 and Table 3-2) in the enablers and goals section which highlight the level of complexity in quality management in the construction industry.

Table 3-3: Five levels of TQM maturity model

Level	TQM index Score	TQM maturity level	Description
1st	0-200	Beginner	The stage when the management needs to exhibit commitment though quality vision and mission to steer the company towards achievement of quality goals.
2nd	201-400	Committed	The stage when the organization has started to realise that it will work towards achieving higher TQM levels i.e. the decision to adopt TQM has been taken.
3rd	401-600	Improver	At this stage, the firm has begun to enjoy some of the benefits of TQM adoption and a more sustained quality strategy and policy is being developed.
4th	601-800	Proficient	At this stage, the firm has started to mature in TQM management and is looking to generate competitive advantage by fine tuning its TQM strategies.
5th	801-1000	Mature	The stage at which the firm is looking to maximise its TQM score and reach a level of perfection. The final constraints to achieving the highest TQM score is eliminated through feedback about process improvement.

3.7 Chapter summary

The EFQM framework was found to be the most suitable framework for this research. It was developed for pan industry application; it needs contextualising for the Saudi construction industry. The five enablers of EFQM model were described for Saudi construction industry. Leadership is the first enabler, which may affect three enablers (people, policy & strategy, partnership & resources). These three enablers, in turn, may affect processes. Quality processes are representative of institutionalisation of quality practices, which affect the firm's quality goals. The four categories of goals identified for the Saudi construction industry are: people related goals, society related goals, project-related goals, and business and financial goals.

The significance of system thinking in TQM implementation is discussed along with a brief overview of the SDM model used for the research. A system dynamics approach will be utilised, incorporating causal loop diagrams, for the management of complexity in the quality management process. Eventually, TQM maturity levels were identified and the criteria for assigning different TQM index scores to different TQM maturity levels were discussed. The TQM index scale is divided into five levels

CHAPTER 4 UNDERSTANDING THE CHARACTERISTICS OF THE KINGDOM OF SAUDI ARABIA CONSTRUCTION INDUSTRY

4.1 Introduction

This chapter aims to establish the significant features of the Saudi construction environment and how it affects the way that firms can achieve higher levels of TQM. Implementation of TQM is driven by both a firm's micro and macro environment. Demand for quality in construction projects is one of the key drivers of TQM implementation in construction firms in a market. Thus, learning about firm's macro and micro environmental context is critical to an understanding of TQM implementation (Thiagarajan and Zairi, (1997). The macro environment includes factors that affect the whole industry, such as economic environment in the country, political stability in the country etc. (Maiellaro, 2013). The micro environment refers to the forces influencing the company and affecting the organization's relationships; these include its suppliers, employees and customers. Learning about the environment, which the firm operates makes it easier to understand the dynamic forces shaping the culture and behaviour.

In context of TQM, this research adopts a system thinking approach. A system is shaped by its internal and external environment, which in turn, shaped by different factors. For example, culture of a country may affect the organisation internally and externally, while the political and economic environment of the country may affect the organisational system by creating exogenous pressures. Knowing the context of the system is crucial to understand how the system is likely to behave, and why is it likely to behave this way. This Chapter looks at the context of Saudi Arabia in general as well as context of Saudi construction industry. This will help the researcher in building the system and also to interpret the behaviour of the system.

4.2 Saudi Arabian market environment

4.2.1 **Economic environment**

Saudi Arabia's 2016 GDP was US$628 billion, with 40% coming from the private sector (IMF, 2016). This marks a significant decline in GDP which dropped from US$754 billion in 2015 to US$628 billion in 2016, largely due to a decline in oil revenues. As the price of oil declined significantly, Saudi Arabian GDP which comprised 75% of oil revenues declined and the contribution of oil revenues fell from 75% to 60% (World Bank, 2017). This indicates a significant issue within the Saudi Arabian economy- it's over reliance on oil revenues which combined with volatility in oil prices, indicate a significant potential threat to the long-term Saudi economy.

The Saudi government is trying to reduce the reliance on oil income and promote other sources of revenue, especially services. This is evident for the 2030 vision published by the Saudi government, which is a plan to reduce Saudi Arabia's dependence on oil and rely on alternatives diverse economy and the development of service sectors such as health, education, infrastructure constructive, recreation and tourism and many more.

While this vision is a formal admittance of the new strategy of the Saudi government, the efforts to diversify the economy started with the government relaxing rules on foreign investment in non-oil businesses. At the same time, the government stepped up its investment in public sector projects to improve infrastructure. Investment opportunities are immense because the government is investing in public services and public infrastructure improvement. This has opened many business opportunities for new and incumbent construction firms.

Competitiveness

The World Economic Forum (WEF) publishes a Global Competitiveness Report, which ranks countries on basis of their competitiveness. The competitiveness ranking "assesses the ability of countries to provide high levels of prosperity to their citizens. This in turn depends on how productively a country uses available resources. Therefore, the Global Competitiveness Index measures the set of institutions, policies, and factors that set the sustainable current and medium-term levels of economic prosperity" (World Economic Forum, 2016). The World Economic Forum (2016) ranks Saudi Arabia as one of the world's top 30 most competitive economies.

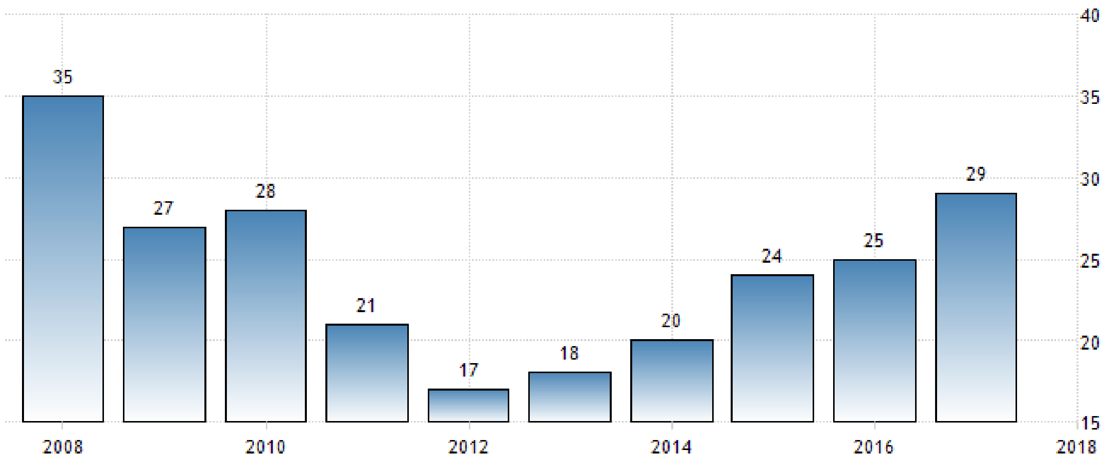

Figure 4-1: Saudi Arabia competitiveness rank

Source: http://www.tradingeconomics.com/Saudi-arabia/competitiveness-rank

Figure 4-1 indicates the significant progress that Saudi Arabia made between 2008 and 2012 but then its position slipped from 17th in 2012 to 29th in 2017. This could be because of a combination of several factors with the two most critical being: politically-unstable environment across the Middle East and volatility in oil prices which have affected economic development in Saudi Arabia. The WEF competitiveness ranking comprises 12 factors (pillars). Figure 4-2 shows the performance of Saudi Arabia across all the 12 pillars compared with the best possible performance.

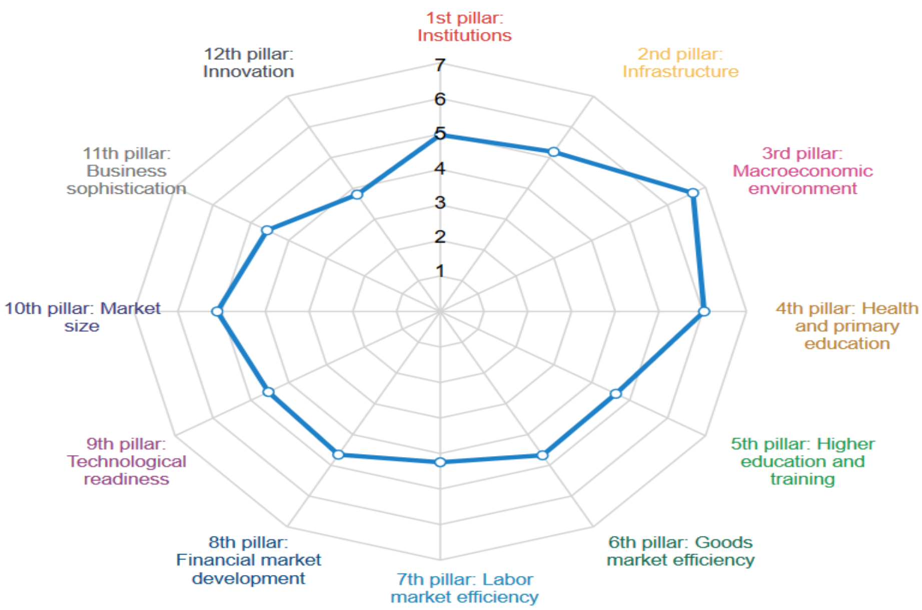

Figure 4-2: Saudi Arabia’s performance overview across competitiveness index measures in 2016

Source: http://reports.weforum.org/global-competitiveness-report-2014-2015/economies/#indexId=GCI&economy=SAU

The ranking reflects the competitiveness of Saudi market, which makes the Kingdom an ideal place to invest in and do business as it has the right macroeconomic environment and market size (Joyce and Al Rasheed, 2016). The country is ranked 3rd in the world for "fiscal freedom" and therefore receives more Foreign Direct Investment than other countries in the region (SAGIA, 2015, cited in Joyce and Al Rasheed, 2016). Furthermore, the country has low inflation rates, boasts of a stable currency (Saudi Riyal (SR)), and allows companies to transfer capital and profit abroad (SAGIA, 2015, cited in Joyce and Al Rasheed, 2016). The problem, however, is the comparatively lower labour market efficiency and business sophistication (score 4.5 out of 7). Score of 4 out of 7 on innovation readiness highlights the high uncertainty avoidance aspects of Saudi culture as discussed later in this chapter.

Global economic slowdown and fall in oil prices had a great impact on the country's slow economic growth in 2014 (Al-Darwish *et al.* 2015). The price of crude oil, which accounts for over 80% of the Kingdom's revenues, has been steadily falling and as a result, the government had to cut spending. According to Bangera (2016), the government also reduced subsidies and introduced taxation in an attempt to compensate for the deficit created by diminishing oil revenues, which resulted in a cut in advance payments to construction contractors involved in government projects. In order to resurrect its economy and steer the country through a period of low oil prices, the government may have to implement significant reforms in the labour market, regulate business and finance (Bangera, 2016)

Privatisation

The government is considering partial privatisation of state assets such as Saudi Aramco (a Saudi Arabian oil company). This is likely to provide both capital boosts to the economy while also improving the management of state owned organizations. In addition, Privatization of its vital (non-oil) economic sectors was a policy measure adopted by the Government with the objective of reducing the role of the state in economic activity and encouraging the development of an efficient and competitive private sector (Al-Darwish *et al.* 2015). The rationale for privatization and diversification is based on the notion that no nation can remain completely insulated from the global economy. One of the key aspects in privatisation is greater accountability and more focus on aspects such as quality. Privatisation might lead to decline in number of project as privatised firms may have more focus on returns on investment than on aspects such as social welfare. This means that only the projects which are considered good investments may be approved (Arlbjørn and Freytag, 2012). What this may also mean is that the procurer may be more involved in the process which may make quality more critical than it is considered today.

The Saudi government has relaxed rules for foreign investment in the country; this is likely to affect the business environment bringing in foreign investment and boosting economic growth and infrastructure development which will improve the business environment for construction firms. The key change will be the demand for higher quality. This is higher in the private sector procurement, compared to public sector procurement (Arlbjørn and Freytag, 2012). Arlbjørn and Freytag (2012) argue that this could be one of the key factors influencing the poor demand and consequently poor state of quality in the industry. Based on the same argument, increased privatisation should lead to increased demand for quality in construction. Demand for quality may have also been boosted because of some high profile events such as the crane crash in Mecca, which killed a number of people and brought negative attention from media and public around the world.

One of the positives for Saudi organizations is that, due to the very important oil and gas industry, it is attracting lot of professional companies from around the world with expertise in quality management. The arrival of these companies improves the overall focus on quality as firms from western nations focus on quality as one of the key aspects of their marketing strategy. This is likely to improve the overall awareness on quality matters as knowledge and awareness about quality diffuses in the industry environment. The Saudi construction industry has undergone major change since 2007, but there are some problems which still persist, such as a lack of enforcement of regulations, high dependence on foreign workers, prevalence of energy-intense manufacturing processes, poor focus on health and safety issues (Alsamari, 2010).

4.2.2 Saudi Arabian labour market

The Saudi labour market is heavily polarized with most Saudi nationals working for the public sector, and the private sector relying mostly on foreign labour. People are one of the key driving forces for any company, industry or country. It is the quality of their skills and knowledge combined with their efforts towards work, which ensures the competency of a firm. The culture of the workforce affects their professional outputs and consequently the performance of the firm.

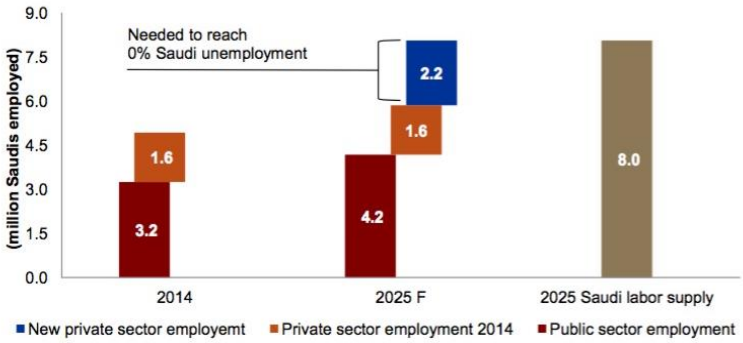

Figure 4-3: Institutional background of Saudi employment

Source; SUSRIS (2015)

Figure 4-3 shows the proportion of Saudis employed in the public and private sectors, with nearly double the number of Saudis employed in the public sector compared to the private sector. Thus the Saudi government will have to absorb additional 2.2 million Saudis in the private sector by 2025 in order to ensure zero unemployment among Saudis, as well as the public sector itself having to absorb an additional 1 million (SUSRIS, 2015). This is one of the key reasons why Saudi government is looking to boost investment in alternative industry sectors.

The Saudi government's national plan pays considerable attention to the unemployment problem. The work force in Saudi Arabia is largely made up of expatriate workers from India, Pakistan, Philippines, Egypt, Jordan, Indonesia, Bangladesh and Sri Lanka. The foreign work force consists of over 8.2 million non-nationals and has been growing at 12% per year (Benchiba-Savenius *et al.,* 2016). As part of its policy of nationalisation or localisation, and in order to protect the rights of its nationals, the Ministry of Labour decided to replace expatriate workers with Saudi-nationals in the public and private sector (Alanezi, 2012). This initiative, known as Saudisation, was in response to the increase in the rate of unemployment among its nationals.

In order to control the increase in foreign labourers entering the country, the government has made serious attempts to localise this cultural dimension, by enacting the "Nitaqat" law (Peck, 2014). This law categorises firms based on their size (Small, Medium, Large and Giant), and encourages the employment of Saudi nationals (Jamali and Sidani, 2012). Organizations with very few employees (less than 10) were exempt from the programme, but larger firms/shops will have to appoint one Saudi national for every 10 expatriate workers (Sadi, 2013, cited in Budhwar and Mellahi, 2016). Firms who successfully comply with the requirements are given incentives. However, firms have been circumventing this mandatory requirement by showing relatives and friends in the employment register who were not actually employees in order to avoid penalties (Mustafa, 2013, cited in Budhwar and Mellahi, 2016).

While the Saudi government is looking to increase the participation of Saudis in the private sector, a survey conducted by Oxford Strategic Consulting found that only 1% of the surveyed Saudi nationals were interested in working in the construction industry, with most focusing on white collar jobs such as in banking sector (Benchiba-Savenius *et al.* 2016). This means that the composition of foreign workers in Saudi construction industry is unlikely to change in near future, except in senior level positions.

4.3 The Saudi construction industry

4.3.1 Overview of the Saudi construction industry

The economic rise of Saudi Arabia began in 1975, when the rise in oil prices sent the economy of Saudi Arabia in a boom cycle. At that time, the major business activity was oil and gas driven. The government was the key procurer for construction projects. The construction industry suffered major setbacks in the 1990s when the oil prices fell coupled with a fall in construction orders. This led to the abandonment of several projects while those which continued suffered from severe time delays and budget overruns (Jeddah Chamber of Commerce & Industry, 2016). What also changed with this first downward cycle in the economy was a shift in government focus. Government was investing significantly in complex mega projects, shifted its focus towards more basic building projects (Al-Sedairy, 2001). The government became more concerned with value for money. Consequently, private sector construction companies came under pressure to perform.

The Saudi Arabian construction industry is dependent on the oil industry; the growth of the construction industry fell to around 1.5 percent per annum when oil prices fell by around 4 percent per annum when oil price fell. It remains one of the key industry sectors, in terms of the number of people it employs with around 40 percent of the total workforce. According to McCarter (2013), the construction industry expects building work to outpace infrastructure projects in Saudi Arabia, with a significant increase in education-related works and healthcare, as well as residential, affordable housing projects. Infrastructure work related to transport connections, as well as water and wastewater provisions will to remain in focus.

The Kingdom of Saudi Arabia is one of the fastest growing construction markets in the Middle East. The annual new construction volume exceeded US$89,897 million by 2013 and US$101,886 Million in 2014 (Ventures Middle East L.L.C, 2012, cited in Alatawi, 2014). Annual output is expected to reach US$148 billion by 2020 (Jeddah Chamber of Commerce & Industry, 2016). Construction contracting is a very competitive business with a high rate of bankruptcy (Algahtany *et al.* 2016). Construction knowledge is noted to be one of the most important resources contributing towards a better understanding of the construction process.

The Saudi construction industry suffers from high rates of project failures (Ikediashi *et al.,* 2014). Some of the reasons cited are (Alsuliman, 2014):
a) poor project management knowledge,
b) diversity of the transient workforce,
d) poor implementation of regulations,
e) lack of professionalism.

To this list can be added, burdensome bureaucracy and procedures, low ethical standards, lack of skills training, lack of investment in research and development, lack of local skills, over reliance upon foreign contractors to undertake the mega projects, over reliance upon foreign workers prepared to tolerate poor working conditions, few large indigenous Saudi owned construction firms, harsh climate for production workers, over reliance upon specialty contractors, and poor safety and health culture. Construction companies have not tackled these problems; they are felt to be national government issues. For example, the crashing of a crane onto the Holy Mosque in Mecca drew global attention; global media started to highlight the problems such as poor-quality processes that have plagued Saudi construction industry for a long time. Lack of clarity on the roles and responsibilities of individuals is one of the key contributors to poor project performance in the industry (Almazyad, 2009).

Bubshait and Al-Musaid (1992) found that the public clients have a very low level of managerial involvement in the project, which leads to miscommunication and contributes to project failures. In particular, public clients seem to have a low level of involvement in the planning and design phase, where client requirements are converted into design requirements. This means that there are frequent design changes at the production stage, which affects quality in construction as quality is determined mainly by client satisfaction.

Poor involvement of client/customers means that contractors do not have a full understanding of client requirements, which affects their ability to satisfy them.

4.3.2 Special characteristics of Saudi construction industry

The construction industry faces an acute deficiency of capable local contractors, consultants, and local workers. In order to fill this void, the government is forced to welcome foreign contractors and allow private sector firms to recruit skilled and unskilled labour from Asian and African countries. There is a shortage of raw-materials. The distinctive characteristics of the Saudi work environment are listed below.

a) Most Saudi firms have to depend on foreign technology and expertise for producing standard quality products and services. Poor technological orientation of Saudi society means that using foreign technology and expertise can be a problematic. This means they often tend to rely on professionals from technologically-advanced societies to undertake decision-making roles. This is evident in the large proportion of western expats in senior positions in the Saudi construction industry.

b) Most contractors are family-owned firms. Such organizations are centrally controlled and the control remains in the same hands for long time. Such organizations often fail to improve because they rely on the knowledge and vision provided by a single individual. For TQM implementation it is essential to find innovative solutions which can only be achieved through decentralisation of control.

c) The expatriate work force has created a multi-cultural work environment. In most cases a diverse workforce will be an asset, but in the construction industry, especially in context of implementation of TQM, diversity can prove to be a hindrance because it leads to issues such as different cultural perspectives of quality, communication issues etc.

d) Construction firms are required to procure all materials for public sector projects from local suppliers. This creates a sort of monopolism of the market in which the local suppliers tend to collude and set their own rules and prices. For TQM to work the market should be as competitive as possible, this puts pressure on players to improve their quality to compete for business.

e) Foreign contractors are required to sub-contract a maximum of 30% of the value of the contract to wholly-owned Saudi firms under the Council of Ministers

Resolution No. 124 (Husein, 2013). This creates a form of incumbency in which local firms win contracts not on basis of their competency, but for the sake of compliance with this law.

f) Natural factors such as the harsh desert climate affect the productivity of construction workers.

g) Job creation is a serious issue facing the government. A vast majority of the work force in the construction sector are foreigners (Bel-Air, 2014). One of the challenges facing government is displacing foreign workers with a youthful Saudi workforce which incidentally has become the focus of the country's Saudization programme (Elamin and Alomaim, 2011). However, it seems most Saudis do not want to work in the construction industry except in white collared positions. This makes the situation very difficult for construction industry players who are left confused over how they can comply with the Saudization laws as there is not enough supply of local manpower.

The government is making substantial investments in infrastructure development (Jeddah Chamber of Commerce & Industry, 2016) to meet the needs of a growing population with increasing disposable personal income. As a result, the construction industry has outpaced all other industries in terms of growth within last two decades in Saudi Arabia (Jeddah Chamber of Commerce & Industry, 2016). Not only is the economy affecting the construction industry but the construction industry itself is also having a positive impact on the Saudi economy by creating positive business environment through infrastructure development (Opoku and Abdul-Muhmin, 2010). The construction projects in various stages of completion in Saudi Arabia are valued at over 1.7 trillion (SR), which constitutes 25 per cent of the expenditure incurred by the GCC states (Jeddah Chamber of Commerce & Industry, 2016). The burgeoning construction sector has registered a compound annual growth rate (CAGR) of 6.94% during the review period (2008–2012) (Jeddah Chamber of Commerce & Industry, 2016). This is expected to rise to 7.05% for the period between 2016 and 2020 as government step up their investment in infrastructure development in order to promote alternative (non-petro chemical) industry sectors (Jeddah Chamber of Commerce & Industry, 2016).

Estimates from the IMF indicate that the Saudi population will rise from 31.5million to around 37 million in the next decade is likely to further boost demand for residential properties (Jeddah Chamber of Commerce & Industry, 2016). Growing economic, social and environmental changes mean nations need to adopt a major shift in the consideration of their existing economic development models. For instance, Saudi Arabia has been trying to find a satisfactory compromise between conserving its oil resources and improving its economic growth (Taher and Al-Hajjar, 2014). Therefore, more impetus was given to the construction sector by the government, as it plays a significant role in socio-cultural and economic development. The sector also provides project-level employment which is important to the growth of the national economy (Myers, 2013). The construction sector is involved in the building of houses, educational institutions, medical facilities, roads, seaports, airports, railway networks, and agriculture systems etc., economic factors such as inflation and low costs are essential economic issues. Social factors, such as the provision of housing for a growing native population is one of the demands of a fast-developing economy (Ventures Middle East, 2011, cited in Alatawi, 2014).

A Timetric report (2014, cited in Alatawi, 2014) highlights some of the key socio-economic factors that have influenced the government to embark on large scale projects for its native population. Firstly, the government wants to keep unemployment rate at an average of over 5.3%, but as it fell to slightly over 5% in 2013, “Saudization” initiatives (nationalising employment by encouraging Saudi nationals to take up jobs in the private sector) were adopted to reduce the reliance upon the foreign work force. Secondly, there is an increase in population growth, which has led to an increase in demand for affordable housing from low and middle-income households. Most of these demands are still unmet. Therefore, the government is making large-scale investments in developing low-income housing. Thirdly, the country has become a very favourable destination for religious tourists who visit the holy cities of Mecca and Medina, which has created a demand for construction of more hotels. Environmentally, the government has also been encouraging sustainability, green construction and “Smart Buildings” although these developments are still at in the initial stages and lack legal enforcement (Ventures Middle East, 2011, cited in Alatawi, 2014).

4.3.3 **Contractors in Saudi Arabia**

The Saudi Arabian construction industry is fragmented with a mix of small and large scale contractors. There are over 3,000 classified construction organizations. According to the Ministry of Commerce and Industry, there are over 180,000 affiliated firms that operate in construction-related activities, such as operation and maintenance and material suppliers. Unclassified contractors are not permitted to offer their services to the public sector, they are deemed to have weak capabilities. Contractors are not required to be classified to operate the private sector.

One of the requirements for the pre-qualification of these contracting firms is that they have to be classified by the Ministry of Municipalities and Rural Affairs (MOMRA). Contractor Classification Law of 2006 is used to classify contractors (ACC, 2014). As shown in the table below contractor's classification scale is based on value of completed projects.

Table 4-1: Classification of contractors based on value of projects completed

Activity category	The class and its financial upper limit of project value ($US million)					
	G1	G2	G3	G4	G5	Unclassified
Building	>74	74	18	5.6	1.8	<1.12
Road	>112	122	37	11.2	3.73	<1.12
Sewage and water	>113	122	37	11.2	3.73	<1.12
Dams	>37	37	18.6	5.6	1.8	<1.12

Note: 1 Saudi Riyal (SR) = US$0.27 (November, 2016)

Most grade 1 contractors are located in Riyadh. However, the maximum numbers of contractors are classified under grades 3, 4 and 5 (ACC, 2014).

4.3.4 Construction projects procurements in Saudi Arabia

Only those contractors who take part in public tenders have the chance of being awarded contracts based on the tenders submitted. The cost of the project is pre-determined by the client team, contractors are required to submit a quote. The lowest-price bidder is supposed to be awarded the contract unless the price exceeds the estimated cost as specified by the government procurement regulation in Saudi Arabia, or is less than 35% of that cost. Contractors are expected to offer a discount to reach the pre-determined costs of the client. The contractor who offers the maximum discount is awarded the contract, but, priority is preserved for the lowest price bidder. The discount has to be uniformly applied to all the various elements of a project in order to avoid exclusion. Foreign contractors are also permitted to bid, provided that 30% of the value of the contract is sub-contracted to wholly-owned Saudi firms (Husein, 2013).

The most prominent procurement systems within the public sector are: fixed price (lump sum contract), quantity with unit price contracts, cost reimbursable or cost plus contract and the two-stage tendering mechanism (Al-Hazmi and McCaffer, 2000). The problem with the current system is excessive focus on price, with little attention paid to quality. Quality is often taken for granted; procurers assume that all the bidders are quoting for the same quality of product. The problem with this perception is that in order to compete, even those contractors who can offer superior quality has to quote lower and offer inferior quality, as this is what their competitors are doing. This may create an environment where quality is not valued and hence not pursued by organizations.

4.3.5 **Challenges facing construction projects in Saudi Arabia**

Conventional project management processes practiced within the construction industry to undertake projects on time and cost-effectively, are not the norm in Saudi Arabia. A great number of construction projects experience delays and cost overruns have been reported in research (Rahman, *et al.* 2016; A-Elawai, *et al.* 2015; Mahamid, 2012). They have discussed the causes of delays in large building construction projects and the findings suggest that these were related to clients, contractors, consultants, materials procurement and delivery, labour shortages, unreasonable contract clauses, payment disputes and non-payment, and poor relationships between stakeholders.

The most important factors in causing delays according to owners were quality related, namely, faulty design, unnecessary excessive formality and routine in firms, and lack of skilled labour. These issues may have occurred due to a lack of quality systems, a view supported by Al-Kharashi and Skitmore (2009) who found that delays were caused by poor quality management systems and poor quality assurance control. Consequently, it is important to examine TQM applications and transferability of these popular management techniques for the advancement of the construction industry in Saudi Arabia (Albayoudh, 2003).

One of the key issues facing the Saudi construction industry is that the public sector (government) is the major client with non-governmental construction comprising a very small proportion of the overall construction work (Albayoudh, 2003). This creates several issues:

- Government, as a client, has poor interaction with construction contractors making it difficult for the contractors to establish the quality criteria for the project.
- The focus for government-sponsored projects is on cost and not on quality, which is often taken as a given. The cost focus leads to intense price competition among

bidders leading to very low margins to focus on quality aspects. In such cases the contractors try to give the least acceptable level of quality for the minimum price.

- The bureaucratic nature of the government sector means the contractors do not develop a professional relationship with the client (i.e. government officials). This leads to a lack of interest in quality issues by both the procurer and the contractor. Too much time is spent ensuring compliance with the regulatory system and not with satisfying the client requirements.
- Government procurement is linked to budget allocations. Clearance of funds can be delayed; this is often factored into the quality assessments of construction firms leading to poor focus on quality management on site. Many government-sponsored projects are delayed because of slow release of funds. Budget allocation can be volatile as government earnings depend significantly on oil prices.

A key issue in Saudi construction industry is the high level of diversity especially among the site workforce, which is dominated by unskilled and poorly educated workers from different parts of world. They speak different languages, which makes it difficult to communicate with these workers about quality issues. Furthermore, these workers have poor perception and knowledge of quality.

Other issues such as project delays, budget overruns etc. affect the Saudi construction industry, much as it affects construction industries around the world. Indeed, there are some unique challenges that the Saudi construction industry faces with such a diverse workforce, lack of professionalism especially among site workers, communication challenges within the industry, high growth rate, and poor quality standards. There is a shortage of adequate research addressing the challenges facing the Saudi construction industry, especially for TQM, despite the claims that this sector is very important and that it contributes largely to the economy.

4.4 Quality movement in Saudi Arabia

Attempts to improve the quality of local products and services commenced in 1973 when the Saudi Arabian Standards Organization (SASO) was established, with the objective of implementing standards. The SASO was responsible for framing and approving national standards for all products and undertook inspections and testing as well as granting quality assurance certificates to manufacturers and service providers (Mazher *et al.* 2015). In the

1990s the "Saudi Arabian Quality Council" was established by Saudi Aramco with the goal of creating awareness of the importance of Total Quality Management.

4.4.1 **ISO 9002 certification in the Saudi construction industry**

The international standard ISO 9001, which specifies requirements for a quality management system (QMS), has been adopted by many industries in Saudi Arabia. The number of Saudi construction organizations opting for ISO certification has grown over the last decade (ISO, 2016). The construction industry is the second industry in Saudi Arabia for the number of ISO9001certifications. In 2013 the number of ISO9001 certified Saudi construction firms was 237 which declined to 156 in 2014, before rising again to 191 in 2015 (ISO, 2016). This change in the number of ISO9001 certified companies indicates a lack of consistency in achieving and maintaining high quality standards. TQM can resolve this to some extent because it proposes continuous improvement and sustaining improvement by ensuring that these are not superficial, but rather made part of organizational culture.

4.4.2 **Total quality management practices in Saudi Arabia**

TQM, which was widely accepted by the Japanese, has been recognised by organizations globally, and is one of the most valuable approaches that are applied in different industries. TQM is a management practice in which stakeholder satisfaction is of utmost importance. Organizations that implement TQM make use of stringent quality control techniques, pay close attention to the process, motivate employees to ensure the quality of a product, and improve productivity. Some construction organizations in Saudi Arabia have been implementing TQM, but it remains elusive for the majority of Saudi construction firms (Al-Otaibi *et al.* 2015; Mazher *et al.* 2015). Firms that have adopted TQM intend to boost industrial performance. For instance, construction firms in Saudi Arabia have adopted TQM to achieve productivity, cost-effectiveness, sustainability and competitiveness (Mazher *et al.* 2015).

Al-Omaim (2002, cited in Shibani *et al.* 2010) conducted research to investigate the understanding of TQM principles, acceptance and deployment in a Saudi organization. Twenty-one factors were identified as critical factors for the implementation of TQM. The factors were classified into three levels of criticality; the critical factors are:

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[2] ISO 9001 is the **only**standard within the ISO 9001 family that an organization can become certified against, because it is the standard that defines the requirements of having a Quality Management System.

- Senior executives' responsibility
- Customer satisfaction and executives' vision
- Identification of customer requirements and feedback and ensuring these requirements influence processes
- Clear mission statement, objectives, values, expectations, policy deployment;
- Workforce commitment, training
- Continuous improvement
- Fact-based processes.

Mazher *et al.* (2015) focused on efforts made by of organizations in the public sector to implement TQM; the findings showed that organizational and social factors in Saudi Arabia hindered successful implementation. This view has been confirmed by Albayoudh (2003), which considered organizational culture as a key factor in implementing TQM in construction firms. Studies that investigated continuous improvement, which is widely acknowledged as being crucial for the successful implementation of TQM, found that the requirements were not met by most organizations (Alhwairini and Foley, 2012).This could be attributed to Arab culture which is very distinct from Western culture and may have a major impact on TQM Practices (Islam *et al.*, 2013).It is concluded that TQM concepts and techniques may not have been applied successfully due to the prevalence of country-specific and socio-cultural factors.

4.5 Culture

4.5.1 **Saudi Arabian culture**

Organizations operate in an ecosystem, which contains a number of human participants. The behaviour of these human participants is dependent on their cultural orientations. Psychologists such as Hofstede (2010), and Schein (1985), focused on understanding the link between different types of cultures (such as organizational, national) and people's behaviour. There is a consensus that culture provides useful insight into how people behave in different circumstances, and how their behaviour is driven by their cultural orientation.

National culture is the set of customs, traditions, behaviours and beliefs of individuals belonging to a sovereign country and also includes language, religion, ethnic and racial identity (Alyousif *et al.* 2010). In Saudi Arabia, Islam influences national culture. This is because the King of Saudi Arabia is the custodian of the Two Holy Mosques in Mecca and Medina. Religious values are at the root of all rights and laws, whether it is social, cultural or political. This has had a different influence on the culture in that Saudi people tend to follow the rules and be inflexible when deviating from the rules. In terms of quality, this means that construction firms tend to follow specifications and rely on contracts.

Geert Hofstede (2003, cited in Cronjé, 2011) used the workforce of the global company IBM for a research project. He identified certain attributes which can be used to differentiate between national cultures. These attributes have five dimensions of national culture. Hofstede's five dimensions are: "power distance, individualism Vs collectivism; masculinity Vs femininity, uncertainty avoidance and time orientation" (Hofstede, 2010). The five dimensions were developed considering the "collective programming of the mind which distinguishes the members of one category of people from another," including the following four components: symbols, heroes, rituals and values, which represent "the deepest level of culture".

The five dimensions in relation to Saudi Arabia are explained below:

Power Distance: Saudi society is a high power distance society with a score of 95 on Hofstede's scale. This indicates that most decision making in Saudi organizations is highly centralised, often the locus of power is at the top (Cronjé, 2011). In such societies individuals at the lower power levels tend not to take decisions and prefer to follow the decisions taken at the top. The inequality in power distribution in such society means that the role of leadership is critical because the rest of the organization works mostly as implementers of the decisions taken by leaders.

Individualism versus Collectivism: This relates to whether the individuals think as individuals or collectively as a group (Cronjé, 2011). Saudi Arabia is a collectivist society, which means that people often act as a group. In Saudi society there is high value for relationships and people are concerned about upholding social values and image in the society. Consequently, they strictly adhere to the social rules and norms (Li et al, 2009).

Masculinity versus Femininity: Masculinity refers to tough values like assertiveness, performance, success, and competition that are usually associated with male roles. They prevail over the fonder feminine values such as quality of life, maintaining warm personal relationships, service, care for the weak, and solidarity (Cronjé, 2011). Saudi Arabia has a score of 60 in this dimension, which indicates that there is preference for both male and female dimensions. This means while family orientation is valued, at the same time, success, performance, and competitiveness are also valued by the Saudi society.

Uncertainty Avoidance: Saudi Arabian ranks very high in uncertainty avoidance with a score of 80. This means that Saudi individuals tend to be risk averse. This could be one of the reasons why individuals tend not to take decisions but follow decisions, because in such cases the onus of success and failure rests on the decision-maker (Cronjé, 2011)

Long-term versus Short-term Time Orientation: This dimension refers to the extent to which the society focuses on the future. Long-term oriented societies delay consumption and persist with their efforts while short-term oriented societies are more likely to be concerned about the present and view future trends with scepticism (Cronjé, 2011). The short-term orientation of Saudi society indicates that individuals tend to be short-term decisions makers. TQM is a long-term strategy, while short-term strategy will be cost focused. This indicates that short-termism of culture could be one of the factors that might contribute to poor quality culture in Saudi firms.

Culture affects the construction industry because it influences the behaviour of people working within the industry. For example, people in certain cultures will be more professional, skilled, and more aware of the health and safety issues as compared to people in other cultures. This means culture affects the policies and practices within the construction industry in every country. Hence, using a universal approach to management in the construction industry may not be the best approach and managers need to contextualize their approach according to the local context.

In order to work in a market, firms have to understand the cultural diversity, views, stereotypes, and values prevalent in the society. The reference to religion has extensive implications on national culture in Saudi Arabia. Culture is a set of norms and behaviour, which a group of individuals share. These norms and behaviour then represent the culture of the group. The norms can include language, types of relationships, family management, money management etc. Anything that characterises the behaviour of a group of people can be considered part of the group’s culture.

Stereotyping is evident in the recruitment strategy of Saudi construction firms, where individuals may be appointed based on their nationalities instead of capabilities. The problem with this approach is that there is a cultural barrier between different levels of management making cooperation, coordination and communication extremely difficult. Saudi culture and tradition does not permit the process of assimilating new ideas (Yurdakul and Ozturkcan, 2014). Following the established norms is preferred; any changes to be implemented have to be in the context of the established norms. This makes it difficult to implement radical changes within Saudi construction firms and so quality improvement may take even longer than in western firms that exhibit higher readiness for change.

People in Saudi Arabia give more importance to personal relations (Al Harbi *et al.* 2016). 'Wasta' is a key concept in the business culture which is a practice used to create and cement interpersonal connections or social networks. People support others in this social network, individuals may disregard competency when offering favours (Yurdakul and Ozturkcan, 2014). This is one of the issues which may create challenges in implementing quality, because people often win contracts on the basis of personal relationships and favours instead of their competencies; the same is true for organizations. For this reason, firms may find it worthwhile to invest in personal-relationship building rather than on performance improvement. Many powerful individuals own organizations that win bids on grounds of personal relationships. This suggests that construction firms involved in projects within the Kingdom will have to recognise the significance of personal relationships, which are essential for conducting negotiations. Although written contracts are important, more emphasis has to be given to personal relationships and the principles of Shariah (Medallah, 2015). In order to resolve disputes on international construction projects, personal relations and personal image play a great role.

4.5.2 **Saudi Arabian management style**

Most modern management practices are bound by socio-political and socio-economic factors (Hofstede, 2010; Alyousif *et al.* 2010). The Arab management style is characterized by the behaviour and attitude of managers who are expected to accept an unequal distribution of power, to want subordinates to respect the authority of their supervisors, have preference for autocratic, centralized structures and decision-making procedures (or concentrated ownership and control) and are more likely to avoid taking risks (Yurdakul and Ozturkcan, 2014). This suggests that more importance may be given to rank and seniority, rather than the ability and performance of an individual. More focus is given to relationship obligation, sticking to the traditional values. People tend to give more value to relationships and consequently, finding the right contact is often the easiest way to get things done. Hierarchy, status, and seniority are important, more value and preference is given during job promotions as a sign of respect to elders. Moreover, the society has embedded co-operation rather than competition (Yurdakul and Ozturkcan, 2014).

Ali (1990) identified factors that are known to influence the Saudi business culture. There are three factors besides Islamic cultural influence: the tradition of obligation in the tribes and families; the continuation of bureaucratic influence inherited by the Ottoman Empire. Research shows that with an increase in interaction with Western cultures, pragmatic management was observed, especially after the Kingdom's accession to WTO (Assad, 2002). As Saudis started exploring the outside world and as more foreigners started to arrive in Saudi Arabia for business and employment, there was a gradual improvement in knowledge of, and respect for other cultures.

People lay great emphasis on personal relationships with business contacts. In Saudi Arabia businessmen prefer to engage in trading or commercial activities with people they trust or are acquainted with. Consequently, favouritism or nepotism prevails in Saudi Arabia, which is believed to be normal and beneficial. Scott-Jackson (2008) and Obeidat *et al.* (2016b) pointed out some characteristics of Arab management style:

- Organizations are centrally controlled with a low level of delegation. This centralisation of power may make it difficult to implement quality policy and strategy because the operational and to some extent tactical decisions are to be made at lower management levels.
- Most of the decisions are made at the top and low level managers try not to make decisions. Without the participation of middle and lower level management, it is not possible to implement quality management policies and strategy. Their role in decision-making is critical because they can provide valuable feedback on implementation issues, which have proven to be a major barrier in implementation of TQM.
- Consultative styles of decision-making are pervasive and dominant. This consultation is usually carried out on a person-to-person basis, thus avoiding group meetings. Decisions are often made in an informal and unstructured manner.

Collectivism is critical at all level in implementing quality management. Lack of group meetings could prove a hindrance in implementing TQM because many of the issues in implementing TQM can only be discovered through collective group discussion including parties from within the organization and outside parties, even the indirect stakeholders. In addition, formalisation is essential for TQM implementation, it must be ingrained in the organizational culture. TQM can only be implemented by ensuring that every process is quality driven, and this require formalisation of process so that their quality orientation can be assessed and if required, improved.

- Affiliation and power needs, and performance objectives drive the efforts of individuals. The problem with TQM implementation is that not all of its outcomes are objectively measurable; hence setting performance objectives is an issue. Evaluating people on qualitative objectives is not easy. TQM provides benefits over the long-term so some indirect measure of performance will have to be used. Managers' feedback may be useful but in Saudi culture, managers are less likely to report matters about their peers and subordinates if they feel that it will affect their wellbeing.
- Managers tend to value loyalty more than performance. They act as guardians of organizations, which they consider as their family where they take all the decisions. The problem with such behaviour is that individuals may get away without following the quality policy and strategy of organization. Unless individuals follow quality management principles in their entirety, it is difficult to achieve the highest levels of TQM.
- There is a low value of professionalism and high value for relationships. People often do not adhere to time constraints. Professionalism is critical for quality management because it requires strict adherence to quality guidelines. Lack of professionalism in the Saudi construction industry is influenced by the high proportion of unskilled and poorly educated migrant workers in the site workforce. There is low expectation from these workers, but site employees have significant influence on quality; hence their role in TQM implementation should not be ignored.

4.6 Chapter summary

This chapter reviewed the context of the Saudi construction industry including the factors that are driving the industry. According to the literature, the industry has experienced significantly high levels of growth in the last decade or so, buoyed by the rising oil wealth, as the Saudi government decided to speed up its spending on infrastructure development. This has brought in a wealth of international competition as foreign contractors looked to benefit from their experience and rising business opportunities. However, the development of local industry has not been as systematic. Sudden decline in oil price in 2014 reduced the development of construction industry. Furthermore, one of the key issues that make it difficult to achieve the quality focus on Saudi construction industry is that the largest procurer is the government sector, which is often cost focused. The cost focus puts downward pressure on quality issues. Some studies suggest that quality is often taken as granted especially in public sector projects even though experiences suggest that excessive cost negotiation affects quality.

One of the key issues that facing the industry is the unavailability of low level manual workers in the local market as these job opportunities are not attractive enough for locals. While the foreign migrants helped the industry to meet the shortfall in labour, it has created a range of other problems. In terms of quality, poor skills, knowledge and perception towards quality among the migrant workers has made it difficult for Saudi contractors to implement quality policies.

This chapter also discussed number of issues that Saudi construction industry players face such as poor project performance on delivery time, cost and poor quality and lack of skilled labour etc. Implementation of TQM is driven by both a firm's micro and macro environment. All these factors directly or indirectly affect the implementation of quality approach such as TQM in Saudi construction firms. TQM has not yet achieved the kind of recognition in Saudi construction industry as ISO9001 has.ISO9001 is by far the most commonly followed quality management approach probably because of its wider recognition which allows Saudi construction firms with ISO9001 to use it to gain competitive advantage over rivals who do not have such certification. However, some of these companies failed to maintain their certification due the absence of continues improvement approach.

One of the most critical aspects discussed in this research is Saudi culture and its impact on implementation of TQM in Saudi construction industry. Hofstede's cultural dimensions are used to evaluate Saudi culture. Saudi culture is high power distance which means most of the decisions are taken at the top. This centralised model is contrary to the principles of TQM which requires more decentralised decision making on quality matters. On the other hand, collectivist nature of Saudi society means once quality culture is established in an organization, all employees are likely to be part of this culture. At the same time the collective resistance to change can also make it difficult to implement quality culture in the organization. The possibility of this is increased by the fact that Saudi culture is ranked high in uncertainty/ risk avoidance. Any organizational change such as TQM implementation involves great deal of uncertainty and because of high risk avoidance culture; Saudi organizations may face stiff challenge from employees while implementing TQM.

CHAPTER 5 RESEARCH METHODOLOGY

5.1 Introduction

This chapter starts with a review of approaches and methods found in the literature, and gives a detailed account of the research strategy pursued in this study. The chapter presents justifications for the selected research methods and discusses the sampling strategy adopted for data collection. Finally, it discusses the system dynamic modelling methodology adopted to build the TQM maturity model. Research methodology is primarily driven from the aim of the research.

5.2 Research Aim

This research aims to propose a TQM implementation policy that will help Saudi construction firms attaining of higher TQM maturity levels in a timely fashion using a system dynamics approach. To achieve this aim, different TQM models and frameworks have been evaluated to identify the factors influencing the development of the TQM maturity in the Saudi construction industry. The research evaluates current quality management policies implemented within selected Saudi construction companies using system dynamics approach to understand whether these policies facilitate or hinder the process of attaining high levels of TQM maturity. In addition, the research seeks to identify policy that can lead to attaining such high levels in a timely fashion.

The TQM maturity model is a structured collection of elements that describe characteristics of effective processes that could enable firms to achieve higher TQM maturity levels. These levels refer to the degree/extent to which firms' processes are designed to achieve higher quality standards. The TQM maturity model is a process-driven model and assumes that TQM performance can only be improved by ensuring that each element and process within the system of the organization is TQM-focused. In other words, the TQM maturity level indicates the level of strategic and operational significance of TQM in the organization; i.e. to what degree TQM is part of the culture and operations of the organization. Firms at higher TQM maturity levels are the firms which have embraced TQM holistically at strategic, tactical and operational levels and where TQM is part of organizational culture. This research first finds the relationship between different TQM enablers and TQM-related goals using the EFQM model. The research then uses a system dynamic modelling technique to identify the best possible policy that Saudi construction firms can embrace to improve their TQM performance in conjunction with their main goals.

This research is based on the view that TQM is a long-term approach and firms need to improve their TQM performance in an iterative manner. It requires an understanding of how TQM principles can be achieved in a complex system like construction work. According to the System Dynamic organization (2017), "system dynamics is a computer-aided approach to policy analysis and design. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems — literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality."

In the system dynamic modelling exercise, the researcher creates a computer-generated model, which replicates the relationships between different variables. Modelling involves simulating the change in variables and their consequential impact on the change of state of the system. In this research, modelling involved creating a TQM maturity model using system dynamics approach in which the change in variables will affect the organizations ability to achieve TQM goals over a time period. Using scenario analysis of this system, the researcher attempted to understand how and when Saudi construction firms can speed up their achievement of higher TQM maturity levels. The dynamic model is simulated over a period of 20 years to see how the interaction of different influencing variables moves the firm towards higher TQM maturity levels.

5.3 Research plan

To achieve the research aim, multiple methods and approaches have been adopted in five stages as shown in Figure 5-1. The mix methods and approach would lead to greater reliability and validity of the study, which is defended by Collis and Hussy (2009). In addition, (Saunders *et al.* 2015) argues that the multiple methods would supplement the weakness of one method with the strength of the other thereby produce convincing finding. The research began with an extensive literature review which was aimed at identifying the research problem and gap in previous researches. Also, influencing factors on the attainment of TQM maturity have been identified from the literature review in order to build a constructs of measurement of TQM maturity model.

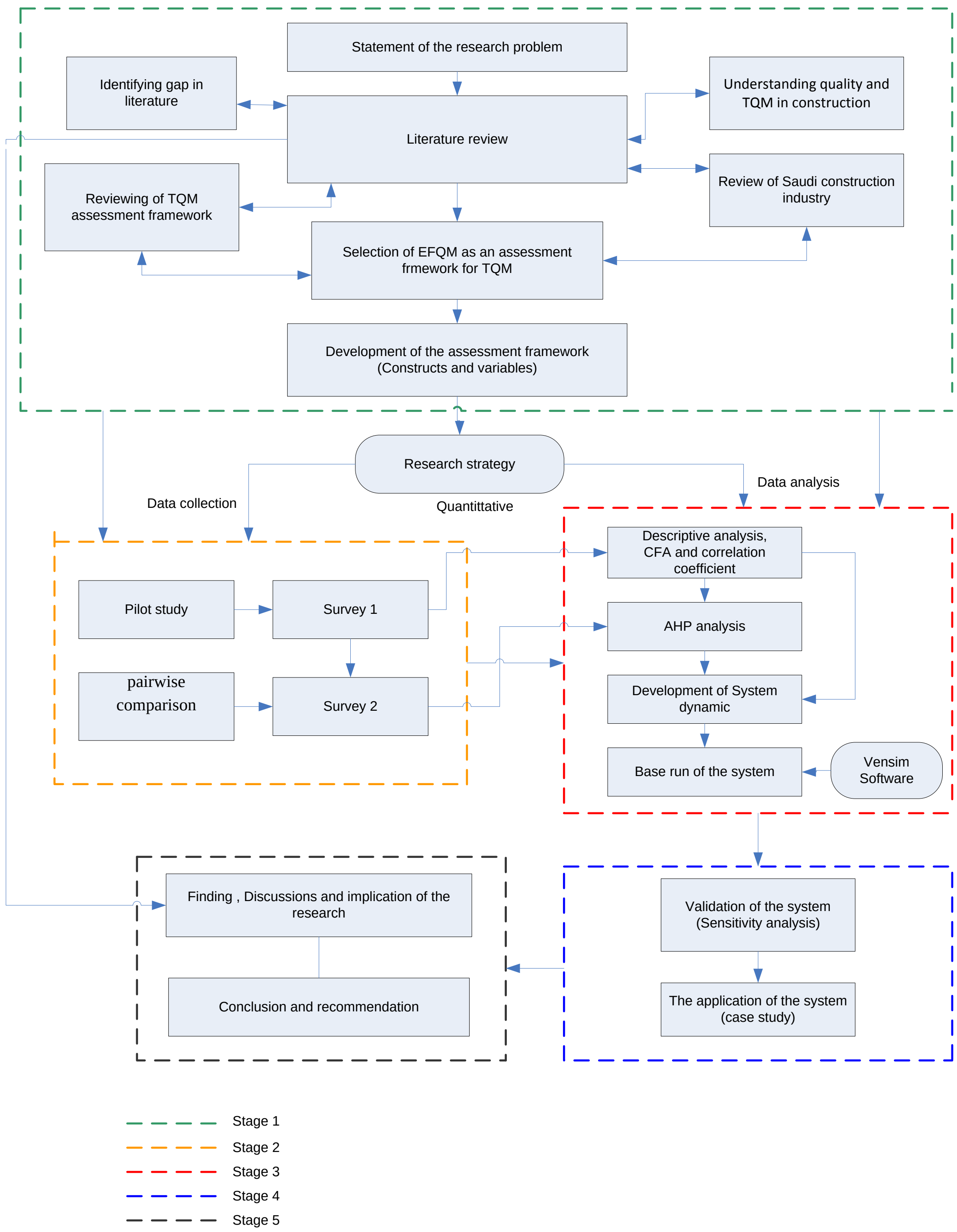


Figure 5-1: The research plan (steps)

The next stage involved data collection. Two questionnaires survey were conducted with quality professionals in the Saudi construction industry. The first questionnaire was aimed to identify the causal impact of variables on TQM performance of Saudi construction firms. The second survey was analysed using Analytical Hieratical Processes (AHP). This approach was selected to identify the relative importance of TQM enablers in achieving high maturity level. In third stage, data were statistically analysed and system dynamic modelling was formulated for the final TQM maturity model for the Saudi construction firms. System dynamic modelling was tested and then validated in fourth stage. The fifth stage contains the discussion and conclusion of the research. Each of these stages is further elaborated and explained in the following sections of this chapter.

5.4 Literature review

The research began with a literature review which was crucial in identifying problems which have not been investigated before. This has been identified through understanding quality and Total Quality Management (TQM) in construction, benefits of TQM and challenges of TQM implementation. Then, Literature review has been conducted of some special characteristics of the Saudi construction sector that could affect the attainments of high TQM maturity level. In this research two key issues were identified. Firstly, the literature does not consider a system thinking approach towards TQM. As mentioned earlier in chapter one, it is essential to think of system as a whole in which the quality performance of organization (as a system) will improve when quality performance of all its components will improve. Secondly, there is lack of understand When construction firms can speed up their attainment of higher TQM maturity levels. Combining these two gaps the researcher identified the key research objective: to investigate the dynamic interaction of different TQM enablers over time period to see what kind of policy Saudi construction firms can adopt to speed up their attainment of higher TQM maturity levels.

Based on this perspective a more thorough review of literature was conducted to see which methods may be useful in evaluating a long-term quality management strategy. Firstly, different TQM models such as EFQM, MBNQA and KAQA were evaluated and subsequently EFQM model was selected as the most suitable model/framework for this research. The justification for this was given in chapter two. Then, Literature review has been conducted to identify and build construct and items of measurement of TQM maturity model in context of the Saudi construction firms. Secondly, system dynamic modelling was identified as useful method because it models dynamic interaction of variables, one of the key requirements for this research.

5.5 First questionnaire survey

The first stage of the data collection was collected by means of a questionnaire survey. The questionnaire was aimed at eliciting the perceptions of selected senior managers in Saudi construction firms about the factors that can influence a firm's ability to attain higher TQM maturity levels. To identify the most effective policies for speeding up attainment of higher TQM maturity levels, it is essential to estimate the causal impact of variables on TQM performance of Saudi construction firms. Since this research involves estimating causal impact of one set of variables on another variable, a quantitative methodology is considered most suitable.

Quantitative methods are popular because of their higher levels of generalisability, validity and reliability (Bryman 2012). Some researchers argue that merely relying on quantitative methodologies restricts understanding of what has already been explored in existing theories or models (Driscoll *et al.* 2007; Bryman, 2012). However, a quantitative strategy was considered most appropriate for this research because it is helpful in understanding causal relationship between variables and it requires generalisation over a large population size. Identification of causality in the relationships of TQM enablers and goals is essential to identify what policy decisions need to be made to speed up TQM maturity attainment. The questionnaire survey aims to achieve this identification using the EFQM framework. The first survey was aimed at quality managers, senior managers and other professionals who are exposed to quality-related issues within Saudi construction firms. It was designed to identify the relationship between different enablers and main organization's goals.

A structured questionnaire method for collecting quantitative data was used for the following reasons:

- System dynamics is quantitative approach that aims to estimate causal impact of one set of variables on another variable over time.
- This research involved collecting a large number of responses in order to generalise the findings. Collecting a large amount of unstructured responses will lead to unclear and inconclusive data, which may be very difficult to analyse.
- Structured questionnaires are easy to administer and require less effort for the users, which increases the response rate.
- Questionnaires were considered appropriate to minimise the effort required by the respondents, hopefully generating a higher number of responses. In this research the questionnaires resulted in effective 51% response rate as explained in the sampling section below.

- The Saudi culture leads to reluctance to speak out publically for fear of reprisal. The researcher wanted to provide respondents anonymity so that they could provide true and accurate responses without any fear of repercussions. However, this means that the researcher could not engage directly with the respondents. Thus the respondents had no choice to clarify any questions if it was ambiguous or if they did not understand the question clearly. It was essential for the researcher to make sure that the questions were worded correctly and unambiguously. This was achieved through a pilot study with a small sample of 10 respondents.
- The questionnaire was self-monitored and could be distributed remotely using an online platform. The researcher remotely administered the questionnaire using an online website googleforms.com. This allowed the researcher to monitor the online questionnaire remotely and continue to make efforts to motivate individuals to respond until the desired numbers of responses were collected.
- Survey respondents are senior managers working in the Saudi construction industry. These individuals have a very busy and hectic schedule and it is difficult for them to find time to participate in academic research. This could have affected the response rates. However, by conducting an online survey, the researcher gave the respondents freedom to complete the survey at their convenience. Taking away anytime or location restriction for participation is likely to not only minimise respondents' discomfort but also improve response rates.

One of the problems with questionnaires is the poor response rate (Saunders *et al.* 2015). However, a good questionnaire survey could influence a high response rate. Longer questionnaires receive low response rate, but there are ways in which the questionnaire can be structured in order to increase the response rate. In this research, the framework contains six variables (Leadership, People, policy and strategy, partnership and resources, processes, goals) which were further subdivided in 42 subcategories. This means that the questionnaire was going to be long and this could have affected the response rate. Considering that the target populations size itself was very small (as explained in the sampling section later in this chapter) the researcher had to ensure that response rate for the questionnaire survey was high. The following steps were taken to increase the response rate:

- A covering letter was included which explained in detail the purpose of the research.

- The questionnaire was set out in clearly-understandable sections so respondents saw section by section rather than seeing the whole questionnaire as a long list of questions.
- Questions were kept very short and simple to minimize the effort required to answer the questions.
- The questionnaire began with very simple questions regarding the respondents' profile and some info about his/her company.
- The questions were logically arranged to make the respondents more settled and comfortable in answering.

5.5.1 **Questionnaire Review and Development Process**

The questionnaire consisted of two sections, which weren't considered too long by pilot survey respondents. Researcher also used neutral colour schemes to make the survey look professional as the target respondents were senior professionals. The first section collected information regarding people's personal profile was to make sure that the respondents were suitable (in terms of their knowledge and experience) to answer the questionnaire. This section also contained two questions asking the respondents about the significance of the idea of quality in relation to their organization's strategy.

Sections two contained six questions related to each one of the six constructs identified in chapter three. Each question was aimed at eliciting respondents' opinions on the different attributes in the context of their current quality management practices and organisational performance using a five-point Likert scale, with point 1 representing 'very low' and point 5 representing 'very high'.

5.5.2 **Questionnaire development process**

Giesen *et al.* (2012) recommends that questionnaires are designed to achieve the following three purposes:

- Questions are understandable without any intervention from the researcher.
- Respondents can respond to the question independently.
- Respondents are willing to answer the questions i.e. they should not feel negatively (such as embarrassed or threatened) in answering the questions.

This research adopted Churchill and Iacobucci's (2002) method of questionnaire design which is shown in the figure 5-2.

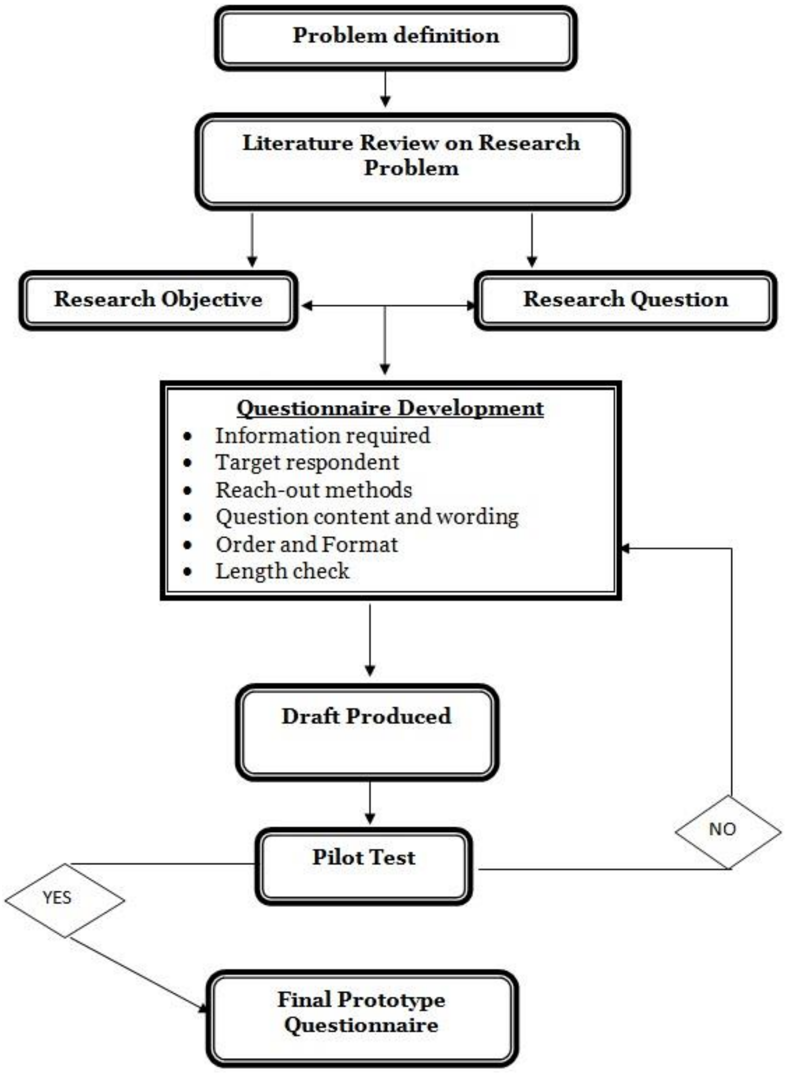


Figure 5-2: Questionnaire development process (Churchill and Iacobucci, 2002)

Step 1: Required information: The aim of the questionnaire survey is to identify which aspects are critical in improving attainment of higher TQM levels in the Saudi construction industry. Analysis from the literature review identified five enablers and their constituting factors that affect attainment of higher TQM levels in construction firms.

Step 2: Target respondents: The quality managers and senior managers who deal with quality related issues in the Saudi construction industry were the target respondents.

Step 3: Reach out methods: An online survey was identified as the best method to administer the questionnaires because of the geographical distance between the respondents and the researcher.

Step 4: Question content and wording: Short and direct questions were selected to minimise the time required to complete the survey. A pilot survey was conducted with 10 quality managers in Saudi construction firms to make the questionnaire refined and focused (Giesen*et al.* 2012). Based on the feedback received 12 questions were reworded, 4 questions were dropped and 1 question was added.

Step 5: Order and format: Questions were grouped together to make it easier for the reader to understand the context of the question (Giesen*et al.* 2012).

Step 6: Length check: For the purposes of clarity and to achieve a better response rate. It was ensured that numbers of questions were maintained at minimum.

5.5.3 **Sampling**

Babbie (2010: 173) defines sampling as "a method of selecting some part of a group to represent the entire population." Strydom and Venter (2002: 198) refer to sampling as "taking a portion of that population or universe and considering it representative of that population or universe". Accurate sampling is as critical for a research as selecting the wrong sources of information will result in wrong data. Figure 5-3 shows the sampling strategies that could be used in a research.

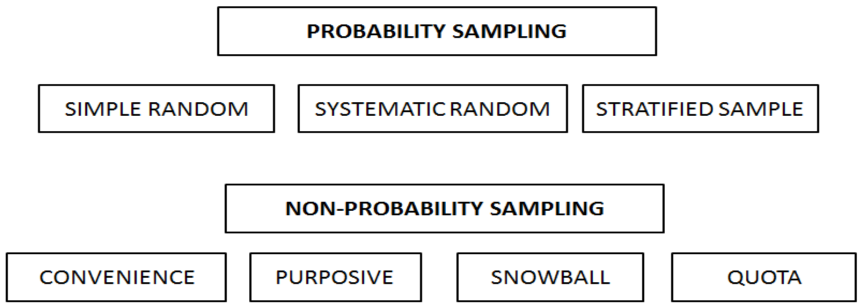


Figure 5-3: Types of sampling strategy

Purposive sampling was considered most suitable as respondents are selected with a purpose and, in most cases, it is to do with their knowledge of the topic under investigation. Purposive sampling strategy involves the researcher selecting the sample based on certain criteria (Babbie, 2010).

Baidoun (2004) recommends that developing a TQM implementation framework is best investigated by studying total quality organizations. However, he suggested when there is no authoritative database of TQM organizations (e.g. Saudi construction industry); the sample could include all ISO-9000 accredited companies as ISO 9000 series certification can be defined as the starting point for the ongoing journey towards TQM (Baidoun, 2004; Chittendenet *et al*,. 1999; van Der *et al.*, 1996; Quazi and Padibjo, 1997; Williams, 1997). ISO9001 certification indicates that these firms have achieved the basic level of TQM. ISO9001 certification is therefore, a very useful indicator of quality focus (Baidoun, 2004).

It can be argued that not all ISO9001 certified companies will have TQM focus and not all TQM focused companies will have ISO9001 certification. However, ISO9001 certification is the only verifiable certificate which provides a measure to identify quality focused organization. This will make sure that firms identified have some form of quality focus which improves the reliability of data. In addition, Oakland (2004) argues that many organizations may implement TQM routinely in their daily business although their leaders and quality managers are not aware of the TQM principles. Therefore, it is expected that what will be the outcome in the form of the answers of the survey questionnaire sheet about TQM practices will be based on practical experience of quality information and quality culture embedded in their organization.

(Egan, 1998) suggested that the entire industry would benefit from any process that makes construction sector performance more efficient and effective. Contractors are significant players in the performance of construction sector in any country. Thus, only contracting firms were selected for this survey. However; other stakeholders such as suppliers, subcontractors and clients are already included in the EFQM model under relevant sections. Contracting firms that are responsible for the whole project are thus a true representation of construction firms which represent the full complexity of construction industry. Furthermore, to ensure that there is consistency and heterogeneous among the sample in term of daily quality practices and common targeted goals, the targeted sample for this research focused solely on contracting firms.

A further filtering of the suitability was carried out based on the how long the firms have held ISO9001 certificates, especially important as TQM maturity is about continuous improvement. In this respect this research was aiming to look at firms continuously improving or at least sustaining the gains made in quality management over certain time period. For this purpose the firms which have held ISO9001 certificate for at least last three years were selected as sample for this research as they represented a sustained/improved commitment their quality management practices over time. Using ISO9001 certification as selection criteria allows the quality management levels within organizations to be benchmarked based on industry-accepted criteria. Only the companies which had their ISO9001 certificates valid at the time of the survey were considered for this survey as this was one of the qualifying criteria used to identify sample for this research. The Saudi Standards, Metrology and Quality Organization (SASO) and three quality consultants' offices were used to obtain the list of construction companies which were ISO9001 certified. Respondents were selected from ISO9001certified firms from the Saudi construction industry. In total a list of 62 companies were identified but after filtering only 43 companies were identified as suitable for this survey. Companies with less than three years' accreditation have been excluded.

After selection of the companies the next question was who should be the respondents from within the organizations selected. It was essential that people who were responding to the survey had strategic and operational level knowledge of quality management in their organizations. This included the Chief executive Officer (CEO), general managers, managing directors, quality managers and TQM managers. These were selected because these individuals are most likely to have the holistic knowledge of the quality management policies and practices in their organizations and can provide information based on facts/ experiences rather than on perception/ assumption. Multiple responses are collected from a single organization. Different informants from the same organization might have different opinion on the same issue due to the difference in their knowledge and perceptions (Kumar, Stern and Anderson, 1993). Therefore, each respondent is considered as an independent case for the further analysis. It is not known how many people received the survey from each firm and who responded as no personal information was collected due to confidentiality. The total number of expected responses was 172 at 4 responses per organization. However, only 93 responses were received. Out of these 6 were rejected for being incomplete or incorrect leaving 87 useful responses. This means that effective response rate was 51%.

5.5.4 **Administering the Questionnaires**

The researcher posted the survey online on googleforms.com. After obtaining the due consent from the HR managers in the organizations, the link to the survey was then sent to the HR managers along with the information sheets to be passed on to the target respondents. Every construction firms have been requested to fill four questionnaires. With target sample of 43 companies the total number of expected responses was, thus, 172 at the rate of four responses per firm.

For this research, Reading University's ethical guidelines for academic research were followed. Respondents were provided full and unbiased information about the research, voluntary participation and freedom to withdraw. Respondents were also informed that no compensation will be provided on their participation in the research. Further, permission was obtained from organization's HR managers seeking permission to conduct survey with their employees. Once the permission was granted the researcher sent an email to the HR managers containing the information sheet and survey link to be forwarded to the target employees within the organizations. Permission of all the participants was sought within the information sheet and respondents were advised to read the information sheet before the survey. Information sheet provided explained researcher's background, purpose of the research, purpose of survey as well as explanation of how survey data will be stored, and used. Anonymity of respondents was guaranteed.

5.5.5 Data Analysis of the first questionnaire survey

The research involved the following statistical tests:

- The first test conducted was a descriptive test which provided the mean and median of the responses along with the skewness.
- A Cronbach's alpha reliability test was used to make sure that the questionnaire was reliable and that there were no questions which were perfectly correlated. Cronbach's alpha figure of 0.7 to 0.95 was taken as acceptable values as per recommendations of Hair et al. (2007).
- Partial Least Squares (PLS) tests used to test the causal relationships among TQM enablers and organizational goals related to TQM.

5.6 Second questionnaire survey

The second stage of the data collection included a short questionnaire survey to identify the weight allocation for different enablers in the EFQM model. Past researches have used a standardised weight system, but the Saudi construction industry is different from mature construction industries in developed countries which were used as a basis to obtain the weights for different EFQM enablers. This means different enablers will have an impact on a firm's ability to achieve higher TQM maturity levels, depending on whether the firm is Saudi or non-Saudi. It was considered essential to obtain weights for EFQM enablers to represent the unique characteristics of the Saudi construction industry. This was done using a questionnaire survey and through Analytical Hierarchy Process analysis of the questionnaire data.

Six respondents shared their email addresses during the first survey while 23 sent an email to the researcher confirming that they are willing to participate in the additional survey. The same steps as in the first survey were followed to conduct the second survey. For AHP one of the key criteria is that the respondents should be experienced. For this reason, it was decided to survey only participants with more than 10 years' experience. Out of the 29 respondents who agreed to participate in the additional survey, 21 had of more than 10 years' experience. These 21 individuals were contacted through email. The email contained the survey in the form of a Word document which the users could download and complete. Out of the 21 who were contacted for the second survey, only 20 completed the survey. The 20 responses were downloaded and analysed using the Analytical Hierarchy Process technique to obtain the weights of different enablers.

5.6.1 **The Analytic Hierarchy Process (AHP)**

The Analytic Hierarchy Process (AHP) involves conducting a pairwise comparison of factors. It relies on expert judgment for deriving priority scales. AHP is used to pairwise rank factors, which cannot be otherwise measured; either because the information about these is not explicitly available or because the information is not measurable. The comparisons are made using a scale of absolute judgements that represents how much more; one element dominates another with respect to a given attribute. The judgements may be inconsistent, and how to measure inconsistency and improve the judgements, when possible to obtain better consistency is a concern of the AHP. The derived priority scales are synthesised by multiplying them by the priority of their parent nodes and adding for all such nodes" (Saaty, 2008: 83).

There are many subjective weighting methods are used for ranking and assessments. The most common methods are Delphi and AHP. However, research suggests that AHP is flexible, simple and it can be used with quantitative and qualitative approaches (Forman *et al.*, 2001; Ho, 2008). In addition, AHP is commonly time and cost -effective when compared to the Delphi method (Yang *et al.*, 2010).

5.7 System dynamic analysis

Jay Forrester formulated System dynamics in 1960s. According to Forrester, complex system with multiple variables influencing outcomes is difficult for humans to analyse and interpret (Forrester, 1980). According to him people tend to adopt selective approach when dealing with complex systems, focusing on a selected few numbers of factors while ignoring a number of other factors. This approach may lead to simple and implementable policies but the problem is that such policies may not lead to desirable outcomes, or may even be counterproductive. For example, a firm may decide to lower costs in order to beat competition but this may deteriorate the quality image and may shrink the profit margins to levels that the firm collapses. Forrester introduced the system dynamics methodology to help improve decision making and policy formation. Policy maker can analyze complex systems by accommodating all relevant causal relationships, time delays and feedback loops which may be contributing to uncertainty within the system.

System dynamic modelling (SDM) captures the dynamic relationship between factors and, using simulation scenarios, can see how the system evolves over a time (Khanna *et al.* 2004). SDM begins with defining problems dynamically, proceeds through mapping and modelling stages, to steps for building confidence in the model and its policy implications. The basic structure of a formal system dynamics computer simulation model is a system of coupled, nonlinear, first-order differential (or integral) equations. Simulation of such systems is easily accomplished by partitioning simulated time into discrete intervals of length (*dt*) and stepping the system through time one *dt* at a time" (System Dynamics Organization, 2017). SDM is particularly useful because it takes into consideration the feedback loops which make the system dynamic (Mohamed and Chinda, 2011). This allows modelling of dynamic interactions between variables which can eventually lead to a change in the state of the system (Rodrigues and Bowers, 1996).

There are several techniques for analysing system such as Process modelling (Aguilar-Saven, 2004), Functional modelling, and Enterprise modelling (Whitten *et al*. 2006). These techniques differ in their scale, complexity and purpose. System Dynamic Modelling is useful because it looks at the system holistically including all its components, their relationships and system evolution over time (Cosenz and Noto, 2016). As Conti (2010) argued, for TQM implementation it is essential to see the organisation as a socio-cultural system. SDM is useful in modelling socio-cultural systems, which have certain degree of unpredictability. In this respect SDM is a useful technique to use computer-based simulation to model a real life evolutionary system.

In the case of quality management, there are several interconnected factors contributing to system improvement and this dynamic relationship of factors can be captured through system dynamic simulation. Simulation is essential because it is not possible to collect accurate information regarding evolution of a system over a long-time period. Simulation allows projection into future. Using simulation, it is possible to see how variation in the starting state and other variables will lead to future development of the system. This can help the decision-makers in deciding what they need to do to achieve desirable results with the system. Sterman (2000) recommended the following five steps in SDM:

- Problem articulation
- Formulating dynamic hypothesis
- Formulating a simulation model
- Testing the system
- Policy design and evaluation

These steps have been followed to develop an effective and useful system dynamic simulation model as described below.

Step 1: Problem articulation

This research began with a critical review of the existing literature which identified several gaps. Firstly, most of the research has been focused on the adoption of TQM, thereby treating it as static process. On the other hand, several researchers argue this is one of the greatest mistakes of quality management research. They recommend looking at it as a dynamic process, taking into consideration the dynamic interaction of TQM enablers over time. For example, one of the key aspects of TQM is developing a quality-focused culture within the organization using an iterative process. In addition to this, there is a lack of research on use of dynamic modelling in TQM in a construction industry context. The system thinking approach is critical to achieving TQM as it requires the consideration of the system as a whole in which any improvements can only be achieved through improvement in all its components.

In this respect, the interactions of the components of the system need to be considered to see how these interact to influence the state of the system. For example, human resources and organizational quality policies are two different components of a system but quality policies are implemented by employees and thus, the effectiveness of policies depends not only on the policies themselves but also on how well these are implemented by people. In this respect, there is a dynamic interaction between the two which affects the overall state of the system. Such system thinking is critical for TQM because unless each and every component of the system is quality-focused it is impossible to achieve TQM. The ultimate purpose of SDM in this research was to identify the policy decisions that will help Saudi construction firms achieve higher TQM maturity levels as well as TQM-related goals.

Step 2: Formulating dynamic hypothesis

The system was formulated based on the EFQM model outlined in chapter 3. All the significant relationships captured by the assumption built on the EFQM model. The EFQM model is based on the view that excellent results with respect to Performance, Customers, People and Society are achieved through Leadership driving Policy and Strategy, People, Partnership and Resources, and Processes (Dale *et al.,* 2007).The relationship between different TQM enablers and goals in EFQM framework were tested using a Partial Least Squares (PLS) regression method to see the causal link between different enablers and TQM-related goals. Based on this the SDM was formulated reflecting the relationship between different TQM enablers and goals.

Step 3: Formulating a simulation model

To formulate a simulation model representing a real-world scenario it is essential to look at both the structure and behaviour of the system (Khanna *et al.* 2003). In modelling applications, the structure and behaviour of a system can be formulated by two diagrams namely the causal loop diagrams and stock/flow diagrams. There are many System Dynamics Modelling softwares available in the market such as Stella, ithink and Vensim. Vensim and most other dynamic modelling software allow the time period for simulation including the time lapses to be specified. Vensim has been used because of the simplicity in its use of a graphical interface.

Causal loop diagrams

The causal loop diagrams include multiple feedback loops. It allows the modeller to understand and conceptualized the real world system in terms of feedback loops (Khanna *et al.* 2003). The causal can comprise many elements including variables, relationships etc. It shows clearly the direction and type of causality among variables. For example, an arrow heading from A to B will indicate that an increase in A is (positively (+) or negatively (-)) affecting B. The positive and negative signs in the model indicate whether the rise in causing variable will cause a positive or negative change in the affected variable (Khanna *et al.* 2003). Figure (5-4) illustrates an example of a causal loop diagram.

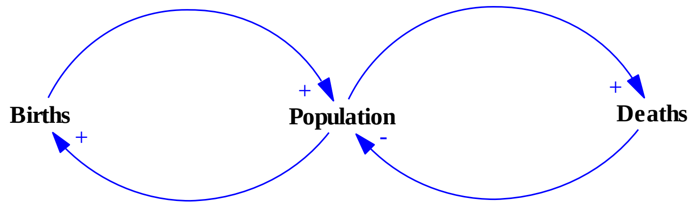


Figure 5-4: An example of a causal loop diagram

From the example, causal loop diagrams represent Increased births will lead to a rise in population size (+). Increased population size will lead to a rise in births (+). Increased population size will lead to a rise in deaths (+). However, increase in death will lead to decease in population size (-). This shows that how different factors may affect population size.

Figure 5-5 shows a sample causal loop for this research. Sine this research assume leadership is the main drives all enablers (based on EFQM model), the loop shows that management commitment is likely to boost qualify-focused strategy, which may improve both empowerment and involvement of people in quality management. Improved involvement in quality management may lead to increasing on quality-based qualification of partners which may positively affect performance measurement. Improved performance measurement might reduce costs. However, increased in cost is likely to decrease management commitment leading to the start of another loop.

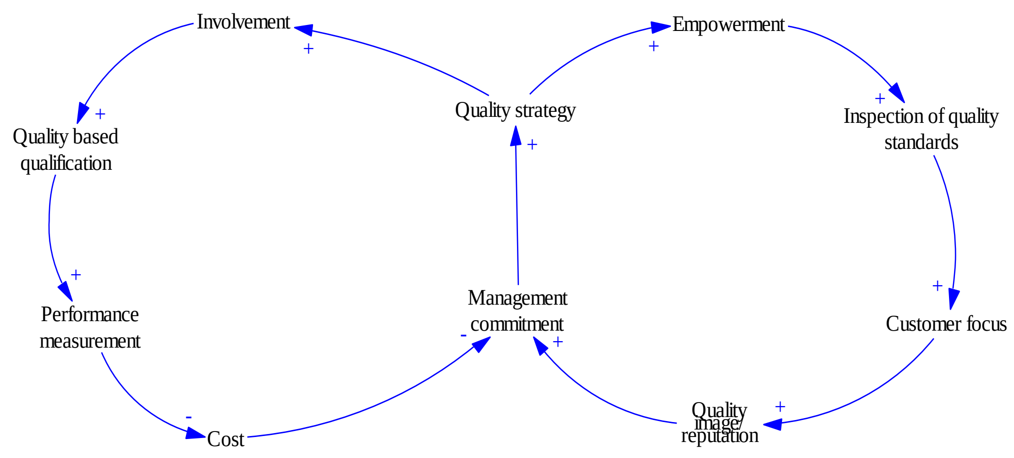


Figure 5-5: A sample causal loop for this research

Similarly, empowerment of employees might improve inspection of quality standards which can help improve customer focus. Improved customer focus is expected to boost the reputation of the image and improved reputation will further enhance management commitment towards quality management.

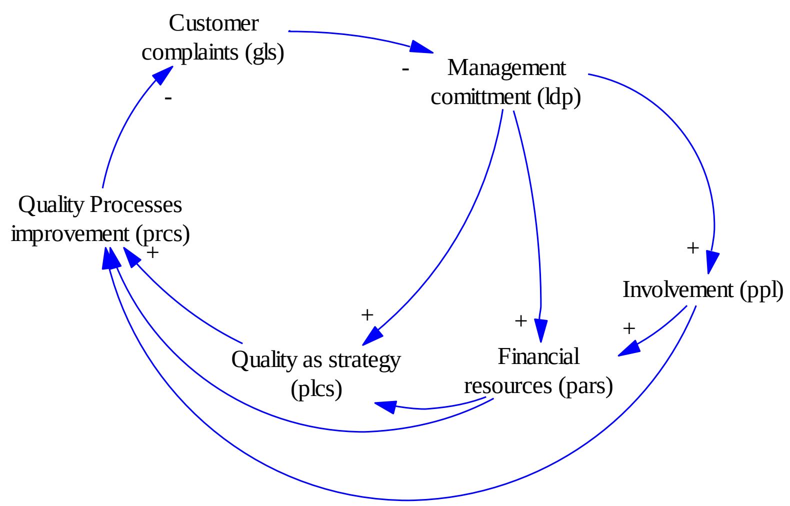


Figure 5-6**:** interaction between the five TQM enablers and goals (Causal loop diagram)

Figure 5-6 further explains the interaction between the five TQM enablers and goals using a causal loop diagram. The figure shows how Management Commitment (ldp) acts as a driver of other enablers; for example, it affects Involvement (ppl). Increased involvement of people will increase the need for resources especially financial Resources (pars).

Increased investment financial resources will strengthen Quality as Strategy (plcs). These three combined will affect Quality Process Improvements (prcs) which will then lead to reduction in Customer Complaints (gls) indicated by a negative relationship. However, an increase in Customer Complaints (gls) will lead to an inverse impact on Leadership as Management Commitment towards quality management will be boosted as managers realise the benefits that quality management is providing to the organization, and vice versa.

All the significant relationships captured by the assumption based on the EFQM model were used in developing the causal loop diagram (Figure 5-7). This figure shows the causal loop diagram of TQM maturity index used for this research. The causal loop in the model consists of seven key elements categorized as five enablers, goals and TQM index. As shown in the figure, the five enablers increase the overall enabler score. The Goals score and the enablers score are added together to get the TQM index score.

In order to achieve higher maturity level firms need to maximise the TQM index by improving the performance of both (the score of enablers and goals). With this improvement, the TQM index gap (i.e. the difference between the desired value of TQM index score which is 1000 and the actual TQM index score) will decrease until it reaches zero. The total value of the system is 1000 points out of which 500 are allocated to goals and 500 are distributed among the five enablers. Enables score is the sum of score of the five enablers namely leadership (*ldp*), people (*ppl*), partnership and resources (*pars*), policies and strategy (*plcs*), and processes (*prcs*). As shown in the following equation:

Enablers score = Σ (*ldp* score + *ppl* score + *pars* score+ *plcs* score + *prcs* score) [5.1]

Goals score can be a maximum of 500 points. The total TQM index score is the sum of enablers score and goals scores as follows:

TQM index score = Enablers score + *Goals score* (At time *t*) [5.2]

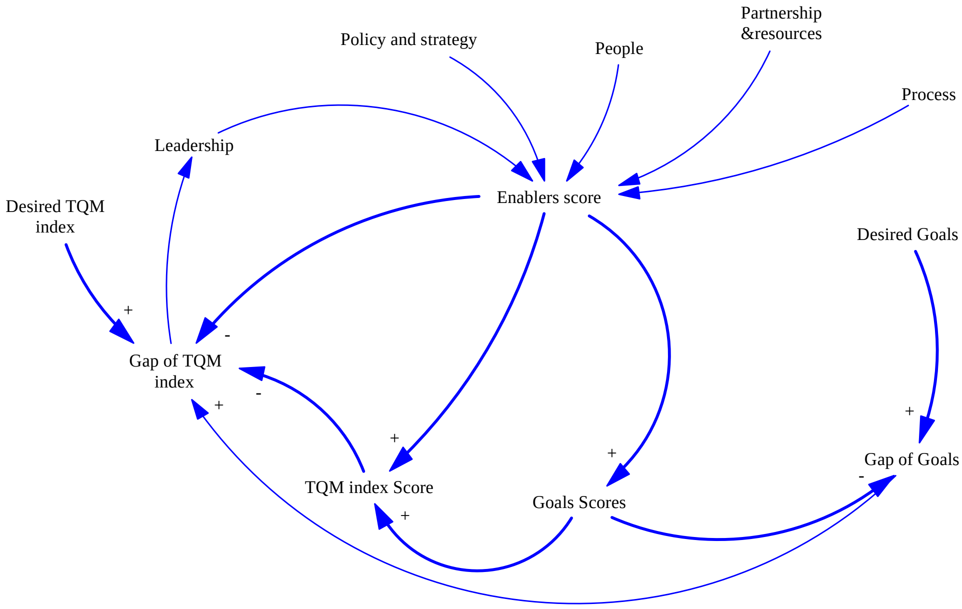


Figure 5-7: A causal loop diagram of TQM maturity index

The Desired Goal Score is set at 500. This is the highest level which an organization will achieve when it has completely met all its goals. Similarly, the Desire Value is set for each enabler in the dynamics model; it is equal to the values generated by the AHP process. These values represent the maximum contribution that particular enabler can make to TQM index score.

Any gap in enablers' values is the difference between the desired value and the actual value at time (t). For example, for leadership score

Leadership score gap = desired leadership score – actual leadership score [5.3]

The Desired TQM index score is 1000 (Maximum score in EFQM). However, it is divided in five categories which indicate the different stages of TQM maturity level (see Table 3.2). These five levels are (1st level 0-200), (2nd level 201-400), (3rd level 401-600), (4th level 601-800) and (5th level 801-1000). For example, if the TQM Index Score at time (t) is 300, that means the firms at the 2nd level of TQM implementation level.

Enablers directly affect the TQM index and goals scores, which leads to a reduction in the goals gap. For example, quality as a strategy will lead to improvement in quality image/reputation and both these will affect the TQM maturity index. The value of enabler or goals has an inverse relationship with the gap because the desired value for each of the enabler and goals are predetermined and remain constant. The weight of each of the enablers depends on the impact it has on the TQM index score. This depends on the country context; for example, in high power distance societies the leaders have more control over outcomes and hence the leadership construct will have a higher weight as compared to countries with a low power distance index which indicates lower leadership impact on outcomes.

Stock and flow

Stock and flow is the heart and soul of the system dynamic model. It aims to quantify different variables and their effects on each other. Once the feedback loops have been identified, the stock and flow diagram can be generated with the help of Vensim (PLE) software. Figure 5-8 shows the key components of the stock and flow diagram in TQM index dynamic model in Vensim software. In system dynamics modelling, dynamic behaviour is assumed to arise due to the Principle of Accumulation. More precisely, this principle states that all dynamic behaviour in the world occurs when ***flows*** accumulate in ***stock*** (System Dynamics Organization, 2017). Many variables influence the rate of flow in the system such as decision factors and decision points and the interrelationships among level variables (Khanna, 2003; Mohamed and Chinda, 2011). The linear relations between these variables was determined based on the researcher's own perception of the TQM maturity model based on the assumption of EFQM model and based on the learning from other studies conducted on System Dynamics modelling. Next, the causal loop diagrams and the linear relationships between these variables are converted into a mathematical model using vensim software (see Section 7.2).

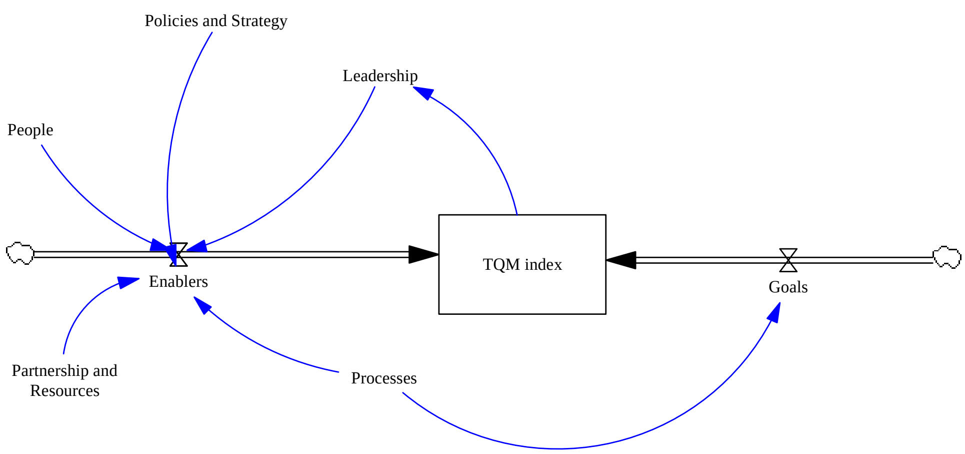


Figure 5-8: stock and flow diagram of TQM Index

TQM index represents the stock of the main dynamics model. While, there are two flows accumulated in this stock namely enablers and goals. Enablers (leadership, people, partnership and resources, policies and strategy, and processes) and goals all are represented by stock and flow diagrams. Further explanation of stock and rate of these variables, decision factors and decision points and the interrelationships among level variable will be in Chapter 7. Also, it will includes encapsulating the rate of changes with complex interactions and to represent the dynamics of the systems, further system dynamic equations have been generated.

Step 4: Testing the system

This study utilised a system dynamic modelling program known as Vensim for converting the causal loop diagrams into stock and flow diagrams. The model is tested in the base run, which here represents an organization which is at the beginning of their TQM journey i.e. the organization with the value of all its enablers equal to zero. This dynamic model was then simulated and different graphs were obtained to explain the findings of the modelling exercise. In order to analyse the behaviour of the model, it was simulated over a 20-year period to see the progression of firm. The change in firms’ TQM index scores was observed over that period to see how the dynamic interaction of the enablers will lead to changes in the TQM index and goals scores.

Behavioural sensitivity analysis also aims to test the robustness of the model, by confirming that the estimating errors and the uncertainties do not significantly affect the overall behaviour of the model (Forrester and Senge, 1980). When a parameter or behavioural relationship is altered and its behaviour does not change drastically, the model is considered robust (Tang and Ogunlana, 2003). In behavioural sensitivity analysis, the values of different parameters were altered to see how the changes in different parameters will affect the overall trend in the TQM index score.

Policy testing of the model was carried out to see the impact of policy decisions on the TQM index score of firms. Using the findings from the literature review, the researcher attempted to understand the behaviour of the SDM to different enablers. How and why the relevance of different enablers can have different impact on the TQM index score and therefore, on firm’s ability to achieve higher TQM maturity levels was discussed.

Step 5: Policy design and evaluation

Policy design here refers to the kind of TQM-related decisions that the decision-makers need to make in order to achieve the desired TQM-related goals. The impact of different policy decisions was tested using system dynamic modelling to evaluate which policy decisions will be most effective. Policy testing analysis was carried out using case studies. Two different organizations (characterised by different initial enablers and goals score) were selected as case studies. Most of the responses (almost 80%) on the survey were from companies which are in second and third level TQM maturity levels (see section 6.4). This indicates that firms in second and third TQM maturity levels may be best representative of the ISO9001 firms. Hence, two case studies were selected from these two levels. Case A was selected randomly from the firms in 2nd TQM level and case B was selected randomly from firms in 3rd TQM level. To confirm that the two set of responses do not represent the same organisation from perspective of two separate respondents due to anonymity of respondents, the profiles of the organisations were checked. This confirmed that the profiles represented two different companies.

Following this, the impact of changes in initial values and invested efforts in different enablers on the TQM index score of the organizations were discussed. This was followed by a discussion on the practical implications of the findings which involved discussing how firms can improve their progression towards higher TQM levels in practice. It was discussed how firms can work on different enablers and what kind of policies they can adopt to speed up their progression towards higher TQM maturity levels.

5.8 Chapter Summary

This chapter presented the research methods and approaches adopted for this research and the reason for adoption of a particular research method. This research is based on the assumption that it is possible to identify particular policy interventions which will help Saudi construction firms to speed up their attainment of higher TQM maturity level .This research involves firstly identifying the causal relationship between enablers and goals. Quantitative methodology was considered suitable due to its usefulness in identifying causality among variables. Identifying this causality is essential in order to build the system dynamic model and in order to identify which policies will be most useful in achieving higher TQM maturity levels. The data collection method for this research involves self-reported questionnaires which were administered online. The administration of questionnaire surveys was carried out following several steps as discussed in this chapter. The sampling strategy adopted for this research is purposive sampling. Firstly only ISO9001-certified Saudi construction contractors who hold a valid ISO9001 certificates for than three years were included in the sample. This is selected because it shows their commitment to improving quality in their organization which is a prerequisite for TQM implementation. Furthermore, only the senior managers and other quality-related professionals who are aware of the quality-related issues were selected for the questionnaire survey. Finally the system dynamic model and the steps followed to build the model were presented. An overview was given of the steps followed to build the feedback loops, stock and flow which act as composite blocks of the system dynamic model.

Chapter 6 : DATA ANALYSIS

6.1 Overview

This chapter is aimed at building the TQM maturity model which will be used to evaluate how firms can progress towards higher TQM maturity levels. This chapter presents the analysis of the questionnaire survey data. It contains details of the sample as well as the details of preliminary analysis of the data. Data were tested for missing values, outliers and normality of the data was also checked. This was followed by a reliability analysis of the data. To examine the causal relationships between the six constructs (five *enablers* and *Goals*), a Partial Least Squares (PLS) method was used. Finally, the last section estimates the EFQM enabler weights as calculated from the empirical data from the Saudi construction industry. This was achieved through conducting a structured questionnaire survey among selected senior managers and quality management representatives in Saudi construction firms; and analysing the questionnaire results using the Analytic Hierarchy Process (AHP).

6.2 Questionnaire: Sampling

The Saudi Standards, Metrology and Quality Organization (SASO) and three quality consultants' offices were used to obtain a list of construction companies, which were ISO9001 certified. Only the companies, which had a valid ISO9001 certificate at the time of the survey (and had held certification for the last three years) were considered. ISO9001 is used as a proxy for organizations which focus on quality (Baidoun, 2004) and an indicator for purposeful sampling. After filtering, 43 companies were identified as suitable for this survey. It was essential that people who were selected for the survey had strategic and operational level knowledge of quality management in their organizations. The sample included the CEO, general managers, managing directors, quality managers and TQM managers as they were are most likely to have a holistic knowledge of their organizations 'quality management policies. The questionnaire survey was conducted online using googleforms. The total number of expected responses was 172 at four responses per organization. However, only 93 responses were received. Out of these 6 were rejected for being incomplete or incorrect leaving 87 useful responses. This means that effective response rate was 51%.

Figure 6-1: Distribution of survey respondents by their position

Figure 6.1 shows the distribution of respondents by position, with 55% of the respondents being quality/TQM managers, 16% CEO/General Managers and 15% were Managing Directors. Having a high proportion of quality managers is understandable; it is very likely that the questionnaire would have been forwarded to them. The most interesting aspect of the respondents' profile is their knowledge of quality management and TQM which will help in improving the quality of the findings. However, other professionals also add value to the findings; they present a different perspective on the issues. For example, quality managers may indicate that their organization considers quality as the most critical actor in success, other respondents may believe that cost, or reputation or something else might be the most critical factor. Individual's different perspectives, especially senior managers, may also indicate a lack of clarity on what quality is which could flag up likely problems in improving quality. Getting a diversified opinion is useful to identify if such issues exist.

Figure 6-2 shows the distributions of the number of years they had worked for the organization.

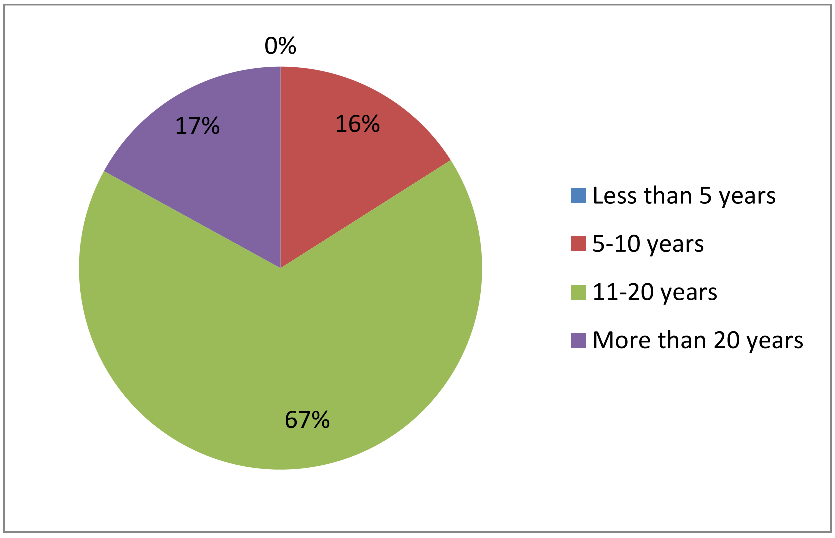


Figure 6-2: Distribution of respondents by their tenure with current organization

17% worked more than 20 years in their organization.67% worked for their employer for between 10 to 20 years, 16% worked less than 10 years. None worked less than five years in their organization. Knowledge and understanding about an organization's quality management policies and practices will improve with length of service in the organization.

Three questions were aimed at giving a profile of the organization. Size was measured by number of full time employees working in the organization. Figure 6-3 shows the distribution of responses:

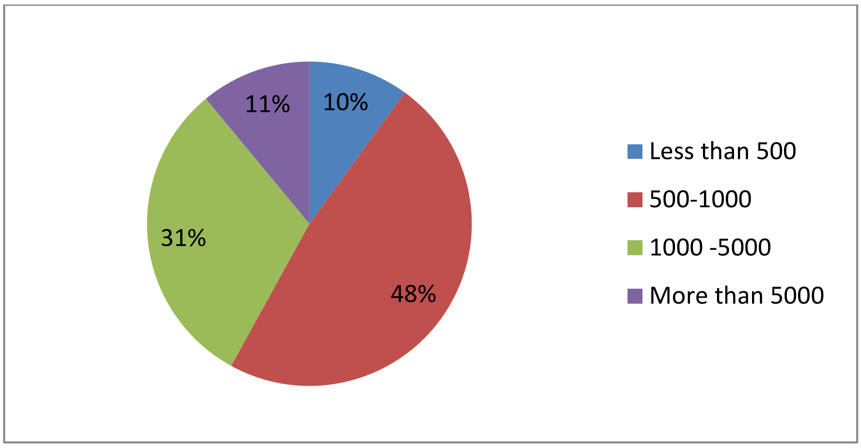


Figure 6-3: Distribution of respondents by size of their organization (number of employees)

10% of the respondents were from small firms (employees less than 500) and 11% from large organizations (employees more than 5,000). 48% were from organizations with between 501-1000 employees and 31% from organizations with 1001-5000 employees. Many Saudi construction firms employ more than these numbers, but the research focused only on full-time employees. Full-time employees in Saudi construction firms are at the managerial level, with other employees such as supervisors and labourers working as temporary employees. There are many large scale firms (in terms of number of permanent employees) in the Saudi construction industry. With few small scale organizations being ISO9000 certified, the sample is an acceptable representation of ISO9000 certified Saudi construction firms.

The second question was the number of years the organization has existed.

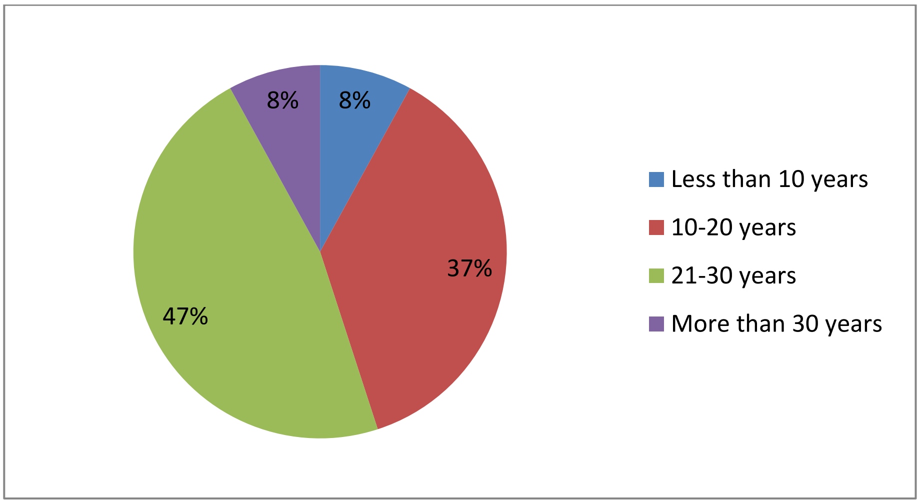


Figure 6-4: Distribution of respondents by years of the organization's existence

Figure 6-4 shows 8% of the organizations are under 10 years old, all the organizations are medium and small-scale firms, with less than 500 employees. 37% of the respondents were from firms between 10-20 years old, and 47% between 20-40 years old. 55% of the responses were from organizations, which have existed over 20 years. This is considered representative of the ISO9000-certified target population. There are few large long established Saudi construction firms. These organizations face more quality issues but are also more capable in terms of resources, capabilities and equity at stake in terms of quality management

The respondents were asked about the main project types that their organization undertakes. Figure 6-5 shows the distribution of responses:

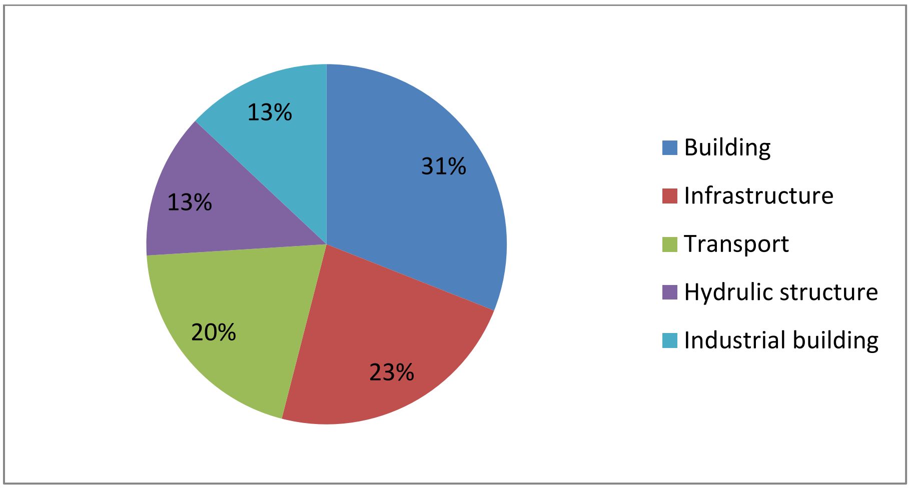


Figure 6-5: Distribution of respondents by project type

Most respondents (31%) were from organizations that undertake building work, while 23% deal with infrastructure projects. 20% respondents were from firms working on transport projects and 13% respondents from firms dealing with hydraulic structure projects and industrial building projects.

Respondents ranked five factors in descending order to describe their perception of quality of project outcomes for their organization. The responses are summarised in Table 6-1.

Table 6-1: Frequency test analysis of responses

Factor (Score)	Least accurate (1)	Not accurate (2)	Neutral (3)	Accurate (4)	Most accurate (5)
Exceeding customer expectations	0	0	14	35	38
Provide best value for money	0	10	20	24	33
Conform to specifications	11	15	28	17	16
Visual appearance	20	41	15	11	0
Cost minimisation	53	21	10	3	0

84% of the respondents agreed that “exceeding customer expectations” is the most relevant measure of quality of project outcomes. The definition of quality is driven by customer expectations for the firms. Most of the TQM frameworks such as MBNQA and AQA are based on the view that customer satisfaction is the primary goal of any quality management programme. However, in EFQM, customer satisfaction is only one of the many goals of TQM. Many of these goals, such as ‘building quality reputation’ are linked with customer satisfaction. Other goals are linked to wider stakeholder satisfaction, which involves both internal and external stakeholders. “Provide best value for money” was ranked second, with 65% of respondents agreeing while further 23% of respondents registered neutral responses. Most respondents selected options ‘accurate’ and ‘most accurate’ to this factor as being the best describer of the terms “quality” were from firms dealing in infrastructure or transport projects. This is understandable because many projects procured by public sector organizations focus on value for money. Cost was highlighted as one of the key barriers in the implementation of quality management; it incurs higher costs in the short-term with gains only appearing in the long-term.

Conforming to specifications was the third most significant factor that describes quality in organizations. Most construction firms work through a bidding/tender process where there is a low profit margin. This makes it difficult to exceed customer expectations because of tight cost constraints. Under the ‘conform to specifications’ factor, 38% of respondents registered affirmative responses, 32% registered neutral responses, while 30% disagreed that is an accurate measure of quality of project outcomes. The wider distribution of responses to the “conform to specifications” indicate that this is what the respondents believe to be the bare minimum in order to maintain high quality standards.

70% of respondents disagreed that ‘Visual appearance’ is an accurate measure of quality of project outcomes. Visual appearance is often decided by the client, the best the construction firm can do is to ensure that it meets the client’s specifications. Visual appearance is not solely in the hands of the construction firm; for example, a client’s perception and preferences may have changed over time leading to poor perception of visual appearance of the project, despite the contractor doing their best to meet client expectations. Respondents (85%) disagreed that “cost minimisation” is an accurate measure of quality of project. The responses indicate that exceeding customer expectations is the key criteria for quality i.e. quality are assessed on the basis of the client’s perception. Quality can be influencing the firm’s reputation indicating a long-term relationship between strategy and quality. This result showed that cost minimisation may be in contrast to quality improvement; cost reduction can be the long-term outcome of quality improvement, but in the short-term, quality improvement is likely to incur higher costs.

Respondents were asked about the most critical project success criteria for their organization. Table 6-2 gives a summary of the responses.

Table 6-2: Project success criteria- frequency of responses

Factor (Score)	Least critical (1)	Not critical (2)	Neutral (3)	Critical (4)	Most Critical (5)
Time compliance	43	23	21	0	0
Cost compliance	33	33	10	11	0
Quality compliance	0	0	11	44	32
Customer satisfaction	0	0	0	32	55
Safety performance (incidents of safety)	11	31	45	0	0

All respondents agreed that customer satisfaction was the most critical project success criteria, with 87% of respondents suggesting it is the 'critical' or 'most critical' project success criteria. The primary focus of the respondents' organizations is on satisfying client specifications and ensuring that everything within the scope of the project has been met. This is in line with previous responses, which indicate that the project success is driven by customer expectations. Quality is the second most critical project success criteria, firms realise that there are limitations to how they can pursue quality; it cannot be pursued at the expense of profitability. Customers may not wish to pay more even if the quality is superior; sometimes there can be a trade of between quality and other goals. In many cases there are budget constraints, which make it difficult for the construction firms to pursue the highest quality level; in such cases priority are generally given to meeting customer satisfaction rather than pursuing a quality agenda.

Safety and health is a key project success criterion, but the largely neutral responses indicate that the firms consider it as a bare minimum requirement, rather than a value-adding goal. Maintaining high safety standards is paramount, but does not necessarily contribute to client satisfaction, or a firm's profitability. Time compliance (i.e. completing project within time) was the least critical goal of the project followed by cost compliance (i.e. completing project within budget). This is surprising because the literature shows that time and budget overruns are the most critical concerns of the construction industry. One of the explanations for this anomaly is that this research is about quality and the respondents were considering their responses in the context of quality. Since focus on cost and timing can affect the quality, this could be one of the reasons why respondents provided the responses. In most construction projects, especially large-scale construction projects, time overruns have become common. As long as it does not affect the overall cost, customers in Saudi Arabia have become immune to time risk, this could be one of the reasons why time was rated as the least important project success criteria.

The respondents were asked about their perception of level of TQM implementation in their organization.

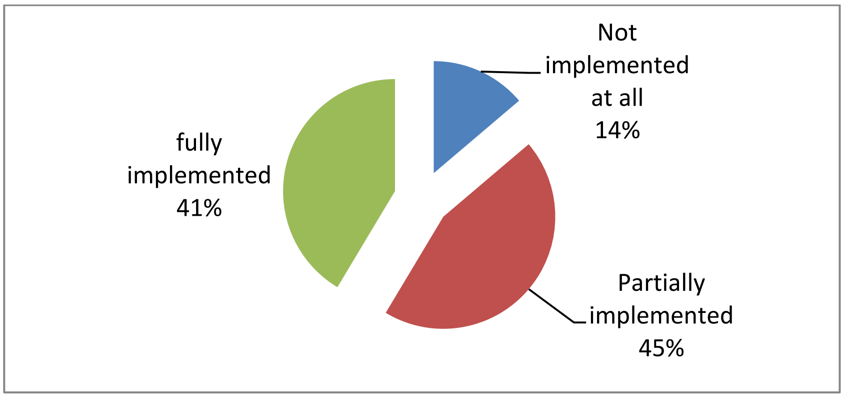


Figure 6-6: Level of TQM implementation in their organization

The sample for this research was selected based on their ISO9001 certification but the research is focused on TQM, hence respondents were asked whether their organization have implemented TQM. The responses shown in the pie chart above indicates that 86% of the respondents were for organizations which have fully or partially implemented TQM. This means that the sample was adequate for this research which focuses on implementation of TQM. The respondents were asked about the average of budget spending by the organization on improving quality management in their organization. The responses ranged from 7% to 13%. The average of the responses was taken, found to be 11% per year.

6.3 TQM scores and levels

The TQM score is the accumulation of Enablers' scores and Goals' score obtained from the respondents. The results classified in five levels of TQM base on obtained scores of each respondent. Level and scores were proposed in chapter three (see Sec. 3.4).

Table 6-3: Distribution of TQM score and levels

Levels	TQM Score	No.	Percentage (%)
1st	0-200	6	6.9
2nd	201-400	37	42.5
3rd	401-600	32	36.8
4th	601-800	8	9.2
5th	801-1000	4	4.6
	Total	87	100

Table 6-3 shows the distribution of respondents by the TQM levels of the organizations. The table indicates that most of the respondents were from organizations which are in the second and third TQM levels. It can be explained on the basis that the firms selected for data collection are all ISO9001 certified companies and are thus expected to have stronger quality focus. Even though they may not be explicitly implementing TQM but because of some overlap on quality principles of earlier levels of TQM and ISO9001 certification, firms following ISO9001 certification are expected to automatically achieve reasonable levels of TQM. Very few responses were from firms which have achieved fourth and fifth TQM levels indicating that ISO9001 will merely help in achieving initial levels of TQM but to achieve higher levels of TQM a different TQM focussed strategy is required.

6.4 Data screening and preliminary analysis

Data from the questionnaire and responses was codified, a preliminary analysis was undertaken. This included checking for missing values and outliers. In addition, the data were checked for normality. All these tests and their results are discussed in the subsections below.

6.4.1 **Handling Missing Data**

Questionnaire data are vulnerable to missing data; many respondents may not understand the question or may be unsure of how to respond. A high percentage of missing responses for any question indicates that the respondents either could not understand the question, or felt it unreasonable to answer. Missing values can cause distortion in the results (Hair *et al.*, 2007). One of the common strategies adopted in quantitative research is to remove the responses containing missing values. However, the sample size was small, to lose more precious responses by simply eliminating them. What was critical was to check for patterns in missing responses because such patterns indicate some serious issues with the formation of the questionnaire (Tabachnick and Fidell, 2007).

Table 6-4 Missing responses analysis

Variable		Total answers	Missing answers	% missing answers
Leadership				
LD1	Management commitment	93	0	0.0%
LD2	Clear vision	93	0	0.0%
LD3	Communication	91	2	2.2%
LD4	Auditing	93	0	0.0%
LD5	Role model	92	1	1.1%
LD6	Continues development	93	0	0.0%
Policy and Strategy				
PS1	Quality vision	92	1	1.1%
PS2	Reviewing and upgrade policy	93	0	0.0%
PS3	Quality as strategy	93	0	0.0%
PS4	Priority of quality	93	0	0.0%
PS5	Customer satisfaction strategy	91	2	2.2%
People				
PL1	Empowerment	89	4	4.5%
PL2	Involvement	92	1	1.1%
PL3	Training	93	0	0.0%
PL4	Accessibility to Information	93	0	0.0%
PL5	Cross-functional team	93	0	0.0%
PL6	Feedback survey	89	4	4.5%
PL7	Rewards and recognition	92	1	1.1%
Partnership and resources				
PR1	Quality-based classification	93	0	0.0%
PR2	Inspection of quality standards	93	0	0.0%
PR3	Financial resources	89	4	4.5%
PR4	Skilled human resources	93	0	0.0%
PR5	Material and equipment	93	0	0.0%
Processes				
PC1	Processes improvement	92	1	1.1%
PC2	Customer focus	91	2	2.2%
CF3	Performance measurement	91	2	2.2%
PC4	Benchmarking	93	0	0.0%
PC5	Innovation and creativity	89	4	4.5%
PC6	Quality tools	89	4	4.5%
PC7	Dissemination of quality improvement	93	0	0.0%
Goals				
GL1	Construction time	89	4	4.5%
GL2	Construction cost	93	0	0.0%
GL3	Defects and rework	93	0	0.0%
GL4	Safety in job site	92	1	1.1%
GL5	Customer satisfaction	91	2	2.2%
GL6	Customer complaints	89	4	4.5%
GL7	Employee satisfaction	89	4	4.5%
GL8	Useful suggestions	89	4	4.5%
GL9	Quality image/ reputation	91	2	2.2%
GL10	Market share	93	0	0.0%
GL11	Competitiveness	93	0	0.0%
GL12	Profits	92	1	1.1%

Missing values were not clustered around a particular question or respondent, which means that it was of less concern. Of the 93 responses received, 5 were found with more than 5% missing values and were eliminated as recommended by Tabachnick and Fidell (2007). The remaining missing responses were replaced by the maximum likelihood estimation method using SPSS. Maximum Likelihood Estimation method utilises all available data observed for each case to compute the maximum likelihood estimate of a parameter. While using regression analysis in SPSS there is a check box to confirm whether the system should use Maximum Likelihood Estimates for the missing values.

6.4.2 **Test of Normality**

This research involves identifying the causal relationship between variables using regression analysis. One of the key requirements for a regression model is that the data should be normally distributed. It was thus essential to check the normality of the data (Tabachnick and Fidell, 2007). Skewness and kurtosis are two methods to check for normality of data. The closer the kurtosis and skewness values are to zero the better is the distribution of the variable (Pallant, 2005).

Morgan and Griego (1998) recommend that as long as the values of statistics values/ standard error are not above 5.5, the distribution can be considered as normal. Curran *et al.* (1996) suggests that, for normalized distribution skewness, should be less than 2 and kurtosis should be less than 7. The skewness and kurtosis values as well as the values of (statistics values/ standard error) are given in Appendix 6. According to the results all the variables are normally distributed.

6.4.3 **Outliers Test**

For a Likert scale of 5, outlier values are values lying outside the mean ± 2. On inspection of data, 5 outliers were found, but 4 were by a single respondent. It was found that that particular respondent had marked the same response for all the questions, and deleted for the final dataset. One of the remaining outliers was replaced by the mean value of the remaining responses. The total number of remaining responses was 87.

6.4.4 **Scale Reliability (Cronbach's Alpha)**

Cronbach's alpha value indicates whether or not the questionnaire is reliable. Researchers argue that a Cronbach's alpha value between 0.7 and 0.95 indicates structural reliability of the questionnaire (Hair *et al.* 2007; Lance, Butts and Michels, 2006). Table 6-5 shows the test results.

Table 6-5: Scale reliability (Cronbach's alpha)

Scale	No. of items	Reliability (α)
Leadership	6	0.862
Policy and strategy	5	0.811
People	7	0.776
Partnerships and resources	5	0.894
Processes	7	0.815
Goals	12	0.875

The results indicate that Cronbach's alpha value for all the variables lies within the permissible limit of 0.7 and 0.95.

6.5 Partial Least Square analysis

The measurement model has been established and in order to determine the causal relationship between variables regression modelling is essential. Regression models help in estimating the path coefficients i.e significance and nature/ direction of causal relationships. Several regression modelling techniques are available and are used based on relevance to the data. For example, PLS regression modelling technique is useful in cases of small sample size.

To confirm the construct validity, and to examine the causal relationships between the six constructs (five enablers and Goals), the Partial Least Squares (PLS) method was used. PLS modelling is a regression modelling technique involving identifying cause-effect relationships among variables (Gudergan *et al.* 2008). PLS provides flexibility in estimating the path coefficient, especially in terms of sample size as compared to structural equation modelling (SEM), which is covariance-based approach (Hair *et al.* 2013). The sample size for the covariance based approach should be more than both the following criteria:

- 10* The number of indicators of the scale with the largest number of formative indicators ;
- 10*the largest number of structural paths directed at a particular construct in the inner path model.

The sample size of 87 is not sufficiently large for the covariance based approach, hence PLS was considered the most suitable process (Henseler and Chin, 2010). The significance of path coefficients is used to test the model in the PLS approach, while the structural modelling technique uses fit indices.

Hair *et al.* (2013) suggest that the certain conditions should be met in order to confirm that the model is a good fit: the feasibility of the parameter estimates; parameter estimates should be statistically significant; the goodness of the fit should be adequate. Only when these conditions are met should the model be considered as a good fit.

Parameter estimates should be of the right size and sign which confirm the theory that underlies the model. If the estimates are not the right sign or they are significantly different from the expected size, it symbolizes that the model is inadequate and that either some wrong information has been entered or there is some key information missing. In all of the models the parameter estimates were less than 1 which is in line with the underlying theory of EFQM model.

R square is an estimation of the percentage of variation in the dependent variable that can be explained using the independent variables in the model. Adj R^2 is the R^2 value adjusted by the number of cases and number of variables. Kline (2005) recommends that Adj R^2 value should be more than 0.5 for the mode to be considered a good fit. The Adj R squared value for all the models is between 0.54 and 0.77 indicating that the models can explain up to 77% variances in the dependent variables. Table 6-6 below summarise the results of the PLS regression test output (For detailed regression outputs refer to Appendix 5).

Table 6-6 Summary of PLS regression test outputs

Dependent variable	Independent variables	Path coefficients	R-Squared	Adj R-Squared
People	Leadership	0.456	0.585	0.580
Partnership and resources	Leadership	0.417	0.715	0.712
	People	0.312		
Policy and strategy	Leadership	0.409	0.776	0.773
	Partnership and resources	0.221		
Processes	People	0.343	0.644	0.640
	Policy and strategy	0.374		
	Partnership& Resources	0.470		
Goals	Processes	0.447	0.551	0.548

Table 6-6 shows that the leadership enabler has a positive and statistically-significant impact on three enablers: People, Partnerships, and Policies & Strategies. The three enablers, in turn, have a positive and statistically significant impact on the Processes enablers, which impact on TQM-related 'Goals'. The Leadership enabler has to be the first enabler to kick start the TQM maturity process. This model shows that TQM maturity cycle will move forward, with the aim of achieving TQM-related goals. TQM improvement cycle will continue until all TQM-related goals have been met.

6.6 The weight of TQM enablers

The EFQM model is managerial initiative that originates within manufacturing which mean its allocated weight may not necessarily appropriate for construction. Factors such as loose structure, high level of complexity, and high level of fragmentation; differentiates the construction industry from the manufacturing industry (Lam *et al.*, 2008). One of these differences is the weight of criteria in the EFQM model and its applicability to construction. The weightings of EFQM criteria are arbitrary, changing over time (Vukomanovic et *al.*, 2014). The construction industry would probably have different weight for EFQM enablers, but this has not yet been identified for the Saudi construction industry. It was considered essential to obtain weights for EFQM enablers to represent the unique characteristics of the Saudi construction industry.

The next section examines the model's original weights converges with the weights calculated by the empirical data for the Saudi construction industry. Structured questionnaire survey among selected senior managers and quality management representatives was conducted in the Saudi construction firms, and analysing the questionnaire results using an Analytic Hierarchy Process (AHP).

6.6.1 **Analytic Hierarchy Process (AHP)**

Forman *et al.* (2001) defines the AHP method as; "a set of axioms that carefully delimits the scope of the problem environment." The AHP method involves using a matrix structure analysis of associated right-eigenvectors to identify the right weights (Forman et al., 2001). The AHP method has four steps: 1) determining the decision hierarchy structure; 2) constructing a set of pairwise comparison matrices; 3) checking for the consistency of judgments, and; 4) prioritising the analysis (Saaty, 2008). These steps can be used to obtain the weights of the enablers following the process shown in Figure 6-7:

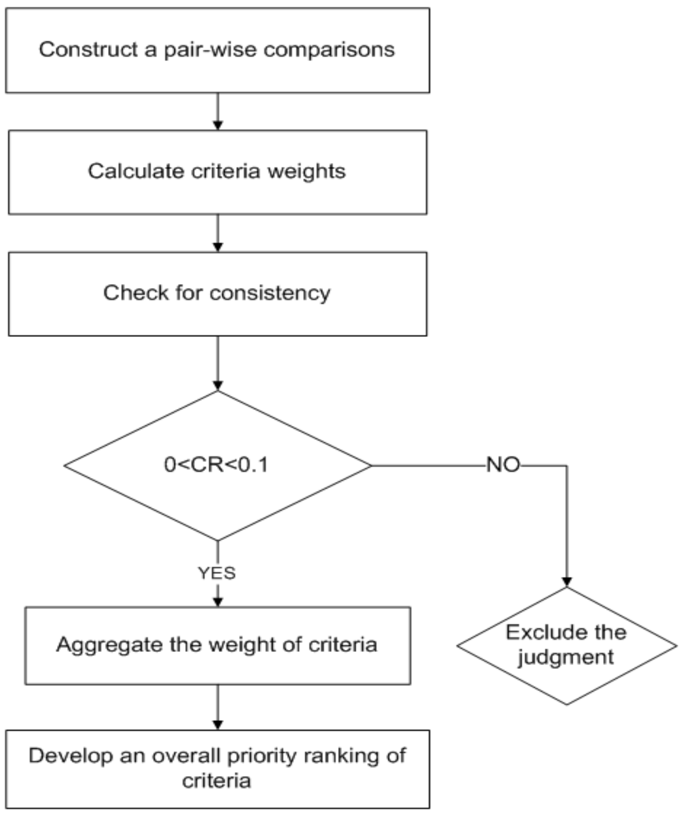


Figure 6-7: Process flowchart of the AHP, adapted from Lee *et al.* (2007)

6.6.2 **Using a matrix for criteria comparison**

Five enablers were identified using the EFQM framework. The matrix has five columns and five rows (i.e. a 5 X 5 matrix). Each diagonal element was a pair-wise comparison. In the matrix below, the first column represents the ratio between the five criteria. The data was obtained from the questionnaire. The equation refers to the ratios obtained for each organization.

In the subjective assessment method for weights, the principle of *eigenvector* is used to calculate the weight vector 'x'. This is then used to allocate weight, which is an indication of the hierarchy of preference for different factors (Saaty, 2003). The matrix shows the pairwise comparison matrix for n number of criteria.

$$A = \begin{array}{c c} & \underline{\text{Criteria}} \\ & \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ \vdots \\ C_n \end{array} & \begin{bmatrix} a_{11} = C_1/C_1 & a_{12} = C_1/C_2 & \dots & a_{1n} = C_1/C_n \\ a_{21} = C_2/C_1 & a_{22} = C_2/C_2 & \dots & a_{2n} = C_2/C_n \\ \vdots & \vdots & & \vdots \\ a_{n1} = C_n/C_1 & a_{n2} = C_n/wC_2 & \dots & a_{nn} = C_n/C_n \end{bmatrix} \end{array} \quad [6.1]$$

Each element represents the preference of one factor over another. This will give the relative weights of each criterion against the rest of criteria given an overall weightage to the entire criteria included in the matrix. An *eigenvalue* approach is used to determine the subjective weight of each of the criterion. The formulation given below is used to obtain eigenvalues.

$$\begin{bmatrix} C1/C1 & C1/C2 & C1/C3 & \cdots & C1/Cn \\ C2/C1 & C2/C2 & C2/C3 & \cdots & C2/C_n \\ \vdots & \vdots & \vdots & & \vdots \\ \vdots & \vdots & \vdots & & \vdots \\ C_n/C1 & Cn/C2 & Cn/C3 & \cdots & Cn/Cn \end{bmatrix} . \begin{bmatrix} W1 \\ W2 \\ \vdots \\ \vdots \\ Wn \end{bmatrix} = \lambda\text{max} . \begin{bmatrix} W1 \\ W2 \\ \vdots \\ \vdots \\ Wn \end{bmatrix} = \begin{bmatrix} b1 \\ b2 \\ \vdots \\ \vdots \\ bn \end{bmatrix} \quad [6.2]$$

Here, w represents the vector of weights (eigenvector); λ_{max} represents the principle eigenvalue of the pairwise comparison matrix A (Saaty, 1990). λ_{max} can be obtained through perturbation of the following equation:

$$\lambda_{max} = \left({}^{1}/_{n}\right) \times \sum_{i=1}^{i=n} \frac{b_i}{w_i} \qquad [6.3]$$

Saaty (1990) recommends using a consistency index (CI) and a consistency ratio (CR) to ensure the consistency of the subjective perception and the accuracy of comparative weights. In order to define CI and CR for pairwise comparison matrix A, the following equation was introduced:

$$CI = (\lambda_{max} - n)/\,(n-1) \qquad [6.4]$$

Where, *n* is the number of criteria.

The Consistency ration can be obtained by

$$CR = CI/\,RI \qquad [6.5]$$

Here, RI represents the random consistency index obtained from the Table (6-7).

Table 6-7: Random Index (RI) values

Numbers of criteria	1	2	3	4	5	6	7	8	9	10
R.I.	0.0	0.0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Source: Saaty *et al.* (2010)

The reliability of results can be estimated from CI and CR values which are unreliable when exceeding 0.10. On the other hand, CI and CR with values of less than 0.10 indicate consistency in the comparison matrix.

6.6.3 **Application of AHP**

Five enablers were identified from the EFQM framework; these were arranged in a 5*5 matrix as shown in the Table 6-9. The relative weights of the variables were obtained from surveying key professionals in the KSA construction industry. A total of 20 questionnaires were completed and returned. However, a total of 17 questionnaires survey were accurate and complete three of the returned questionnaires were inconsistent. The creation of a matrix based on one of the questionnaire survey is explained below. A pairwise comparison has been made according to the relative contribution to quality management. To give an explanation of this process in detail, an example of pairwise comparison of the five criteria (enablers) as determined by an expert is presented in the Table 6-8.

Table 6-8: Pairwise comparison of the five criteria (enablers) in AHP

	Leadership	People	Policy and strategy	Partnerships and resources	Processes	**Eigenvector**
Leadership	1.000	3.000	3.000	7.000	3.000	0.426621
People	0.333	1.000	0.500	2.000	0.200	0.091937
Policy and strategy	0.333	2.000	1.000	3.000	0.333	0.138821
Partnerships and resources	0.143	0.500	0.333	1.000	0.200	0.050099
Processes	0.333	5.000	3.000	5.000	1.000	0.292523
λ *max*= 5.3456; CI= 0.0864 ; CR= 0.0778						1.000

Based on the pairwise comparison scores allocated by the respondents, researcher calculated the eigenvector and eigenvalue. Utilising the eigenvector (weights) in Table 6.8, the subjective weight enablers of TQM was calculated at the first side of equation [6.1] as following:

$$\begin{bmatrix} 1 & 3 & 3 & 7 & 3 \\ 0.333 & 1 & 5 & 2 & 2 \\ 0.333 & 2 & 1 & 3 & 0333 \\ 0.143 & 0.5 & 0.333 & 1 & 0.2 \\ 0.333 & 5 & 3 & 5 & 1 \end{bmatrix} \begin{bmatrix} 0.427 \\ 0.092 \\ 0.139 \\ 0.050 \\ 0.292 \end{bmatrix} = \begin{bmatrix} 0.914 \\ 1.057 \\ 1.088 \\ 0.902 \\ 1.384 \end{bmatrix} \quad [6.6]$$

Using equation [6.4], CI has been obtained from the following calculation:

$$CI = (5.3456-5)/ (5-1) = 0.0864 \qquad [6.7]$$

According to Table 6-7, RI =1.11 as the numbers of criteria are 5.

Then, The Consistency ratio has been calculated according to equation [6.5]:

$$CR = 0.0864/ 1.11 = 0.0778 \qquad [6.8]$$

From the above calculations it can be seen that Consistency Index (CI) and Consistency Ratio (CR) do not exceed 0.10. Hence, the expert's comparisons in Table 6.8 are consistent to a satisfactory degree. These processes have been repeated for all experts' comparison.

The next step aims to combine the results obtained from all experts.

6.6.4 **Aggregate Individual Judgments**

The final step involves consolidating the responses in order to get a final matrix. Either of the two available methods can be used for this purpose; the voting method and the mathematical aggregation method (Wang *et al.*, 2009). In the voting method, a group of experts discuss and agree on an arrangement. This is time-consuming and getting many experts to discuss together is not easy. The simpler and more convenient option is the *mathematical aggregation method* in which weights are aggregated using the geometric mean. Research indicates that this methods yields reliable results in aggregating individual responses (Saaty, 2008). In this research the geometric mean approach was adopted for aggregating expert judgment using the following formula:

$$B = \begin{bmatrix} \sqrt[m]{a_{(11)_1} \times a_{(11)_2} \times, \ldots, a_{(11)_m}}, & \sqrt[m]{a_{(12)_1} \times a_{(12)_2} \times, \ldots, a_{(12)_m}} & \cdots & \sqrt[m]{a_{(1n)_1} \times a_{(1n)_2} \times, \ldots, a_{(1n)_m}} \\ \sqrt[m]{a_{(21)_1} \times a_{(21)_2} \times, \ldots, a_{(21)_m}}, & \sqrt[m]{a_{(22)_1} \times a_{(22)_2} \times, \ldots, a_{(22)_m}}, & \cdots & \sqrt[m]{a_{(2n)_1} \times a_{(2n)_2} \times, \ldots, a_{(2n)_m}} \\ \vdots & \vdots & \ddots & \vdots \\ \sqrt[m]{a_{(n1)_1} \times a_{(n1)_2} \times, \ldots, a_{(n1)_m}}, & \sqrt[m]{a_{(n2)_1} \times a_{(n2)_2} \times, \ldots, a_{(n2)_m}}, & \cdots & \sqrt[m]{a_{(nn)_1} \times a_{(nn)_2} \times, \ldots, a_{(nn)_m}} \end{bmatrix} \quad [6.9]$$

For this formula, matrix B represents the aggregation of comparison matrices for enablers. Each element (a) embodies the relative preference of one criterion over another as evaluated by an expert. Each row of B identifies the ratios of the weights of each enabler with respect to all others (Saaty, 2010). In this formula, m denotes the number of experts participated in judgments (i.e. 17).

Table 6-9: Aggregation of comparison matrix

	Leadership	People	Policy and strategy	Partnerships and resources	Processes	**Eigenvector**	**Weight**
Leadership	1.000	1.003	1.102	2.001	1.017	0.2247786	112.3893477
People	0.997	1.000	1.130	1.307	0.800	0.1974254	98.71273638
Policy and strategy	0.907	0.885	1.000	2.388	0.500	0.1979614	98.98070313
Partnerships &resources	0.500	0.765	0.419	1.000	0.960	0.1395504	69.77522416
Processes	0.983	1.250	2.000	1.042	1.000	0.2402839	120.1419886
λ *max*= 5.1803; CI= 0.045081 ; CR= 0.0406						1.000	500

The same processes that have been carried out in the previous pairwise comparison were followed to obtain $\lambda_{max,}$ CI, CR of aggregation matrix. Table 6-9 shows the aggregation of comparison matrix. It can be seen in Table 6.10 that Process and Leadership enablers represent the highest priority criteria to improve quality management in Saudi construction firms. Process and Leadership represent 0.24 and 0.22 respectively. Meanwhile, Partnership and Resources represent the lowest weight at 0.13. People, Policy and strategy have the same weight at 0.19. Table 6.10 shows the updated criteria weights for the priority of enablers. The main benefit of the updated weighting is that it provides a model tailored to the construction industry, especially from a Saudi contractors' perspective. Table 6.10 shows the comparison of the EFQM score versus the scores obtained from AHP.

Table 6-10: AHP weights calculated for Saudi construction industry vs. EFQM.

TQM enablers	AHP Weight (Saudi construction industry)	EFQM weights
Leadership	112	100
People	99	90
Policy and strategy	99	80
Partnerships and resources	70	90
Processes	120	140
Total	**500**	**500**

The new weights were calculated using AHP because of the inherent differences between the Saudi construction industry and other industries, which formed the basis for the weights used in past research. This table highlights that in Saudi context there is more emphasis on leadership, people and, policy and strategy enablers. On the other hand, there is lesser impact of partnership and resources and processes enablers as compared to in the normal EFQM scale. Due to the highly social nature of Saudi society, the People enabler is likely to have more impact on quality management achievements of an organization as compared to other enablers. Also being a high power distance society means the Leadership enabler will have a higher impact on People enabler as compared to low power distance societies like the USA and European societies where most EFQM studies have been conducted leading to origination of these weights. Policy and strategy enabler weight could be attributed to centralised decisions making as Saudi employees tend to follow rules.

6.7 Final model

Figure 6-8 shows the final modified version of EFQM contextualised as per Saudi construction industry and used to build the system dynamic model in this research. The modified EFQM model indicates that all the relationships are statistically significant. The positive signs of all path coefficients show that the independent variables affect the dependent variables positively. The Leadership enabler is found to affect the People enabler positively and their relationship is statistically significant. This suggests that leaders should assume responsibility of guiding people towards, for example, as a quality-based culture of working. Leadership here refers not only to the top managers, but also intermediate managers are responsible for translating the strategic goals into tactical and operational goals. Top managers may use communication and vision as tools to develop the quality-conscious culture within the organization. This is especially true in countries like Saudi where the high power distance culture gives the leaders more power to influence the behaviour of followers. Exhibiting strong commitment to quality is a useful strategy as the followers are likely to follow the aspects considered valuable by their leaders.

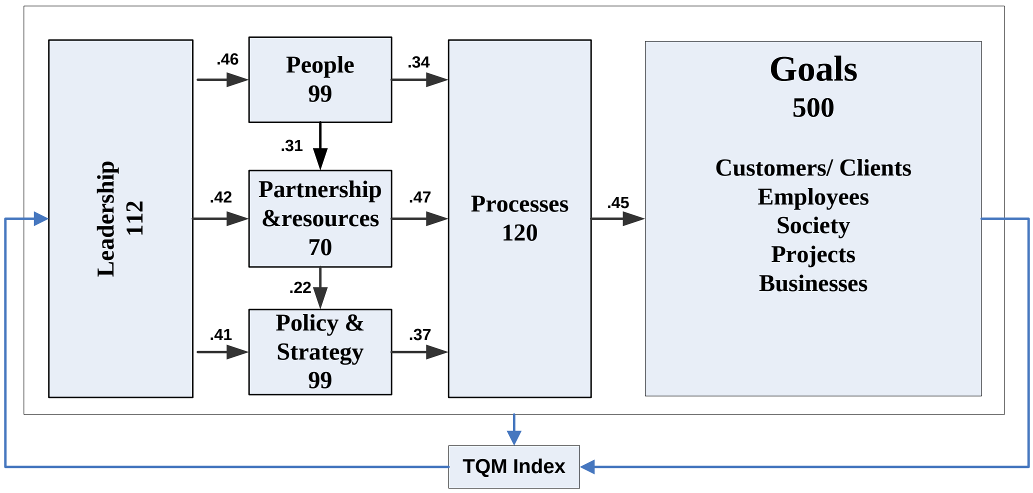


Figure 6-8: The final model

Leaders can have a direct impact on partnership and resources because they devise the strategy, which is then translated by intermediate managers into the operational policy which guides them. Furthermore, the leadership can affect how quality conscious the supplier and partner network for the organization is by ensuring that only partners and suppliers with adequate quality reputation are selected for business. By emphasizing quality the leaders can send a message as to what kind of networks are to be built. The most significant manner in which the leaders affect partnership and resources is allocation of resources which is directly and significantly guided by the strategy decided at the top. To ensure that quality management is practiced throughout the supply chain leaders can allocate sufficient financial and human resources towards quality management in the firm's value network.

Leadership enabler affects the Policy and strategy enabler towards quality management. This is quite intuitive and just confirms what most of the researchers have found in the past. The policy and strategy of organizations, especially in countries like Saudi Arabia, are heavily driven from the top. It is thus, quite understandable that the Leadership enabler affects the quality policy and strategy of the organization as was confirmed in the model.

The People, Partnership and resources, and Policies and strategy enablers, all positively and significantly affect the Quality processes enabler in the organization. The significance of people is understandable because it is the employees who operationalise the quality policy and strategy of the organization. Construction, quality aspects may not be immediately visible, hence the support of people in operationalising quality policy and strategy cannot be ignored. People affect partnership and resources because in Saudi society the relationships are built on social cohesion. People are central to any partnership. Saudi culture is based on relationships, which play a vital role in decision-making. Partnership and resources affect the quality processes in the Saudi construction industry as is confirmed by the model. This is particularly true in the construction industry due to the fragmented and interdependent nature making every firm dependent on its partners to pursue the quality policy and strategy.

In quality management, partnership and resources have become more critical; quality management does not occur instantly. It is an outcome of a long and incremental strategy, which eventually guides the organization towards its quality goals. It is essential for the firm to take a long-term approach towards partnership and resource management to improve quality. The partners and internal human resources must work together to achieving the quality goals.

The model indicates that quality processes may lead to quality goals. To achieve the highest level of TQM, every process within the organization and the project must be aimed at achieving the highest level of quality. Process improvement occurs over a long time; new processes need to be implemented and further refined to an acceptable level of performance.

The system is designed to achieve the desired value for all the enablers and goals and to function till the gap between desired and actual values of enablers and goals is nil. The equations are designed so that the value of Goals is half of the higher range of TQM index score of the corresponding TQM maturity level. The TQM index score at any stage (which is the sum of all the values of all the enablers at that point of time) determines the level of TQM maturity. The system is driven by the gap in actual value of enablers and goals, and not by any particular component alone. the gap in goals is dependent on the TQM maturity stage- for every stage the firm is in the desired value of goals is set a half the value of TQM index score. This is in line with system thinking approach, which indicates that the system works as an outcome of the function of all its components and is not driven by any single component.

6.8 Chapter summary

This chapter involved testing the reliability of the questionnaire and estimating the relationship between different enablers and TQM goals. The EFQM model was selected and modified. PLS regression was carried out to estimate the causal relationship between the different EFQM constructs. According to the PLS regression results, people enabler is affected only by leadership enabler but both these together affect the Partnership & resources enabler. Similarly, Partnership & Resources enabler as well as leadership enabler affects Policy and Strategy enabler. As expected all three enablers (People, Partnership & Resources, Policy & Strategy) affect Processes enabler who, in turn, affects the TQM related Goals.

PLS regression was followed by Analytical Hierarchy Processing of questionnaire data to estimate the weight of different TQM enablers in the Saudi construction industry.

It is important to contextualize the EFQM framework. The most critical aspects of contextualization are the need to identify the weights of the variables in which EFQM is being applied. The AHP process involves pairwise comparison of variables using experts' judgment. The EFQM model is contextualized for both the construction industry and in the Saudi Arabian industry context.

Chapter 7 SYSTEM DYNAMICS MODELLING OF TQM IN SAUDI CONSTRUCTION INDUSTRY

7.1 General overview

Section 5.10 identified the five steps involved in system dynamic modelling. These are (Sherman, 2000):

- Problem articulation
- Formulating dynamic hypothesis
- Formulating a simulation model
- Testing the system
- Policy design and evaluation

This chapter presents two steps namely the formulation of a simulation model and testing the system. The system dynamics model is aimed at capturing the complex and dynamic relationship over time between the five TQM enablers and the organizational goals in Saudi construction firms.

Vensim software (v.6.4) was used to formulate the system dynamics model and the simulations were run over a 20-year period to see how different enablers will affect the TQM maturity in Saudi construction firms. A 20-year period was chosen because implementation of TQM is a long-term strategy. The regression models indicated that the Leadership enabler has a dynamic relationship with the People, Partnership and resources, and Policies and strategy enablers. These three enablers have a dynamic relationship with the Processes enabler, which has a dynamic relationship with TQM related goals. The model is tested in the base run, which here represents an organization which is at the beginning of their TQM journey i.e. the organization with the value of all its enablers equal to zero.

This chapter includes sensitivity analysis and policy testing of the model. Sensitivity analysis involves testing the robustness of the model. It evaluates whether the behaviour of the system (as noted by the shape of the curve) will change if the assumptions made in building the model are altered. Two scenarios were considered: in the first scenario the assumed values of the parameters were increased/ reduced by $\pm$10% of their base runs values of the parameters. In second scenario the assumed values of the parameters were increased/ reduced by ±25% of their base runs values. The parameters selected for sensitivity analysis were: Desired value of each enabler, Path coefficient determining relationships between different enablers and goals. In policy testing, it was tested whether certain policies adopted by organisations such as investing more effort into improving any particular enabler, is likely to lead to any significant improvement in the performance of the organisation in terms of achieving its TQM maturity.

7.2 The TQM maturity Model

The TQM maturity model is designed to capture the interaction between the five *enablers* and *Goals.* The TQM maturity model is measured based on a TQM index score, which is used to identify the TQM maturity level of an organization. The TQM index score represents the sum of the *Goals* and *enablers* score. The maximum TQM index score is 1,000. By improving the enablers score, the firm can improve its overall TQM index score which then improves its TQM maturity level. Firms with a TQM index of between 0 and 200 are considered to be at the first TQM maturity level, those with a TQM index score between 201 and 400 are at the second TQM maturity level, and so on. Firms with a TQM index score between 801and1000 are considered to be at the top TQM maturity level.

According to this model, the TQM maturity level, identified by firm's TQM index score, will rise with the rise in enablers' and goals' score. This means that firms which are more focused on quality management and those who actively work towards quality management, are likely to find better quality results including not only product-related benefits but also market-related benefits.

For all the variables mentioned in the TQM index model, the units are TQM index units unless otherwise stated. TQM index units refer to the TQM index maturity scale, which is divided in 1000 points each point representing one TQM index unit. All the variables are continuous variables meaning they can have any possible value from within their range. The range of the variables is stated as required with each variable. TQM maturity scale ranges from 0-1000 with TQM index score, being a continuous variable taking any value within this range.

The individual components (the five enablers, goals and TQM index) of the TQM maturity dynamic model used for this research are discussed below.

7.2.1 **Leadership enabler**

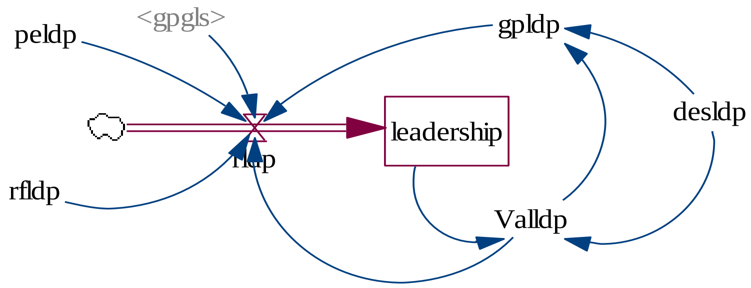


Figure 7-1: Leadership enabler dynamic model

Figure 7-1 shows the Leadership enabler dynamic model. It is a simple stock and flow representation where leadership is the stock. Table 7-1 explains the abbreviations used in the diagram.

Table 7-1: Abbreviations used in leadership enabler dynamic model

Abbreviation	**Explanation**	**units**
rldp	Rate of leadership. This represents the inflow which leads to a change in leadership stock. If leadership value is 40 points this year and 50 points next year. The difference in leadership stock this year was 50-40= 10. This means that the rate of leadership will be 10 points per year.	Points/ year
leadership	It is leadership stock.	points
Valldp	Value of leadership is value at any given time.If a survey was conducted at any given point of time to estimate the current value of leadership enabler the total value obtained will be the same as Value of leadership.	Points
peldp	Percentage of effort put into improving leadership. Firms who look to boost their quality management performance need to do this through investment of time and resources in certain activities, policies, strategy which will result in improvement in a particular enabler and consequently in the TQM index score. *Peldp* refers to the amount of effort that the organization invests in improving their leadership score (*valldp*). It is the additional effort (in terms of investment of time and resources) that the organization allocates to push the value of leadership towards the maximum score.	%/ year
gpldp	Gap between desired and achieved level of leadership.	Points
desldp	Desired level of leadership. The maximum score that can be achieved for the leadership enabler.	Points
rfldp	Rate fraction of leadership. This is the percentage of annual budget is spent on improving quality management	%/year
Gpgls	Gap between achieved level of Goals and desired goals score in TQM index.	Points

The following equations define the leadership dynamic model:

leadership = INTEG (rldp, 0) Equation 7.1

This means that the stock value of leadership enabler is equal to the integration of rate of leadership and past value of leadership stock. This is written zero, because the values of all the enablers is set at zero to begin with in the base run.

rldp = ((*Valldp*+*gpgls*)**rfldp*) +(*gpldp***peldp*) Equation 7.2

Rate of leadership (*rldp*) represents the rate of flow, which leads to a change in leadership stock. According to the equation rate of leadership is changed by *valldp*rfldp* + *gpgls*rfldp*+ *gpldp*peldp.*

Vallldp*rfldp refers to the percentage of budget invested to improve Value of leadership stock at any given time. *gpgls*rfldp* refers to the percentage of budget invested at any stage in overcoming the gap in goals. *gpldp*peldp* refers to the percentage of efforts invested in improving leadership stock to overcome the gap between desired value and current value of the leadership enabler.

The leadership dynamic model in equation 7.2 indicates that *rldp* increases with a rise in *gpldp*. This suggests that leaders need to respond to a rise in *gpldp* in order to minimise this gap. Leaders can do this in many ways, such as committing to quality improvement, sharing a clear quality-focussed vision with the employees and acting as role models for quality management. This will result in a rise in *rldp,* which in turn will increase the *leadership* stock as show the leadership dynamic model and in equation 7.1, which shows that leadership stock rises with *rldp*. The increased leadership stock will be evident in *valldp,* which is the value of the leadership used and, since *gpldp* has an inverse relationship with *valldp* (equation 7.3 and equation 7.4), the rise in *valldp* will lead to a decrease in *gpldp*.

The Gap in leadership stock (*gpldp*) is the difference between the desired level of leadership and the value of leadership at any given time t. This is given by the equation:

gpldp = *desldp*-*Valldp* *Equation 7.3*

Where,

Valldp = MIN (*leadership*, *desldp*) *Equation 7.4*

Equation 7.4 controls the value of *Valldp* to ensure that it does not exceed the *desldp* value.The desired level of leadership is a constant which is obtained though the AHP process described earlier:

desldp = 112 *Equation 7.5*

peldp= INITIAL (0) *Equation 7.6*

peldp is the percentage effort that the organization may put into improving leadership, in order to improve quality management. This is likely to add to the existing value of leadership thereby boosting leadership towards it maximum achievable score given by *desldp*. Initial value is set at zero in the base run as shown in equation 7.6.

rfldp = 0.11 *Equation 7.7*

rfldp is the leadership rate fraction, obtained by taking the average of budget spending by the organisation on implementing quality management in their organisation. According to the results of the questionnaire survey, this is 0.11 i.e. 11% (see Sec. 6.2). This is slightly higher because the organisations included in the survey are all ISO 9001-certified, which indicates their greater contribution towards quality management. These organisations have maintained this status over at least last three years, suggesting that their focus on quality has been consistent or has been improving over time.

Leadership affects people directly and also the organization by influencing partnerships, policies and practices. This is true in the context of quality management as well. The regression models in chapter 6 confirmed the relationship between leadership and the three enablers: People, Partnerships and resources, and Policies and strategy. This is particularly true for a high power-distance society like Saudi Arabia (Hofstede, 2011). Its high power distance index score of 95 indicates that the Saudi society is a hierarchy-based society where the powerful make decisions which are followed without question. This means that leaders can play a key role in pushing reforms and agendas such as quality management in their organizations.

7.2.2 **People Dynamic Model**

Table 7-2explains the abbreviations used for the various variables in the People enabler dynamic model.

Table 7-2: Abbreviations used in people enabler dynamic model

Abbreviation	**Description**	**Units**
Rpeople	Rate of people enabler	points/year
Valppl	Value of people enabler used	Points
Peppl	Percentage of effort put into improving people enabler.	%/year
Gpppl	Gap between desired and achieved level of people enabler	Points
Desppl	Desired level of people enabler	Points

Cof ldp ppl	Path coefficient between leadership and people enabler	Constant (=0.456)
DF ldp ppl	Decision fractions between leadership and people	%/ year

Research has confirmed the link between leadership and people (Obeidat *et al*. 2016a; Mazher *et al*.2015; Alotaibi *et al*. 2013; Jacobs and Suckling, 2007; Oakland and Marosszeky, 2006).This is particularly true in countries with a high power-distance index such as Saudi Arabia, people's behaviour in a group is affected by their group leaders' decisions e.g. quality management. In the People dynamic model, this is shown by the impact of *valldp* on *rpeople*. The *Valldp* variable (shown in in grey in Figure 7-2) is a shadow variable as a reference to its appearance in the leadership enabler system dynamic diagram in the previous subsection (the Vensim methodology for showing connections between variables without additional complexity in view). The figure shows the people dynamic model, where it can be seen that *rpeople* is affected by *valldp* and *pepple* then affects the *valppl* value.

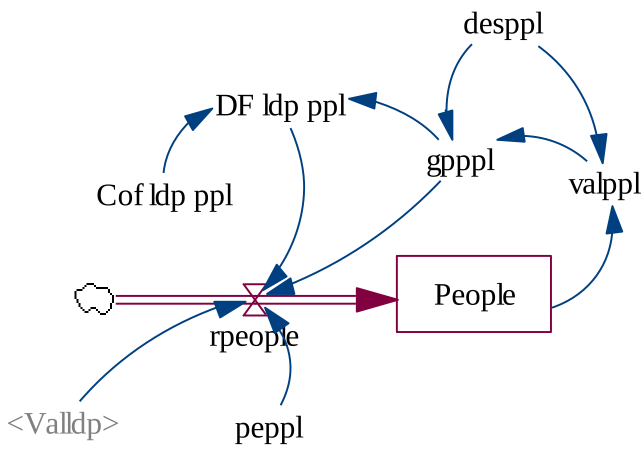


Figure 7-2: People enabler dynamic model

The following equations define the people dynamic model:

People = INTEG (*rppl*, 0) *Equation 7.8*

This means that the stock value of people enabler is equal to the integration of rate of people and past value of people stock. The zero in equation 7.8 indicates that the starting value of the people stock is set at zero in the base run.

rpeople= (*Valldp***DF ldp ppl*) + (*gpppl***peppl*) *Equation 7.9*

Where,

*DF ldp ppl = gpppl*Cof ldp ppl*/100 *Equation 7.10*

This means that rate of flow of people enabler is equal to (*Valldp*DF ldp ppl*) + (*gpppl*peppl*). Valldp*DF ldp ppl refers to the current value of leadership stock multiplied by *DF ldp ppl*, which means what is the current value of leadership stock and how much will it contribute to overcoming the gap in people enabler (Equation 7.10).

The gap in the people enabler (*gpppl*) is the difference between the desired level of people enabler and the actual value of people enabler at any given time t. This is given by the equation:

gpppl = desppl - valppl *Equation 7.11*

Where,

valppl = MIN (*People*, *desppl*) *Equation 7.12*

Equation 7.12 controls the value of *valppl* to ensure that it does not exceed the *desppl* value.

The desired level of people enablers is a constant, which is obtained though the AHP process described earlier:

desppl = 99 *Equation 7.13*

peppl indicates the effort put into improving the People enabler. The initial value of *peppl* is zero in the base run as shown in equation 7.14.

peppl= INITIAL (0) *Equation 7.14*

As shown in equation 7.10, the '*DF_ppl_ldp'* value depends on the *gpppl* and Path coefficient between the Leadership and People enablers. *Gpppl*, as shown in equation 7.11, is the difference between the *desppl*, desired value of people enabler (given in equation 7.13 as 99) and *valppl*, the actual value of people enabler used which is given in equation 7.12.

In the final model, the People enabler affects partnerships and resources and hence the *valppl* score will affect the Partnerships and resources dynamic model as well as *valldp*.

7.2.3 **Partnerships and Resources Dynamic Model**

Partnerships exists between organizations and individuals and is one of the most critical resources that any organization has, especially in terms of quality management is human resources. Hence, it is quite intuitive that the People enabler affects the Partnerships and resources enabler. At the same time partnerships and resources are also affected by leadership as leaders decide the allocation of resources through their decision making.

Table 7-3 explains the abbreviations of the various variables used in the Partnership and Resources' dynamic model

Table 7-3: Abbreviations used in Partnership & resources enabler dynamic model

Abbreviation	**Description**	**Units**
rpars	Rate of Partnerships and resources enabler	Points/ year
valpars	Value of Partnerships and resources enabler used	Points
Cof ldp pars	Path coefficient between theLeadership and Partnership and resources enablers	Constant (=0.417)
Cof ppl pars	Path coefficient between the People and Partnership and resources enablers	Constant (=0.312)
pepars	Percentage of effort put into improving partnerships and resources enabler.	%/year
gppars	Gap between desired and achieved level of the Partnerships and resources enabler	Points
despairs	Desired level of Partnerships and resources enabler	Points
DF ldp pars	Decision fractions between the Leadership and Partnerships and resources enablers	%/year
DF ppl pars	Decision fractions between the People and Partnership and resources enablers	%/year

The Partnership and resources dynamic model is shown in Figure 7-3. Since the regression model suggested that the People and Leadership enablers affect the Partnerships and resources enabler, this means that *valppl* and *valldp* both affect the rate of the Partnerships and resources enabler as shown in Figure 7-3.

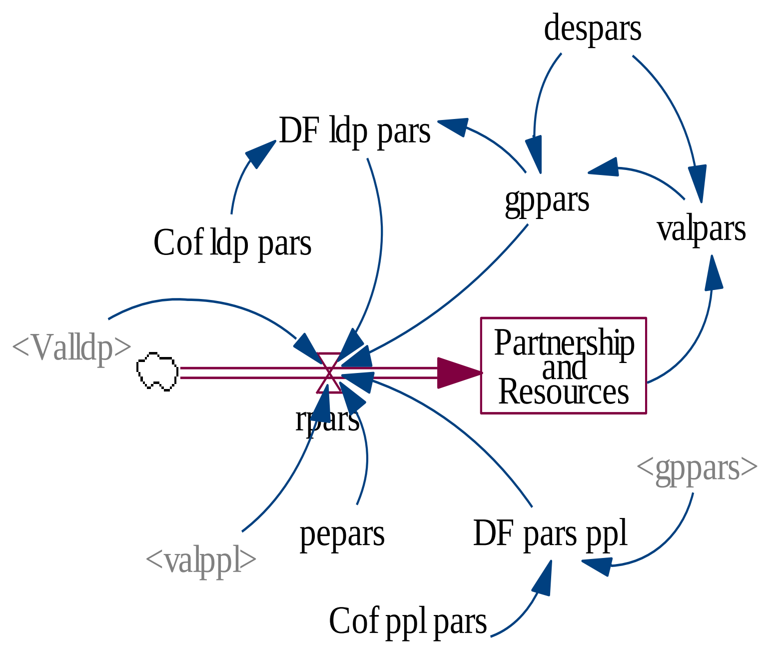


Figure 7-3: Partnership & resources enabler dynamic model

The following equations define the Partnerships and Resources dynamic model:

Equation 7.15 below shows that stock value of Partnership and Resources enabler is equal to the integration of rate of flow of Partnership and Resources and past value of Partnership and Resources stock. The zero in equation 7.16 indicates that the starting value of the Partnership and Resources stock is set at zero.

Partnership and Resources = INTEG (*rpars*, 0) *Equation 7.15*

Where,

rpars = (*valldp**DF ldp pars*) + (*valppl**DF pars ppl*) + (*gppars**pepars*) *Equation 7.16*

In this equation,

DF ldp pars = *gppars***Cof ldp pars*/100 *Equation 7.17*

DF ppl pars = *gppars***Cof ppl pars*/100 *Equation 7.18*

Equation 7.16 indicates that rate of flow of Partnership & Resources enabler is equal to (*valldp***DF ldp pars*) + (*valppl***DF pars ppl*) + (*gppars***pepars*). *Valldp***DF ldp pars* refers to the current value of leadership stock multiplied by *DF ldp pars* which means what is the current value of leadership stock and how much will it contribute to overcoming the gap in Partnership & Resources enabler enabler (equation 7.17). *Valppl***DF ppl pars* refers to the current value of People stock multiplied by *DF ppl pars* which means what is the current value of People stock and how much will it contribute to overcoming the gap in Partnership & Resources enabler enabler (equation 7.18).

gppars = *despars* – *valpars* *Equation 7.19*

valpars = MIN (Partnership and Resources, *despars*) *Equation 7.20*

Equation 7.20 controls the value of *valpars* to ensure that it does not exceed the *despars* value. The desired level of the Partnership and resources enabler is a constant, which is obtained though the AHP process described earlier:

despars = 70 *Equation 7.21*

pepars= INITIAL (0) *Equation 7.22*

pepars indicates the effort put in improving partnerships and resources enabler. Initial value of *pepars* is zero as shown in equation 7.22.

7.2.4 **Policy and Strategy Dynamic Model**

Policy and strategy in an organization is affected by leadership, as well as Partnership and resources as described in chapter 6. Resources include both human and non-human resources. Leaders establish the policy and strategy for quality of the organizations, and adopted across the value chain of the organization. This eventually leads to a rise in the Partnerships and resources enabler, which is why *rplcs* (policy and strategy rate) is affected by both *valpars* and *valldp* as shown in the partnership and resources dynamic model – Figure 7-4.

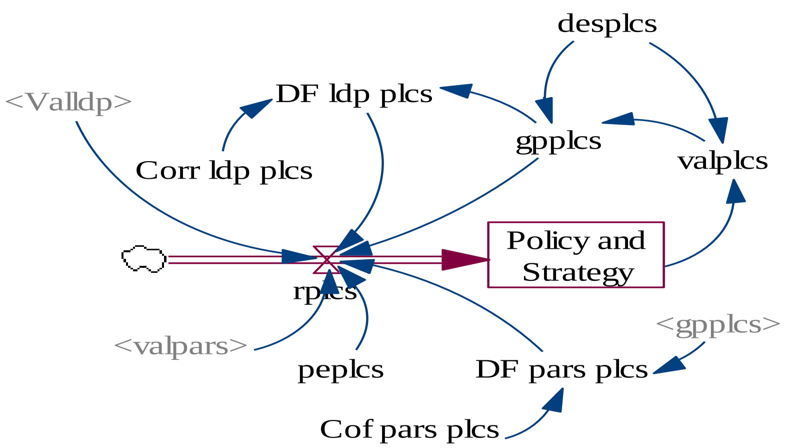


Figure 7-4: Policies and strategy enabler dynamic model

Table 7-4 explains the abbreviations of the various variables used in the Policy and strategies dynamic model

Table 7-4: Abbreviations in Policies and strategy enabler dynamic model

Abbreviation	**Description**	**Units**
rplcs	Rate of Policy and strategies enabler	Points/year
valplcs	Value of Policy and strategies enabler used	Points
Cof ldp plcs	Path coefficient between leadership and Policy and strategies enablers	Constant (=0.409)
Cof pars plcs	Path coefficient between partnership and resources and Policy and strategies enablers	Constant (=0.221)
peplcs	Percentage of effort put into improving Policy and strategies enabler.	%/year
gpplcs	Gap between desired and achieved level of Policy and strategies enabler	Points
desplcs	Desired level of Policy and strategies enabler	Points
DF ldp plcs	Decision fractions between leadership and Policy and strategies	%/ year
DF pars plcs	Decision fractions between partnership and resources and Policy and strategies enablers	%/ year

Equation 7.23 shows that the stock value of Policy and strategies enabler is equal to the integration of rate of flow of Policy and strategies and past value of Policy and strategies stock. The zero in equation 7.23 indicates that the starting value of the Policy and strategies stock is set at zero.

The following equations define the Policy and strategies dynamic model:

Policy and strategies = INTEG (*rplcs*, 0) *Equation 7.23*

Where,

*rplcs =(Valldp*DF ldp plcs)+(gpplcs*peplcs)+(valpars*DF plcs pars)* *Equation 7.24*

In this equation,

*DF ldp plcs = gpplcs*Cof ldp plcs*/100 *Equation 7.25*

*DF parsplcs = gpplcs*Cof pars plcs*/100 *Equation 7.26*

Equation 7.24 indicates that *rplcs* i.e. rate of flow of Policies and Strategy enabler is equal to *(Valldp*DF ldp plcs)+(gpplcs*peplcs)+(valpars*DF plcs pars)*. *Valldp*DF ldp plcs* refers to the current value of leadership stock multiplied by *DF ldp plcs* which means what is the current value of leadership stock and how much will it contribute to overcoming the gap in Policies and Strategy enabler (equation 7.25). *Valpars*DF plcs pars* refers to the current value of Partnership & Resources stock multiplied by *DF plcs pars* which means what is the current value of Partnership & Resources stock and how much will it contribute to overcoming the gap in Policies and Strategy enabler (equation 7.26). *gpplcs*peplcs* refer to the percentage of efforts that will go in improving policies and strategy enabler in order to overcome the *gpplcs* (i.e. gap in improving policies and strategy enabler stock).

gpplcs = *desplcs* – *valplcs* *Equation 7.27*

And

valplcs = MIN (Policy and strategies, *desplcs*) *Equation 7.28*

Equation 7.28 controls the value of *valplcs* to ensure that it does not exceed the *desplcs* value. The desired/ maximum value of Policy and strategies enablers is a constant, which is obtained though the AHP process described earlier:

desplcs = 99 *Equation 7.29*

peplcs indicates the effort put in improving Policy and strategies enabler. Initial value of *peplcs* is zero as shown in equation 7.30.

peplcs= INITIAL (0) Equation 7.30

7.2.5 **The Processes Dynamic Model**

The processes in an organization are adopted by the people working in the organization, and in many cases, are both formal and informal methods characterising the impact of people on those processes. Similarly, partnerships and resource building with a quality focus leads to the development of long-term quality-focused processes. The policies and strategy of the organization has a definitive impact on the quality processes in an organization as these work to institutionalise quality practices by embedding them into core processes. This is why the value of the People enabler (*valppl*), Partnerships and resources enabler (*valpars*) and Policies and strategy enabler (*valplcs*) all affect *rprcs* i.e. the rate of processes. Figure 7-5 shows the processes enabler dynamic model; Table 5 explains the abbreviations used.

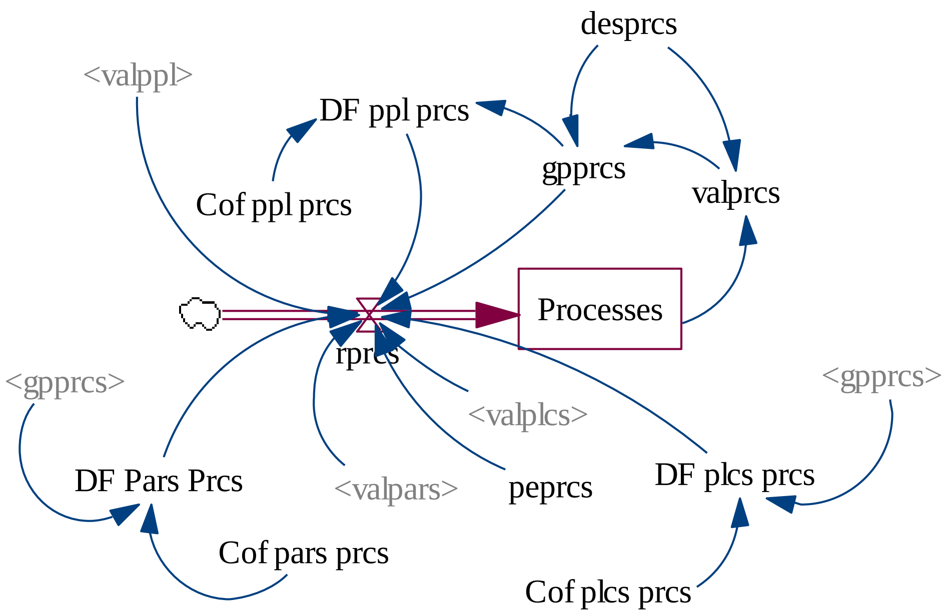


Figure 7-5: Processes enabler dynamic model

Table 7-5: Abbreviations in Processes enabler dynamic model

Abbreviation	Description	Units
rprcs	Rate of Processes enabler	Points/ year
valprcs	Value of Processes enabler used	Points
Cof plcs prcs	Path coefficient between Policy and strategies and processes enablers	Constant (=0.372)
Cof pars prcs	Path coefficient between the Partnership and resources and Processes enablers	Constant (=0.47)
Cof ppls prcs	Path coefficient between the People and Processes enablers	Constant (=0.343)
peprcs	Percentage of effort put into improving the Processes enabler.	%/ year
gpprcs	Gap between desired and achieved level of the Processes enabler	Points
desprcs	Desired level of Processes enabler	Points
DF plcs prcs	Decision fractions between Policy and strategies and Processes enablers	%/ year
DF pars prcs	Decision fractions between partnership and resources and Processes enablers	%/ year
DF ppl prcs	Decision fractions between People and Processes enablers	%/ year

Equation 7.31 shows that the stock value of Processes enabler is equal to the integration of rate of flow of Processes and past value of Processes stock. The zero in equation 7.31 indicates that the starting value of the Processes stock is set at zero.

The equations below explain the various relationships in the processes dynamic model:

Processes = INTEG (*rprcs*, 0) *Equation 7.31*

Where,

*rprcs = (gpprcs*peprcs) + (valppl*DF ppl prcs) + (valplcs*DF plcs prcs) + (valpars*DF Pars Prcs)* *Equation 7.32*

In this equation,

*DF plcs prcs = gpprcs*Cof plcs prcs*/100 *Equation 7.33*

*DF pars prcs = gpprcs*Cof pars prcs*/100 *Equation 7.34*

*DF ppl prcs = gpprcs*Cof ppl prcs*/100 *Equation 7.35*

Equation 7.32 indicates that *rplcs* i.e. rate of flow of Processes enabler is equal to *(gpprcs*peprcs) + (valppl*DF ppl prcs) + (valplcs*DF plcs prcs) + (valpars*DF Pars Prcs). valppl*DF ppl prcs* refers to the current value of people stock multiplied by *DF ppl prcs* which means what is the current value of people stock and how much will it contribute to overcoming the gap in Processes enabler (equation 7.35). *valplcs*DF plcs prcs* refers to the current value of Policies and strategy stock multiplied by *DF plcs prcs,* which means what is the current value of Policies and strategy stock and how much it will contribute to overcoming the gap in Processes enabler (equation 7.33). *valpars*DF pars prcs* refers to the current value of Partnership & Resources stock multiplied by *DF pars prcs,* which means what is the current value of Partnership &Resources stock and how much will it contribute to overcoming the gap in Processes enabler (equation 7.34). *gpprcs*peprcs* refer to the percentage of efforts that will go in improving the processes enabler in order to overcome the *gpprcs* (i.e. gap in processes enabler stock).

gpprcs = *desprcs – valprcs* *Equation 7.36*

And

valprcs = MIN (Processes, *desprcs*) *Equation 7.37*

Equation 7.37 controls the value of *valprcs* to ensure that it does not exceed the *desprcs* value. The desired level of the Processes enabler is a constant, which is obtained though the AHP process described earlier.

desprcs =120 *Equation 7.38*

peprcs indicates the effort put in improving Processes enabler. Initial value of *peprcs* is zero as shown in equation 7.39.

peprcs= INITIAL (0) *Equation 7.39*

Increasing the rate of processes will improve the value of the processes enabler used, this is likely to boost the rate of goals as explained in the goals dynamic model in the next subsection.

7.2.6 **Goals Dynamic Model**

The final model confirms that processes affect organizational goals; a rise in value of the Processes enabler used increases the rate of organizational goals. Figure 7-6 shows the goals dynamic model. Table 7-6 explains the abbreviations used.

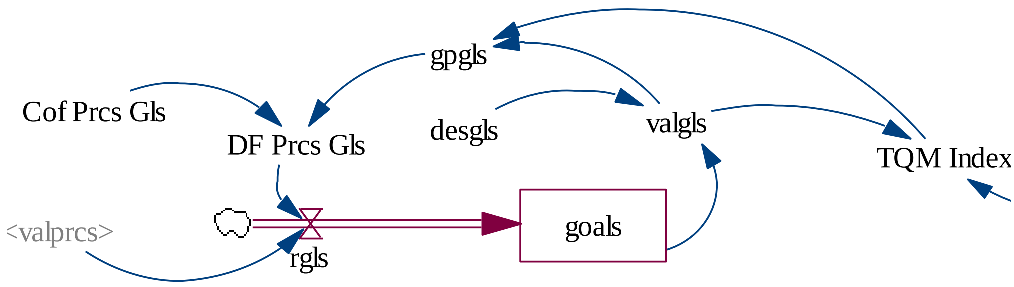


Figure 7-6: Goals dynamic model

Table 7-6: Abbreviations used in Goals dynamic model

Abbreviation	**Description**	**Units**
rgls	Rate of Goals	Points/ year
valprcs	Value of Processes enabler used	Points
Cof prcs gls	Path coefficient between processes and goals	Constant (=0.447)
gpgls	Gap between achieved level of Goals and desired goals score in TQM index.	Points
desgls	Desired level of goals	Points
valgls	Value of Goals at (t) time	Points
DF gls prcs	Decision fractions between goals and Processes enabler	%/ years
TQM Index	TQM index score	Points

Equation 7.40 shows that the stock value of Goals is equal to the integration of rate of flow of Goals and past value of Goals stock. The zero in equation 7.40 indicates that the starting value of the Goals stock is set at 89, explained below in section 7.3.1.

The equations explain the various relationships in the Goals dynamic model:

goals= INTEG (rgls, 89) *Equation 7.40*

Where,

*rgls = valprcs*DF Gls Prcs* *Equation 7.41*

In this equation,

*DF Gls Prcs = Cof Prcs Gls*gpgls/100* *Equation 7.42*

And,

gpgls= If Then Else (TQM Index <= 200, 100 - valgls, If Then Else (TQM Index <=400

, 200 - valgls, If Then Else (TQM Index <= 600, 300 - valgls, If Then Else (TQM Index <= 800, 400 - valgls, 500 - valgls)))) *Equation 7.43*

Equation 7.41 indicates that *rgls* i.e. rate of flow of goals is equal to *valprcs*DF Gls Prcs*. This refers to the current value of Goals stock multiplied by *DF Gls Prcs,* which means what is the current value of processes stock and how much will it contribute to overcoming the gap in Goals (look at equation 7.42). Like in previous equations degree of fraction is given by gap of goals multiplied by correlation between processes and goals i.e. how much of processes enabler will contribute towards overcoming the gap in goals.

Equation 7.43 sets the value of gap in goals. It states that if the firm is in first TQM stage, i.e. TQM index score is between 0 and 200, then gap in goals will be 100 minus value of goals at that time. This equation shows that gap in goals is dependent on the TQM maturity stage - for every stage the firm is in the desired value of goals is set a half the value of TQM index score. For example, if the firm is in third TQM maturity stage then the maximum TMQ index score for third TQM maturity stage is 600. Hence, the desired value of goals for that stage is 300. In order for firm to achieve goals value of more than 300, it will need to reach higher TQM maturity stage, which means the fourth stage.

And,

valgls = MIN (desgls, goals) *Equation 7.44*

Equation 7.44 controls the value of *valgls* to ensure that it does not exceed the *desgls* value. The desired level of Goals is a constant:

desgls = 500 *Equation 7.45*

According to the equation and model it can be seen that *rgoals* affect *valgls.Valgls* also increases with rise in *valprcs*. Arise in *valgls* leads to a reduction in *gpgls,* which in turn affects *rldp*.

7.2.7 **TQM Index dynamic model**

Figure 7-7 shows the TQM index dynamic model.

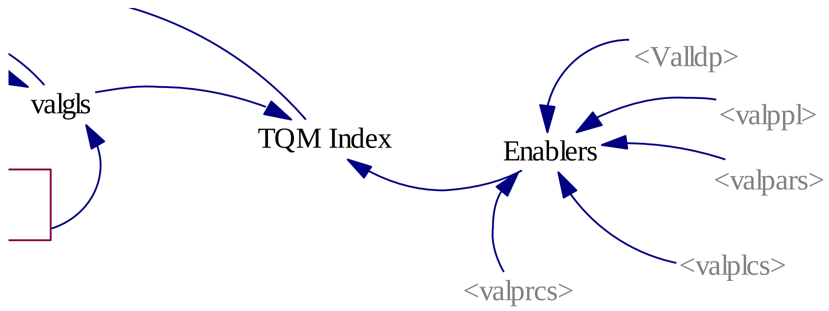


Figure 7-7 TQM Index dynamic model

Enablers = valldp + valpars + valplcs + valppl + valprcs *Equation 7.46*

TQM Index =Enablers + valgls *Equation 7.47*

Simulations of the TQM maturity model involve iterative cycles from leadership to TQM Index where the score of enablers is changed along with the goals score. The gradual iterative cycles lead to a rise in the TQM index score until it reaches a maximum of 1000. This growth in TQM score is considered to increase the TQM maturity level from beginner to mature. Based on the dynamic models mentioned above, the TQM maturity model was created and is shown in Figure 7-8.

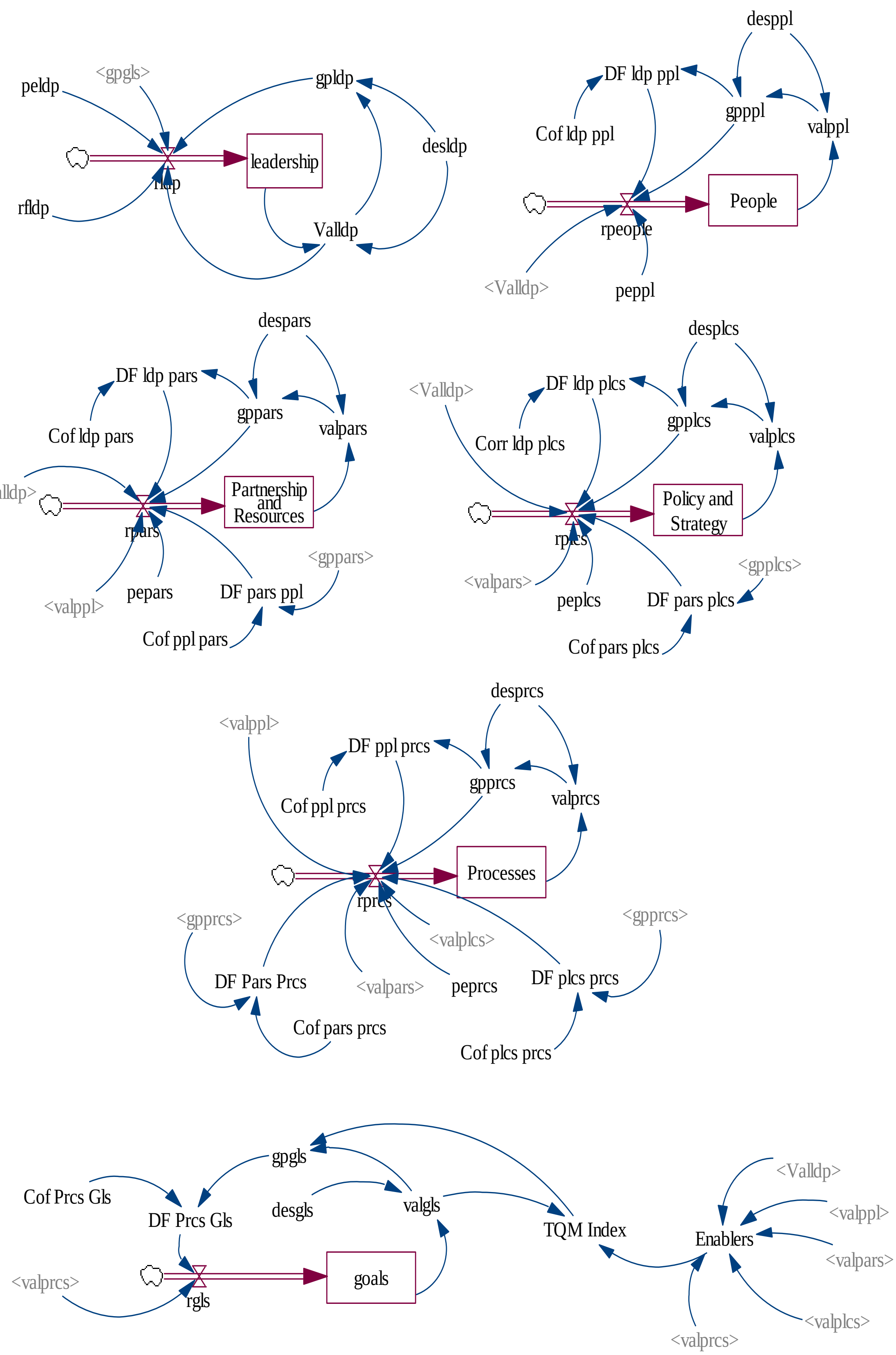


Figure 7-8: The complete System Dynamic model for the TQM maturity

7.3 Simulation results

7.3.1 Base Run Results

The initial value of all five enablers was set to zero i.e. Organizations with no prior experience of quality management. The starting value of goals was obtained from the regression model. The data from the questionnaire survey was used to conduct a regression model, which indicated that when the hypothetical value of the enablers is zero, the goals have a value of 89 (See Appendix 5.6). This is represented by the constant value in the regression model as organizations are careful about certain aspects such as competitiveness, safety, reworking etc. and because it might directly affect their profits and reputation. This means that the goals do not depend entirely on the five enablers and firms are likely to achieve some of the goals even if they are not focusing specifically on quality management.

Equation:

Goals = 89 + (0.6 * *Enablers*) *Equation 7.48*

As shown in the Goals dynamic model the initial value of Goals (Equation 7.40) is given as 89. The time period for the running was set at 20 years with a time lapse of 1 year. Vensim and most other dynamic modelling software allow the time period for simulation including the time lapses to be specified. The simulation exercise is continued until the TQM index reaches 1000. The following tables and figures show the outputs of the dynamic simulation results.

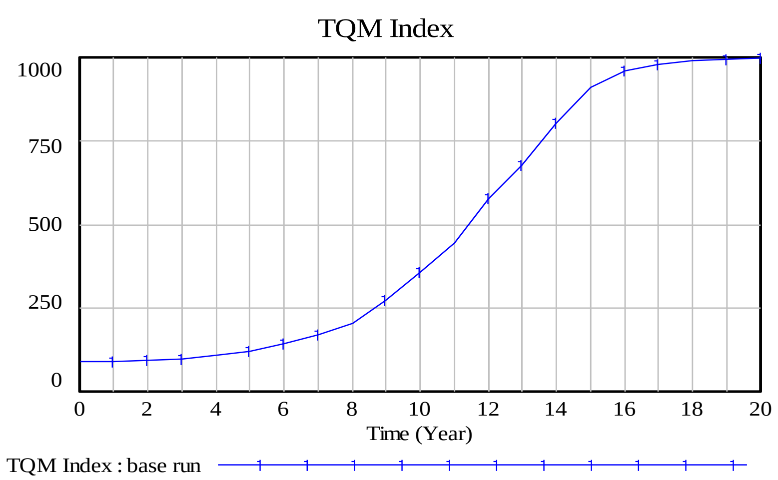


Figure 7-9: TQM index score over time

Figure 7-9 shows that construction firms took approximately 19 years to reach the 1000 score. This means that for an organization, which has a zero score of enablers (i.e. no existing quality management policy); it will take around 19 years to reach the top score of 1000. However, the top TQM maturity level has a starting point of 800, which, according to Figure 7-9, can be reached in the 14th year. This means that the organization will achieve its top TQM maturity level within the 14th year, but the absolute top score will be reached only somewhere around the 19th year. The indicates that the organization will enter the second maturity level in the 8th year, 3rd level in the 11th year, fourth level in the 13th year, and the fifth and the top maturity level in the 14th year.

Figure 7-9 shows that the progression of the firm's TQM maturity is really slow in the beginning taking 7 years to move from first stage to second. However the later progression is really quick with a firm moving from second to third stage within three years and from third to fourth within 2 years. It takes only one year for the firm to move from the fourth to the fifth maturity level. This indicates that the beginning of implementation of the quality management culture within the organization is the most difficult stage, but once the firm starts to follow a quality management strategy the progression towards higher TQM maturity levels is quite quick. It is intuitive as well because changing organizational culture for non-quality focused to quality-focused is a time and resource consuming exercise.

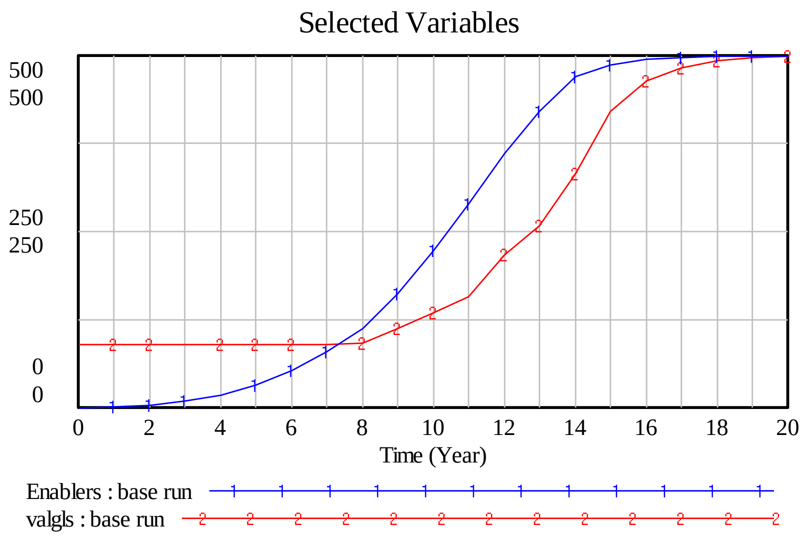
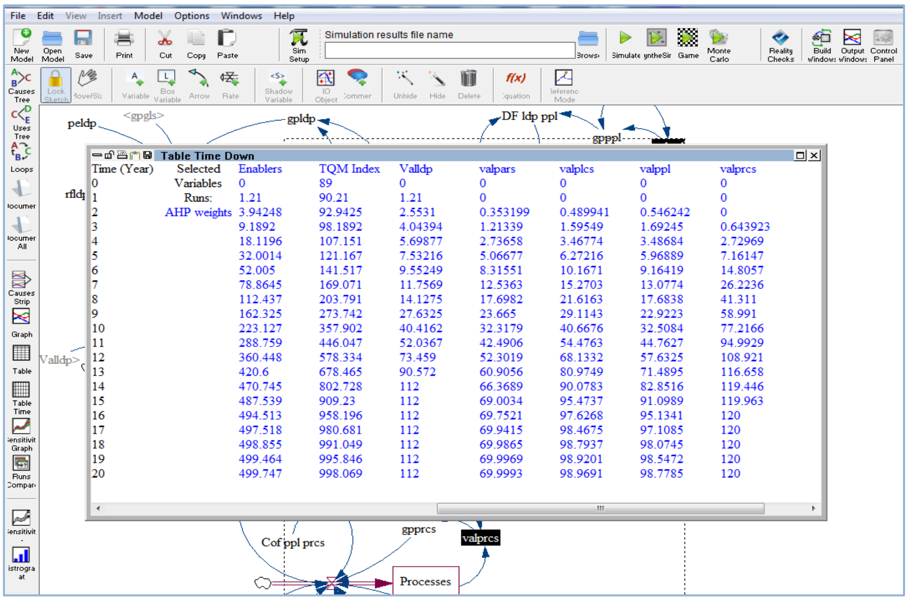


Figure 7-10: Score of Enablers and goals over a set time period

Figure 7-10 show the results of the simulation of enablers and goals in the base run. It can be seen that the goals score does not start to rise considerably until year 8. Then it rises sharply between years 9 and 17. This indicates that firms looking to achieve high TQM score may not see much improvement in results initially; they need to be persistent with quality efforts because quality focused strategy is not short-term. Figure 7-11 presents screenshot of Vensim output window.



Time (Year)	Selected	Enablers	TQM Index	Valldp	valpars	valplcs	valppl	valprcs
0	Variables	0	89	0	0	0	0	0
1	Runs:	1.21	90.21	1.21	0	0	0	0
2	AHP weights	3.94248	92.9425	2.5531	0.353199	0.489941	0.546242	0
3		9.1892	98.1892	4.04394	1.21339	1.59549	1.69245	0.643923
4		18.1196	107.151	5.69877	2.73658	3.46774	3.48684	2.72969
5		32.0014	121.167	7.53216	5.06677	6.27216	5.96889	7.16147
6		52.005	141.517	9.55249	8.31551	10.1671	9.16419	14.8057
7		78.8645	169.071	11.7569	12.5363	15.2703	13.0774	26.2236
8		112.437	203.791	14.1275	17.6982	21.6163	17.6838	41.311
9		162.325	273.742	27.6325	23.665	29.1143	22.9223	58.991
10		223.127	357.902	40.4162	32.3179	40.6676	32.5084	77.2166
11		288.759	446.047	52.0367	42.4906	54.4763	44.7627	94.9929
12		360.448	578.334	73.459	52.3019	68.1332	57.6325	108.921
13		420.6	678.465	90.572	60.9056	80.9749	71.4895	116.658
14		470.745	802.728	112	66.3689	90.0783	82.8516	119.446
15		487.539	909.23	112	69.0034	95.4737	91.0989	119.963
16		494.513	958.196	112	69.7521	97.6268	95.1341	120
17		497.518	980.681	112	69.9415	98.4675	97.1085	120
18		498.855	991.049	112	69.9865	98.7937	98.0745	120
19		499.464	995.846	112	69.9969	98.9201	98.5472	120
20		499.747	998.069	112	69.9993	98.9691	98.7785	120

Figure 7-11: Screenshot of Vensim output window for TQM index and values of enablers in system dynamic model

The following Table 7-7 is a summary of the TQM enabler scores and TQM index scores over a 20-year period.

Table 7-7: Summary of TQM enabler scores and TQM index scores over a 20-year period

Time (Year)	*valprcs*	*Valldp*	*valpars*	*valplcs*	*valppl*	Enablers	TQM Index	TQM maturity level
0	0	0	0	0	0	0	89	1st
1	0.00	1.21	0.00	0.00	0.00	1.21	90.21	1st
2	0.00	2.55	0.35	0.49	0.55	3.94	92.94	1st
3	0.64	4.04	1.21	1.60	1.69	9.19	98.19	1st
4	2.73	5.70	2.74	3.47	3.49	18.12	107.15	1st
5	7.16	7.53	5.07	6.27	5.97	32.00	121.17	1st
6	14.81	9.55	8.32	10.17	9.16	52.01	141.52	1st
7	26.22	11.76	12.54	15.27	13.08	78.86	169.07	1st
8	41.31	14.13	17.70	21.62	17.68	112.44	203.79	2nd
9	58.99	27.63	23.67	29.11	22.92	162.33	273.74	2nd
10	77.22	40.42	32.32	40.67	32.51	223.13	357.90	2nd
11	94.99	52.04	42.49	54.48	44.76	288.76	446.05	3rd
12	108.92	73.46	52.30	68.13	57.63	360.45	578.33	3rd
13	116.66	90.57	60.91	80.97	71.49	420.60	678.47	4th
14	119.45	112.00	66.37	90.08	82.85	470.75	802.73	5th
15	119.96	112.00	69.00	95.47	91.10	487.54	909.23	5th
16	120.00	112.00	69.75	97.63	95.13	494.51	958.20	5th
17	120.00	112.00	69.94	98.47	97.11	497.52	980.68	5th
18	120.00	112.00	69.99	98.79	98.07	498.85	991.05	5th
19	120.00	112.00	70.00	98.92	98.55	499.46	995.85	5th
20	120.00	112.00	70.00	98.97	98.78	499.75	998.07	5th

It can be seen from Table 7-7 that Processes enablers were the strongest contributor in moving the firm from TQM maturity level 1 to level 2. This means that, unless there are quality-related improvements in processes, the TQM maturity level will not improve. Achieving improvement in processes requires time and this could explain why the first TQM maturity level takes the longest to finish. The Leadership enabler plays a key role, but does not in itself result in lifting the firm from first to second TQM maturity level. However, it does play a key role in moving the firms through the third, fourth and fifth maturity levels.

The second most critical enabler in the initial stages was found to be the Partnership and resources enabler. The strongest contribution was from the Processes enabler followed by the Policies and strategy enabler. The contribution of each of the enablers is different, which provides an insight into how a firm's TQM maturity levels may evolve overtime. Leadership starts to make a significant contribution from year 8 onwards, reaching its peak at year 14. At year10 the strongest contribution is still from the Processes enabler, but between years 8 and 10 the Leadership enabler rises from being the weakest contributor to second highest contributor. This means that continued leadership commitment and dedication to TQM implementation past the 8th year, when the firm has already moved to second TQM maturity level, is critical in moving to higher TQM maturity levels. This is the stage where management must exhibit their continued commitment to quality and engage in quality culture reinforcement approaches such as quality auditing and continuous quality development exercises. What is also noticeable is that as the Leadership enabler starts to pick up in year 8, the rise in the maturity level becomes much faster and the firms rise through maturity levels much more quickly. What these results mean that is that firms need to focus on the Leadership enabler in order to expedite their progression through the TQM maturity levels. This is intuitive as leadership affects the People, Partnerships and resources, Policies and strategy enablers. It has a multifaceted impact on Goals by affecting People, Partnership and Resources, Policies and Strategy enablers.

Table 7-8 shows the year-on-year percent changes in the enablers, the TQM index and the goals score.

Table 7-8: Year-on-Year percent changes in enablers, Goals score and TQM index.

Time (Year)	Enablers	Year on year % change in Enablers score	Goals	Year on year % change in Goals score	TQM Index	Year on year % change in TQM index score	TQM maturity level
0	0		89		89		1st
1	1.21		89	0.00%	90.21		1st
2	3.94	225.82%	89	0.00%	92.94	3.03%	1st
3	9.19	133.08%	89	0.00%	98.19	5.65%	1st
4	18.12	97.18%	89.03166	0.00%	107.15	9.13%	1st
5	32	76.61%	89.1655	0.20%	121.17	13.08%	1st
6	52.01	62.51%	89.51233	0.40%	141.52	16.80%	1st
7	78.86	51.65%	90.20642	0.80%	169.07	19.47%	1st
8	112.44	42.57%	91.35442	1.30%	203.79	20.54%	2nd
9	162.33	44.37%	111.417	22.00%	273.74	34.32%	2nd
10	223.13	37.46%	134.7754	21.00%	357.9	30.74%	2nd
11	288.76	29.41%	157.2882	16.70%	446.05	24.63%	3rd
12	360.45	24.83%	217.8862	38.50%	578.33	29.66%	3rd
13	420.6	16.69%	257.8657	18.30%	678.47	17.31%	4th
14	470.75	11.92%	331.9831	28.70%	802.73	18.32%	5th
15	487.54	3.57%	421.6915	27.00%	909.23	13.27%	5th
16	494.51	1.43%	463.6832	10.00%	958.2	5.39%	5th
17	497.52	0.61%	483.1635	4.20%	980.68	2.35%	5th
18	498.85	0.27%	492.1946	1.90%	991.05	1.06%	5th
19	499.46	0.12%	496.3814	0.90%	995.85	0.48%	5th
20	499.75	0.06%	498.3224	0.40%	998.07	0.22%	5th

Figure 7-9 and Table 7-8 shows the enablers' score was initially zero and then started to rise. Over time, the % change in rise of this score goes down, but the real change (in number of units) goes up. The Enabler's score reaches its peak in the 17th year, yet Goals score and TQM index score reach its peak two years later in the 19th year (Table 7-8). This shows the lag between the efforts towards quality management and improvement and the visibility of results which always occur a few years later. At the beginning, the enabler's score is zero and Goal score is 89. The TQM index score which is the sum of Goals and Enablers' score is also 89. This means at the beginning the value of different gaps is as follows:

Table 7-9: Gap between desired and actual value of enablers and goals at the beginning in system index model

	Desired	Value	Gap
Leadership	112	0	112
People	99	0	99
Policy and strategy	99	0	99
Partnerships and resources	70	0	70
Processes	120	0	120
Goals	500	89	411
Total			**911**

The big gap in Goals is what boosts the leadership, as leaders are observant of the results. This is evident in the rise of the value of leadership. However, leadership does not affect the goals directly but through the other four enablers. The rise in leadership leads to rise in the other four enablers. This eventually leads to rise in Goals Score as well as TQM index score. Figure 7-12 indicates the graph for scores of different enablers.

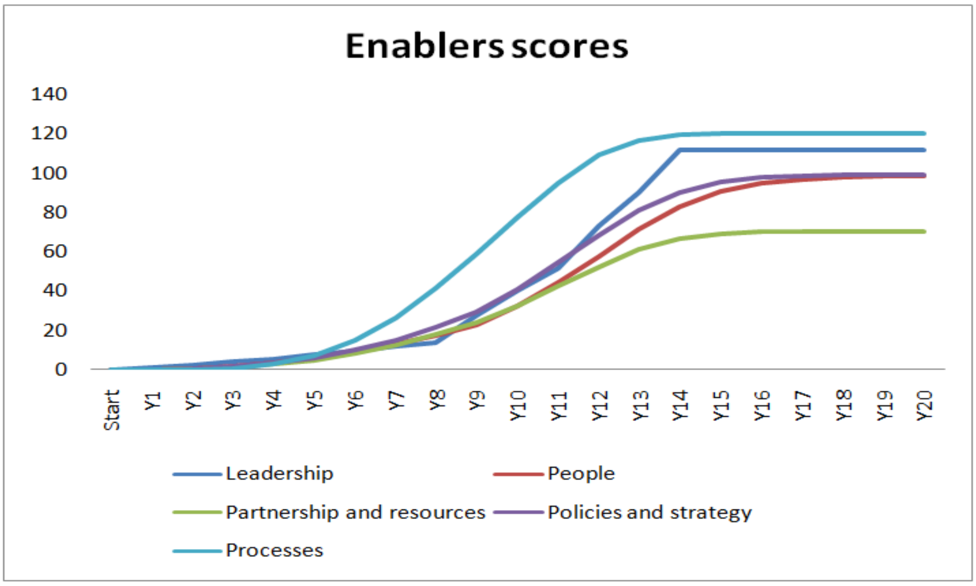


Figure 7-12: Trend of different enablers over time

Table 7-10: Percentage change in values of enablers over time

(TimeYear)	Leadership		People		Partnership &resources		Policies and strategy		Processes		Goals score	
	Score	% change	Score	% change	Score	% change	Score	% change	Score	% change	Score	% change
0	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	89	
1	1.21	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	89	0.00%
2	2.5531	111.00%	0.54624	0.00%	0.3532	0.00%	0.48994	0.00%	0	0.00%	89	0.00%
3	4.04394	58.39%	1.69245	209.84%	1.21339	243.54%	1.59549	225.65%	0.64392	0.00%	89	0.00%
4	5.69877	40.92%	3.48684	106.02%	2.73658	125.53%	3.46774	117.35%	2.72969	323.92%	89.03166	0.00%
5	7.53216	32.17%	5.96889	71.18%	5.06677	85.15%	6.27216	80.87%	7.16147	162.35%	89.1655	0.20%
6	9.55249	26.82%	9.16419	53.53%	8.31551	64.12%	10.16711	62.10%	14.80571	106.74%	89.51233	0.40%
7	11.75691	23.08%	13.07738	42.70%	12.53634	50.76%	15.27029	50.19%	26.22362	77.12%	90.20642	0.80%
8	14.12746	20.16%	17.68382	35.22%	17.69817	41.17%	21.61626	41.56%	41.31103	57.53%	91.35442	1.30%
9	27.6325	95.59%	22.92231	29.62%	23.66503	33.71%	29.1143	34.69%	58.991	42.80%	111.417	22.00%
10	40.41621	46.26%	32.50842	41.82%	32.31786	36.56%	40.66757	39.68%	77.21663	30.90%	134.7754	21.00%
11	52.0367	28.75%	44.76267	37.70%	42.4906	31.48%	54.4763	33.96%	94.99288	23.02%	157.2882	16.70%
12	73.45903	41.17%	57.6325	28.75%	52.3019	23.09%	68.13325	25.07%	108.9214	14.66%	217.8862	38.50%
13	90.57204	23.30%	71.4895	24.04%	60.90561	16.45%	80.97488	18.85%	116.6578	7.10%	257.8657	18.30%
14	112	23.66%	82.85157	15.89%	66.3689	8.97%	90.07831	11.24%	119.4462	2.39%	331.9831	28.70%
15	112	0.00%	91.0989	9.95%	69.0034	3.97%	95.47375	5.99%	119.9629	0.43%	421.6915	27.00%
16	112	0.00%	95.13415	4.43%	69.75211	1.09%	97.6268	2.26%	119.9998	0.03%	463.6832	10.00%
17	112	0.00%	97.10851	2.08%	69.94147	0.27%	98.46751	0.86%	120	0.00%	483.1635	4.20%
18	112	0.00%	98.07453	0.99%	69.98654	0.06%	98.79374	0.33%	120	0.00%	492.1946	1.90%
19	112	0.00%	98.54719	0.48%	69.99695	0.01%	98.92013	0.13%	120	0.00%	496.3814	0.90%
20	112	0.00%	98.77845	0.23%	69.99931	0.00%	98.96907	0.05%	120	0.00%	498.3224	0.40%

It is evident from Table 7-10 that the first enabler to change is Leadership, which starts to rise in year 1; the other enablers do not change within year 1 only. They start to change in year 2. Figure 7-12 shows trend of different enablers over time. This indicates that there is a lag between different enablers working resulting in an increase in TQM index score. Thus, any efforts invested in improving quality will only yield results after a few years. Persistence with efforts is therefore required. One of the reasons why TQM initiatives often fail in organizations is that they expect instant results and are not willing to invest time, effort and resources in initiatives which provide only long-term benefits and no short-term benefits.

In addition to the simulation results above, tests were considered to compare how the five enablers change with the change in TQM index score. The first was to compare the Leadership and TQM index scores.

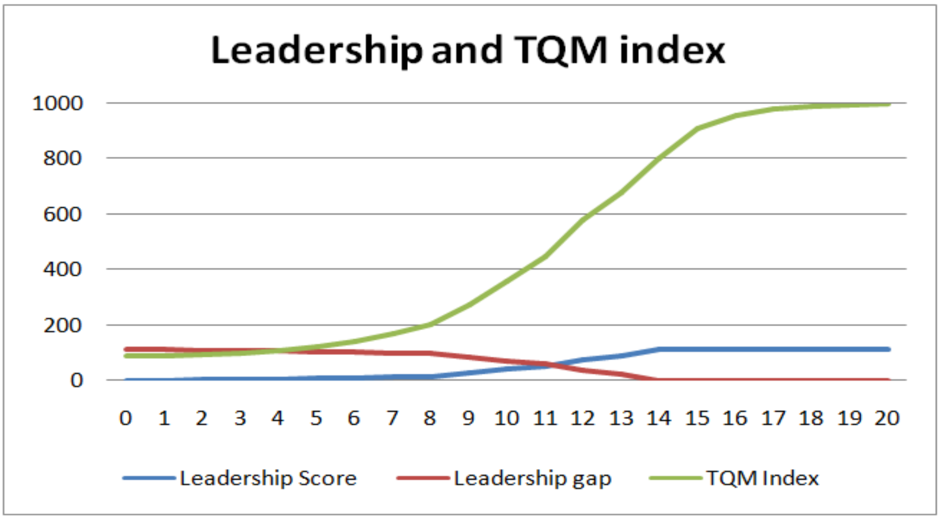


Figure 7-13: Trends in leadership enabler and TQM index score over time

According to Figure 7-13, the leadership gap declines to almost zero in year 14when the firms reaches top maturity level. The firm however, almost reaches the top score of 1000 in almost year 19. This means that from year 14 to year 19 i.e. the time period from when firm enters the top level to the time when firm reaches the top maturity index score, the contribution of leadership enabler is quite low. This means that beyond year 14(i.e. beyond the time when firm enters the top maturity level) the impact of the Leadership enabler on TQM score may be saturated. Also the contribution of leadership enabler rises significantly from year 8 onwards i.e. when the firm is in second maturity level to 14th year i.e. when the firm enters the top maturity level. This means that the leadership enabler's most significant contribution is in lifting organization from the second to the top maturity level.

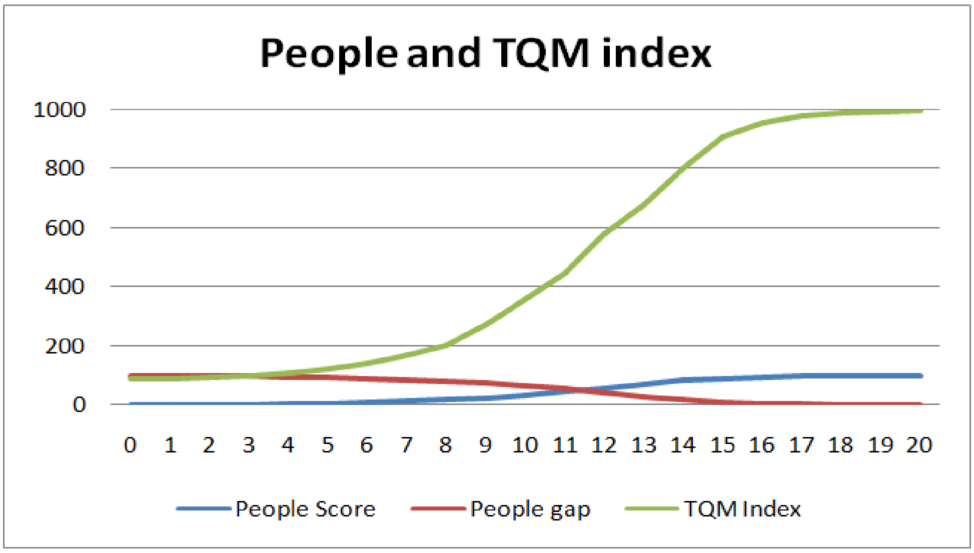


Figure 7-14: Trends in People enabler and TQM index score over time

In Figure 7-14, the people score gap declines significantly after 14th year i.e. after when the firm enters the top TQM maturity level. The contribution becomes negligible after 15th year. This means that people's enabler, like leadership enabler, makes most significant contribution in lifting organization from 2nd to 5th TQM maturity level.

Figures 7-15 to 7-17 indicate that the three enablers People; Partnership and Resources, and; Policies and strategy, continue to affect the TQM score till the TQM index score of 1000 is achieved. This means that the impact of the People, Partnership and Resources, and Policies and strategy enablers will be higher towards the end of the TQM index curve. However, improvement in TQM maturity levels will be seen only with an improvement in the Processes enabler as explained before. This means that, unless improvement in the Leadership enabler leads to improvement in the Processes enabler, the firm's TQM maturity level will not improve. The Process enabler will improve through the three enablers (People, Partnership and Resources, Policies and Strategy) which are affected by the Leadership enabler. This means that the Leadership enabler must improve other enablers before the state of the system changes from TQM maturity level 1 to TQM maturity level 2. Once the process change have been initiated and the firm has moved through the first two TQM maturity levels, improvement in enablers such as Leadership and People will have a more significant impact on TQM index score. This will speed up the firm's progression from 2nd to 5th maturity levels.

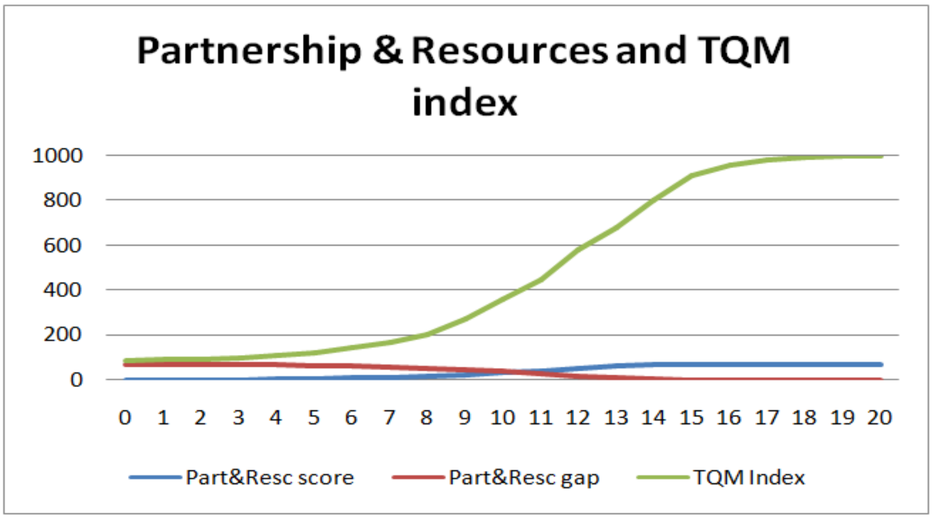


Figure 7-15: Trends in Partnership & resources enabler and TQM index score over time

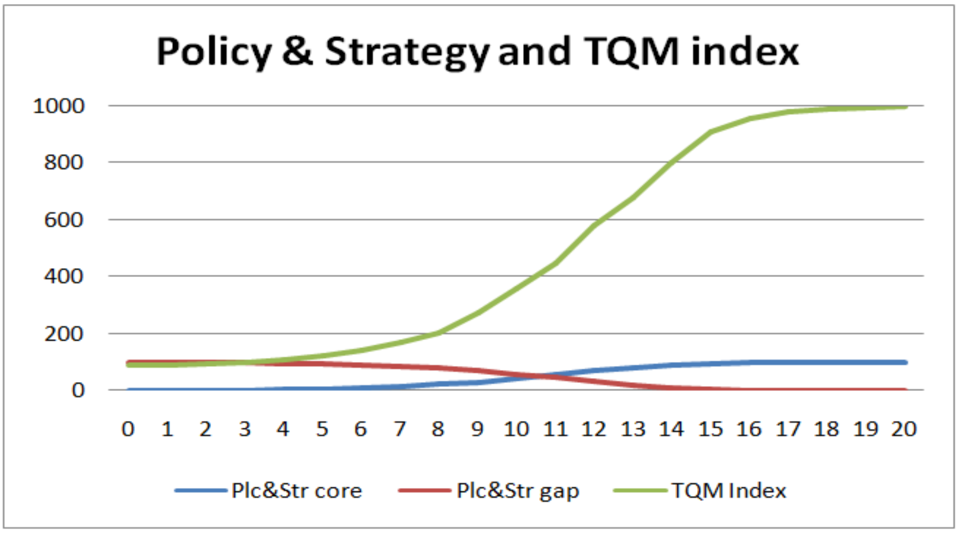


Figure 7-16: Trends in Policies & Strategy enabler and TQM index score over time

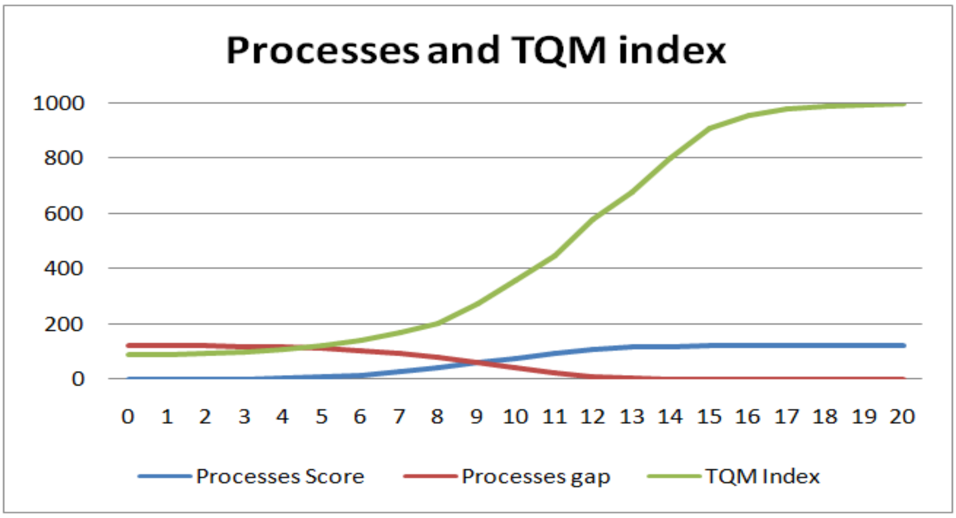


Figure 7-17: Trends in Processes enabler and Goals score over time

7.4 Validation of the model

Validation of the model is an important procedure in its development (Wong and Li, 2010). The validation process aims to ensure that the findings can be generalised and that they represent the characteristics of a general population (Hair *et al.* 1998). There are two dimensions of the validation process: external validation and internal validation. External validation refers to the expert opinion using face-to-face interviews or a postal survey to validate the model. For the external validation of this research's model, pilot study with10 Saudi quality managers have been conducted to obtain the expert opinion of the model's measures. The managers were requested to comment on all aspects of the measures including its layout, distribution of questions in each section, nature of questions, ease of understanding each and every question and, in addition, any recommendations on how the questionnaire could be improved for better understanding of individuals who will have no direct access to the researcher.

Internal validation comprises two steps: Cronbach's alpha to confirm the reliability of the measures of TQM and second a behavioural sensitivity analysis. Behavioural sensitivity analysis aims to test the robustness of the model, by confirming that the estimating errors and the uncertainties do not significantly affect the overall behaviour of the model (Forrester and Senge, 1980). When a parameter or behavioural relationship is altered and its behaviour does not change drastically, the model is considered robust (Tang and Ogunlana, 2003).

7.4.1 **Behavioural Sensitivity analysis**

Sensitivity analysis is used to determine how "sensitive" a model is to changes in the value of the parameters of the model, and to changes in the structure of the model (Skribans, 2016; Saltelli, 2002). Sensitivity analysis is an important tool in the model building process. By showing that the system does not react greatly to a change in a parameter value, it reduces the modeller's uncertainty in the behaviour (Wan, Kumaraswamy and Liu, 2013). In addition, it gives an opportunity for a better understanding of the dynamic behaviour of the system.

Sensitivity analysis is useful in understanding how the TQM index score is likely to change with changes in values of different parameters. The modeller must pick the parameters expected to have most influence on the behaviour, or the exhibit uncertainty, and only use those in the sensitivity analysis. In this research there are two sets of parameters:

First parameter is the desired value of each enabler which is the weight that has been determined using the AHP process. The system is designed to seek these desired values for each enabler and goals. Since these desired values are what drive the system, changing these values may actually affect the behaviour of the system. One of the parameters used for sensitivity analysis was the desired value of the enablers. The values were changed – increased and decreased by 10% and 25% of the desired value obtained through the AHP process. The rise or decline in the enabler's desired value was equally compensated by altering the desired values of the other four enablers, so as the total of the desired values of five enablers remained 500.

Second set of parameters that is likely to affect the system is the path coefficients, which determine the relationship between different enablers as well as between enablers and goals. The change in these path coefficients may affect the system, both in terms of how soon it reaches top maturity stage, and in terms of the path the system takes in order to reach the top maturity stage. Like the desired value parameters, path coefficient were increased and decreased by 25% of their base values. However, unlike sensitivity analysis for the desired value parameters, changes in path coefficients did not involve altering the values of other path coefficients.

Discussed below are the outputs of different sensitivity analysis tests.

7.4.1.1 Sensitivity analysis for desired values of each enabler

Sensitivity to desired value of Leadership enabler

Desldp is increased by 10% and then decrease by 10%. The same process was repeated for varying the desired value of leadership enabler by 25%. For example, Desldp is increased by 25% from 112 to 140. The increase of 28 units in desldp was balanced by reducing the desired value of the remaining four enablers by 28/4 = 7 units so that the total of the desired value of the enablers score remains at 500. The revised scores are used to review the model and the corresponding simulation was named as "*desldp*+25%". Next *desldp* value was reduced by 25% from 112 to 84. The reduction of 28 units in *desldp* was balanced by increasing the desired value of the remaining four enablers by 28/4 = 7 units so that the total of the desired value of the enablers score remains at 500. The revised scores are used to review the model and the corresponding simulation was named as "*desldp*-25%".The revised scores are presented in table below:

Table 7-11 Values of different enablers used to conduct analysis of system sensitivity to the desired value of leadership enabler

Desired value of TQM enablers	AHP Weight (Base run)	*desldp* + 10%	*desldp* -10%	*desldp* + 25%	*desldp* -25%
Leadership	112	123.2	100.8	140	84
People	99	96.2	101.8	92	106
Policy and strategy	99	96.2	101.8	92	106
Partnerships and resources	70	67.2	72.8	63	77
Processes	120	117.2	122.8	113	127
Total	500	500	500	500	500

The Figure 7-18 shows the TQM index score for the four set of values given in the table above:

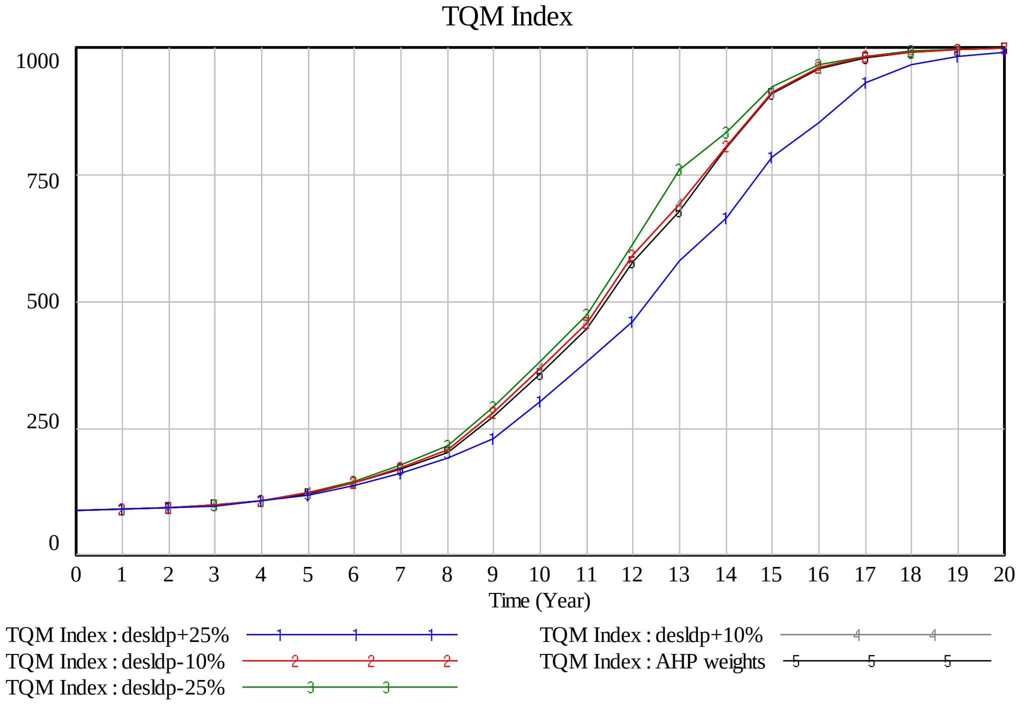


Figure 7-18 Sensitivity of system to the variation in desired value of leadership enabler

The Figure (7-18) shows that while the shape of the curve remains the same there is shift in the positioning of the curve. When the desired leadership enabler values are increased or reduced by 10% of the original (base run values) there is minimal impact on the curve. With the *desldp* value lowered by 25% the system may reach TQM maturity stages sooner than it does in the base run, which again is sooner than the case when *desldp* value is 25% higher. This means that the leadership enabler plays a significant role in the achievement of higher levels of TQM maturity. The higher desired value of leadership represents higher contribution of leadership enabler. This represents countries with high power distance where decision-making is centralised. According to the Figure 7-18, it will take longer to achieve TQM maturity in environments where the desired value of leadership enabler is high i.e. in countries where the decision-making is more centralised. Organisations with decentralised decision making are likely to achieve TQM maturity sooner in comparison to organisation with less decentralisation of decision making.

The shape of the curve remains the same, which indicates that the variation in *desldp* value is unlikely to affect how the system behaves.

Sensitivity to desired value of People enabler

The second sensitivity analysis test involved changing the desired value of people enabler i.e. *desppl* by 10 and 25%.

The revised scores are presented in Table 7-12 below:

Table 7-12 Values of different enablers used to conduct analysis of system sensitivity to the desired value of people enabler

Desired value of TQM enablers	AHP Weight (Base run)	*desppl* + 10%	despp -10%	*desppl* + 25%	*desppl* -25%
Leadership	112	109.525	114.475	105.8125	118.1875
People	99	108.9	89.1	123.75	74.25
Policy and strategy	99	96.525	101.475	92.8125	105.1875
Partnerships and resources	70	67.525	72.475	63.8125	76.1875
Processes	120	117.525	122.475	113.8125	126.1875
Total	500	500	500	500	500

The chart below shows the TQM index score for the cases mentioned in the table above:

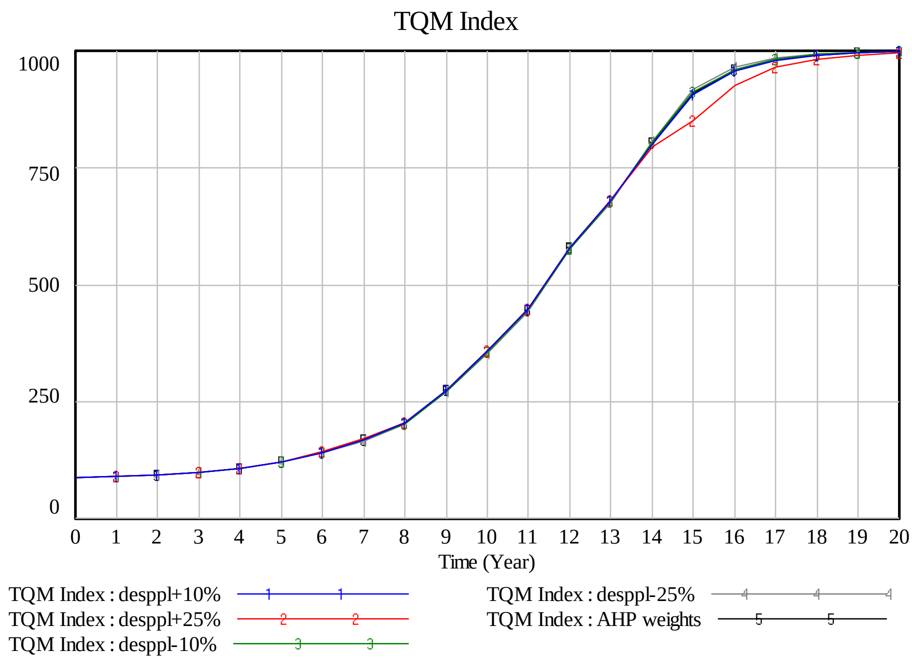


Figure 7-19 Sensitivity of system to the variation in desired value of people enabler

No change was recorded when the desired value of desppl was raised or reduced by 10%. Figure 7-19 indicates that when the desired value of people enabler is altered by 25% of its base value, the shape of the curve remains the same, but there is some shift in the positioning of the curve in the fifth TQM maturity stage. This shows that the system is insensitive to +25% variations in the desired value of people enabler. The impact in the final stage of TQM maturity indicates that changing the desired value of people enabler by +25% will have no impact on the firm’s ability to reach the highest TQM maturity stage but it may somewhat affect the firm in the final TQM maturity stage.

The shape of the curve slightly remains the same which indicates that the variation in *desppl* value up to +25% is unlikely to affect how the system behaves.

Sensitivity to desired value of Policies and strategy enabler

The third sensitivity analysis test involved changing the desired value of policies and strategy enabler i.e. *desplcs* by 10 and 25%. The revised scores are presented in Table 7-13:

Table 7-13 Values of different enablers used to conduct analysis of system sensitivity to the desired value of Policies and Strategy enabler

Desired value of TQM enablers	AHP Weight (Base run)	*desplcs* + 10%	*desplcs* -10%	*desplcs* + 25%	*desplcs* -25%
Leadership	112	109.525	114.475	105.8125	118.1875
People	99	96.525	101.475	92.8125	105.1875
Policy and strategy	99	108.9	89.1	123.75	74.25
Partnerships and resources	70	67.525	72.475	63.8125	76.1875
Processes	120	117.525	122.475	113.8125	126.1875
Total	500	500	500	500	500

The figure 7-20 shows the TQM index score for the cases mentioned in the table above:

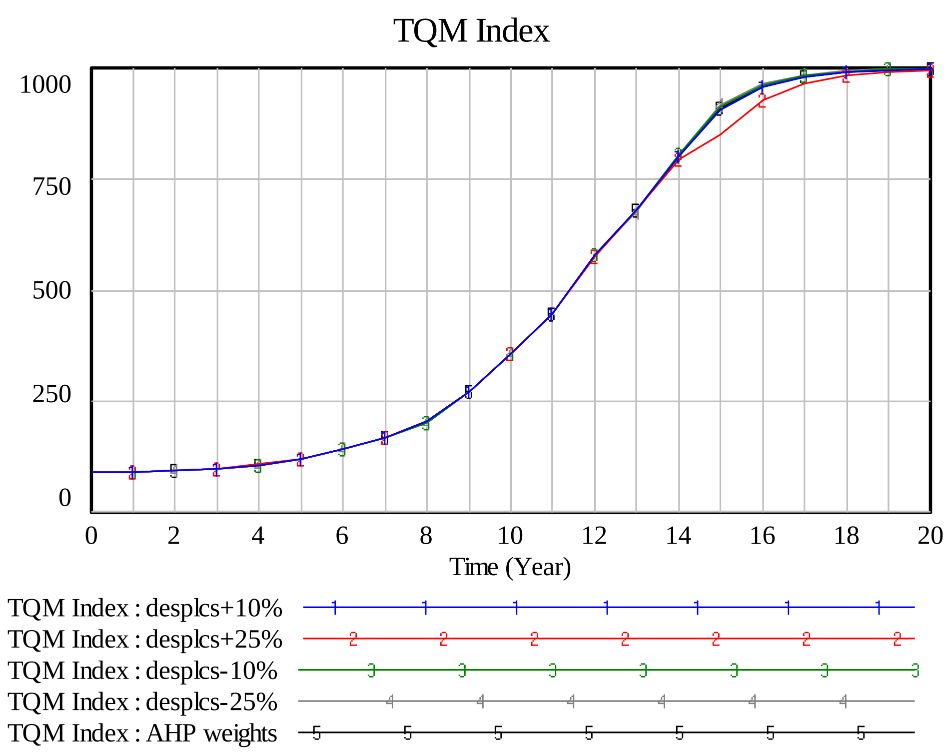


Figure 7-20 Sensitivity of system to the variation in desired value of Policies and Strategy enabler

With change in desired value of policies and strategy enabler also the system only shows slight deviation from its original (i.e. base run). the shape of the curve remains S shaped indicating that the system's behaviour remains slightly similar even with 25% rise or decline in *desplcs* value.

Sensitivity to desired value of Partnership & Resources enabler

The fourth sensitivity analysis test involved changing the desired value of Partnership & Resources enabler i.e. *despars* by 10 and 25%.

The revised scores are presented in table below:

Table 7-14 Values of different enablers used to conduct analysis of system sensitivity to the desired value of Partnership & Resources enabler

Desired value of TQM enablers	AHP Weight (Base run)	*despars* + 10%	*despars* -10%	*despars* + 25%	*despars* -25%
Leadership	112	110.25	113.75	107.625	116.375
People	99	97.25	100.75	94.625	103.375
Policy and strategy	99	97.25	100.75	94.625	103.375
Partnerships and resources	70	77	63	87.5	52.5
Processes	120	118.25	121.75	115.625	124.375
Total	500	500	500	500	500

The chart below shows the TQM index score for the cases mentioned in the table above:

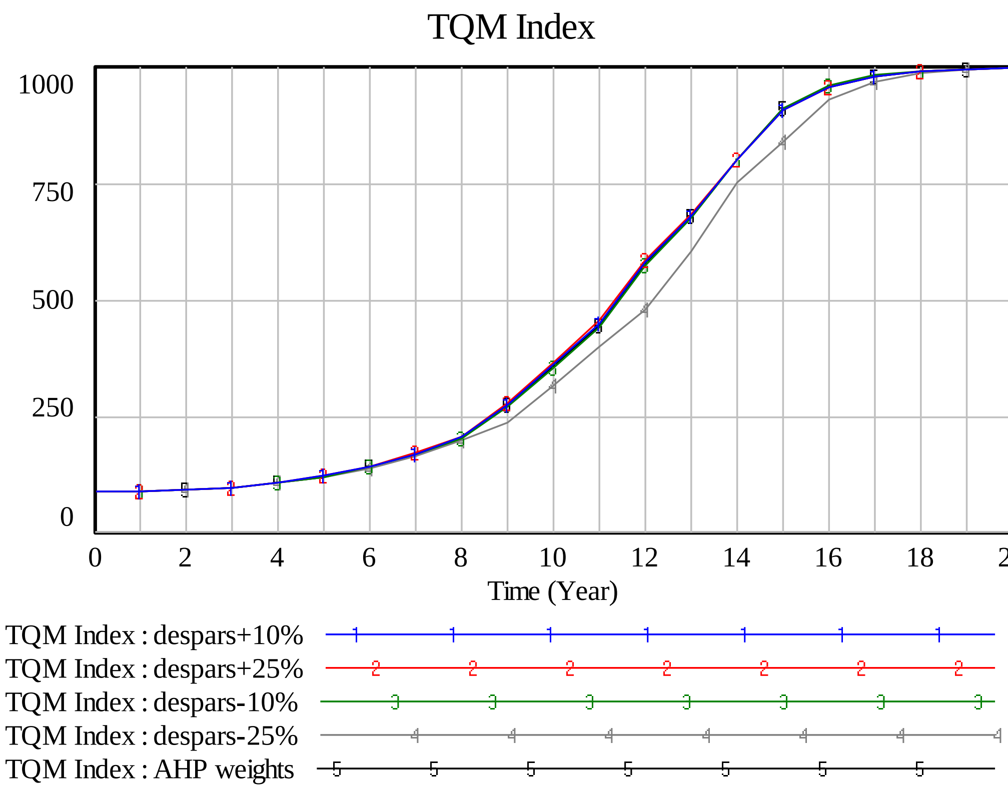


Figure 7-21 Sensitivity of system to the variation in desired value of Partnership & Resources enabler

Figure 7-21 shows that with 10% reduction in value of *despars*, no shift in curve is observed indicating insensitivity to 10% variation in the *despars* value. It also shows that the curve remains *S* shaped and follow the same path when *despars* in increased by 25%. However, when *despars* is reduced by 25% the time taken to reach higher TQM maturity stages is slightly prolonged. This is probably because the decline in *despars* is reflected in the rise in values of desired values of other enablers in particular the leadership and people enablers. Leadership and people enablers should reach their desired values quicker than any other enabler; hence increasing their desired value is likely to prolong the achievement of higher TQM maturity levels.

The curves have minimal change in positions but remains *S* shaped reaching the top maturity score around the same time. This shows that the system does not behave abnormally with rise or decline in the value of *despars* up to 25% rise.

Sensitivity to desired value of Processes enabler

The fifth sensitivity analysis test involved changing the desired value of Processes enabler i.e. *desprcs* by 25%.

The revised scores are presented in table below:

Table 7-15 Values of different enablers used to conduct analysis of system sensitivity to the desired value of Processes enabler

Desired value of TQM enablers	AHP Weight (Base run)	*desprcs* + 10%	*desprcs* -10%	*desprcs* + 25%	*desprcs* -25%
Leadership	112	109	115	104.5	119.5
People	99	96	102	91.5	106.5
Policy and strategy	99	96	102	91.5	106.5
Partnerships and resources	70	67	73	62.5	77.5
Processes	120	132	108	150	90
Total	500	500	500	500	500

The chart below shows the TQM index score for the cases mentioned in the table above:

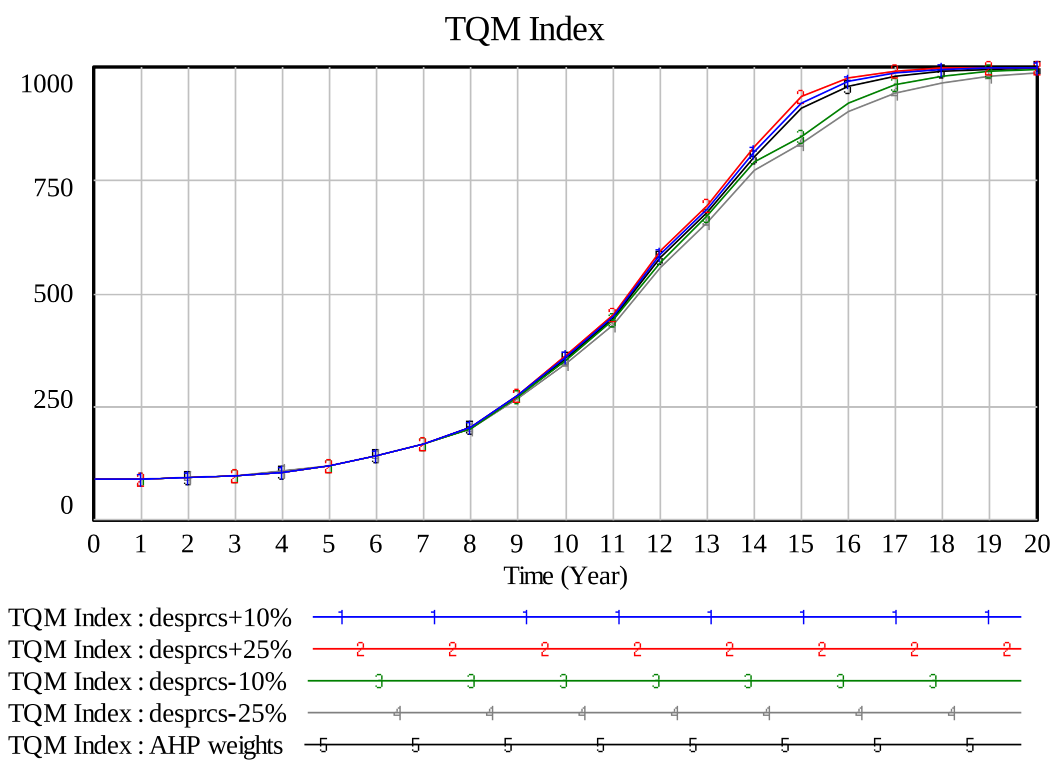


Figure 7-22 Sensitivity of system to the variation in desired value of Processes enabler

Figure 7-22 shows that the curve remains *S* shaped and follow the same path when *desprcs* in increased by 25%. Like in case of *despars*, reduction in values of *desprcs* also prolongs firm's attainment of the higher TQM maturity stages. As mention before, this could be because reduction in *desprcs* leads to rise in desired value of other enablers and because they all are expected to reach the desired level before Processes enabler, some degree of prolongation is expected with decline in *desprcs*.

The curves are just shifted slightly in positions but remains *S* shaped reaching the top maturity score around the same time. This shows that the system does not behave abnormally with rise or decline in the value of *desprcs*.

Sensitivity analysis for path coefficients

Sensitivity analysis for the path coefficients was conducted by varying the values of the path coefficients by ±25% of their original (i.e. base run) values. Table 7-16 shows the values of the path coefficients used for different sensitivity analysis tests:

Table 7-16 Values of the path coefficients used for different sensitivity analysis tests

Path coefficients	Base run values	Path coefficients +25%	Path coefficients -25%
Cof ldp pars	0.417	0.52125	0.31275
Cof ldp plcs	0.409	0.51125	0.30675
Cof ldp ppl	0.456	0.57	0.342
Cof ppl pars	0.312	0.39	0.234
Cof pars prcs	0.47	0.5875	0.3525
Cof pars plcs	0.221	0.27625	0.16575
Cof plcs prcs	0.374	0.4675	0.2805
Cof ppl prcs	0.343	0.42875	0.25725
Cof Prcs Gls	0.447	0.55875	0.33525

Figures 7-23 to 7-31 show the TQM maturity graphs for sensitivity test of different path coefficients:

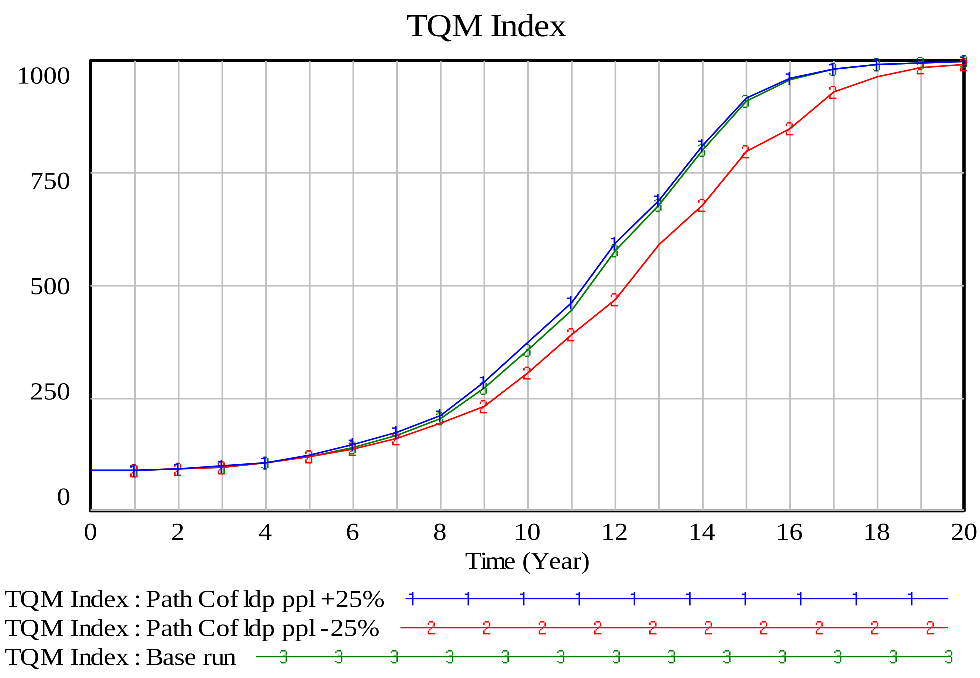


Figure 7-23 Sensitivity of system to the variation in path coefficient between leadership and people enabler

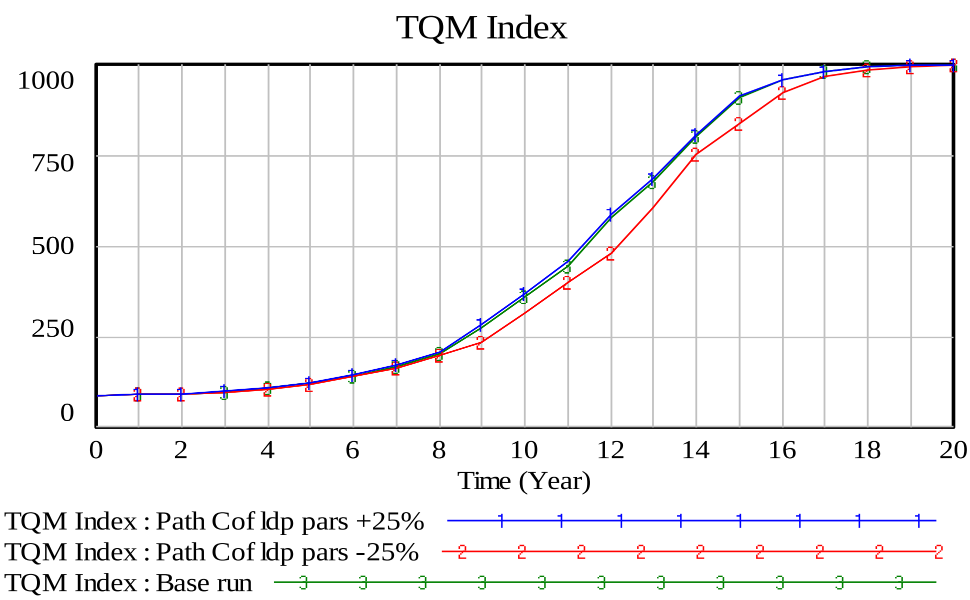


Figure 7-24 Sensitivity of system to the variation in path coefficient between Leadership and Partnership & resources enabler

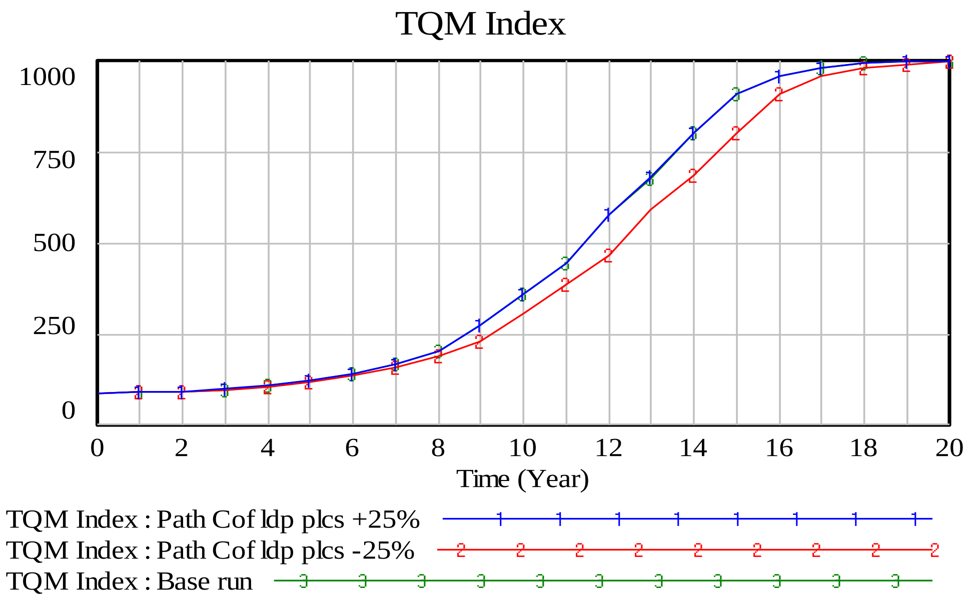


Figure 7-25 Sensitivity of system to the variation in path coefficient between Leadership and Polcies & Strategy enabler

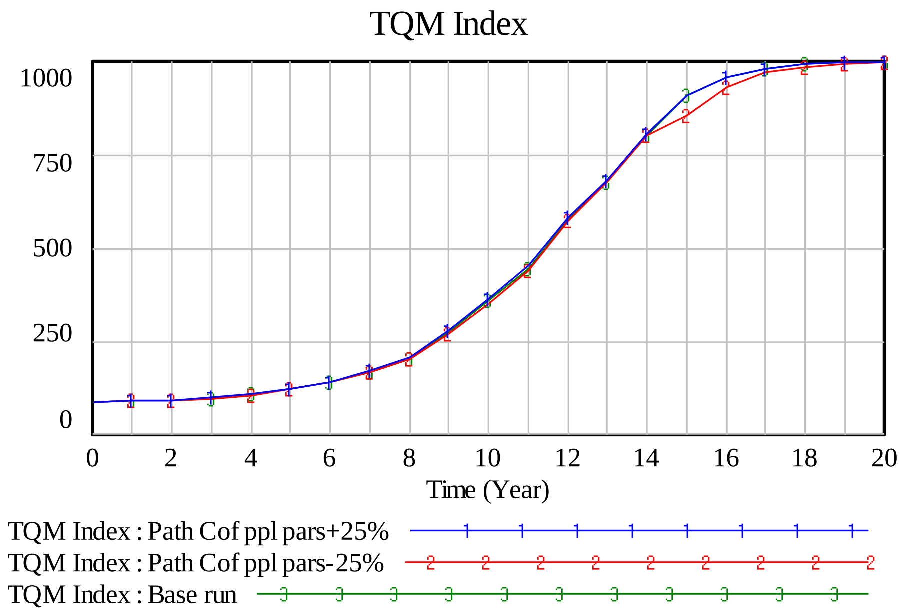


Figure 7-26 Sensitivity of system to the variation in path coefficient between People and Partnership & Resources enabler

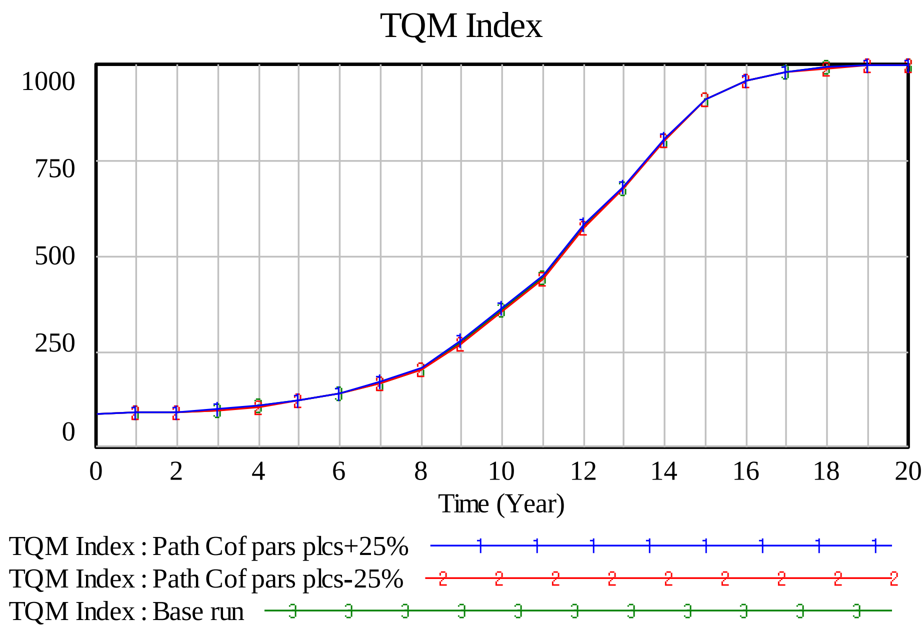


Figure 7-27 Sensitivity of system to the variation in path coefficient between Partnership & Resources and Policies & Strategy enabler

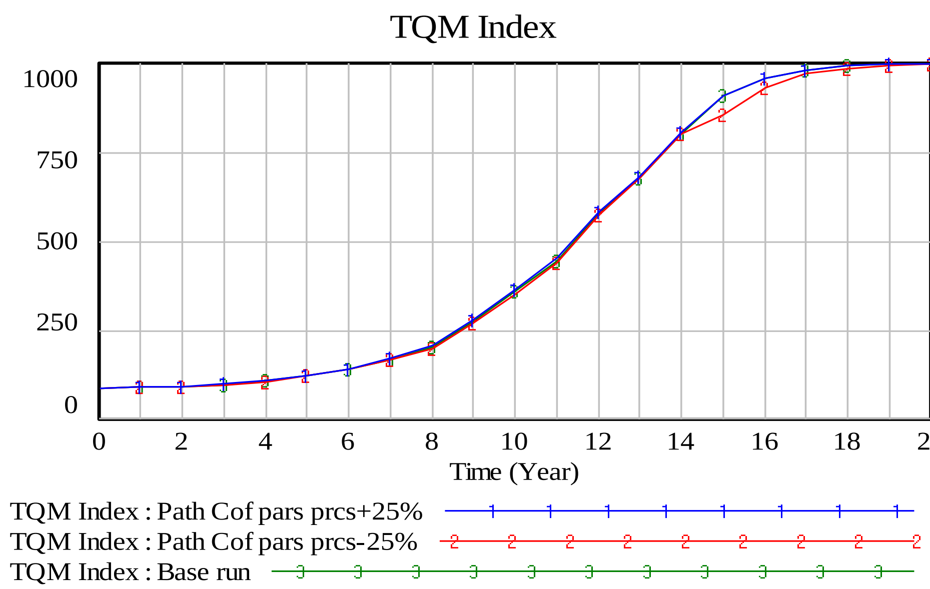


Figure 7-28 Sensitivity of system to the variation in path coefficient between Partnership & Resources and Processes enabler

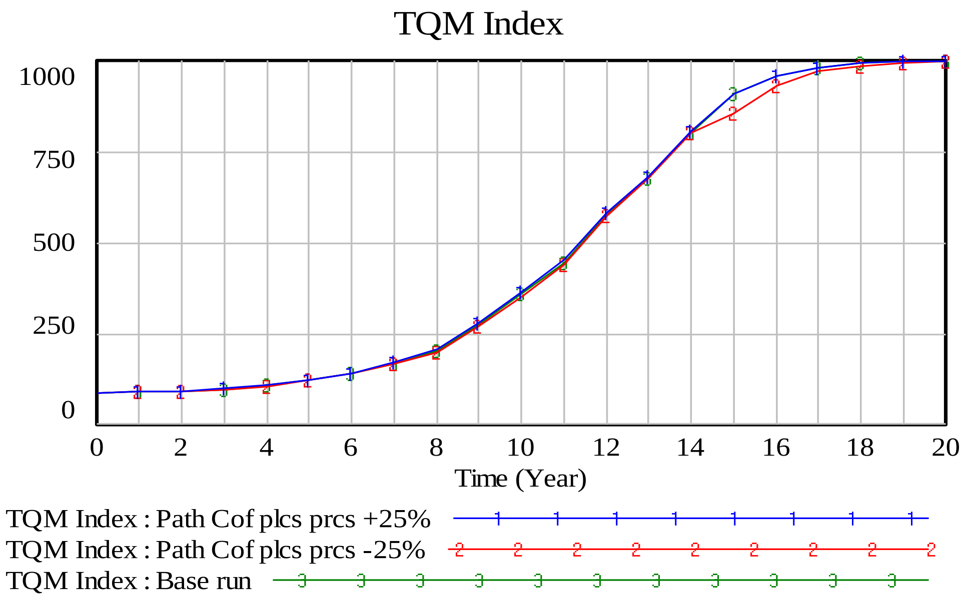


Figure 7-29 Sensitivity of system to the variation in path coefficient between Policies & Strategy and Processes enabler

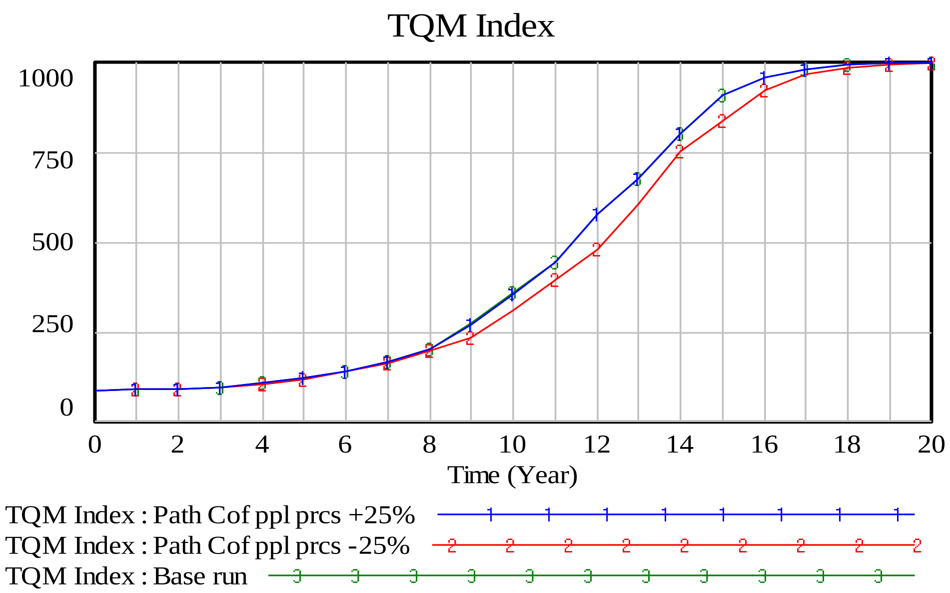


Figure 7-30 Sensitivity of system to the variation in path coefficient between People and Processes enabler

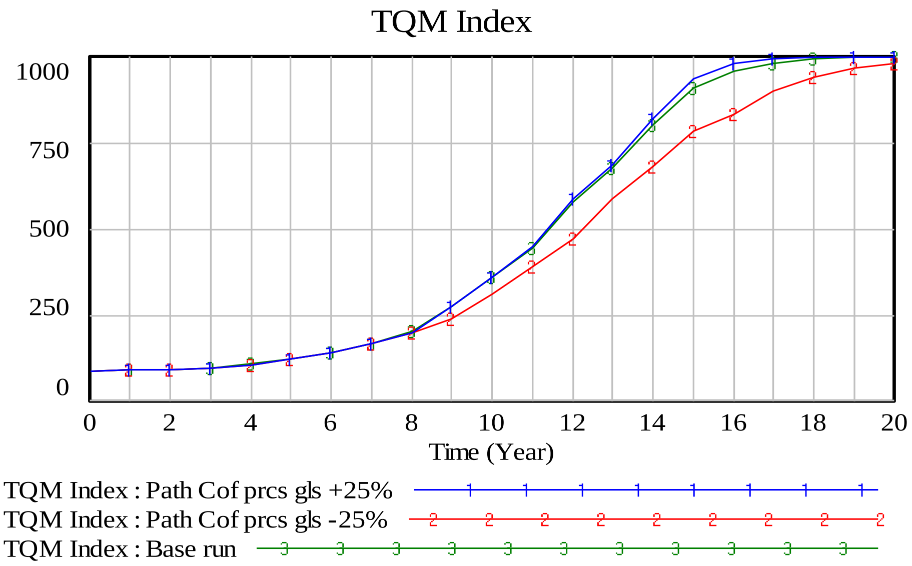


Figure 7-31 Sensitivity of system to the variation in path coefficient between Processes and Goals enabler

In all of the above cases the curve remains slightly the same with change in values of path coefficients suggesting that the system is not sensitive to the change in values of path coefficients. In all of the sensitivity tests above, the parameter values were changed by +25%, indicating that the system is robust and stable up to at least 25% variation in the parameter estimates. Even in the cases where the curve showed some deviation from the base run curve, the shape of the S shaped curve remains the same, indicating that the system behaves as expected.

7.5 Policy testing

Policy testing of a model involves varying the policy decisions and estimating their impact on the system. Policy testing of this kind helps in identifying which enablers should be paid more attention in order to achieve the desired results quicker. This is because organizations have limited resources to spend on quality management. By optimizing these resources, the organization can maximize its gains from utilizing available resources. Policy testing plays a critical role in quality related decision making.

In the first policy test, the value of *peldp* (percentage of effort invested in improving leadership enabler) was increased to 10% i.e. its initial value was set to 0.1 instead of 0 while leaving everything else the same. Then the simulation was run and the simulation results were saved as "*peldp* 10". After this the value of *peldp* was turned back to zero and the value of *peppl* (percentage of effort invested in improving people enabler) was increased to 10% i.e. its initial value was set to 0.1 instead of 0, while leaving everything else the same. Then the simulation was run and the simulation results were saved as "*pepple* 10". The same exercise was repeated for all the enablers and the simulation results were saved with their respective names. Then a graph shows the results of the impact of increasing the percentage efforts in improving different enablers and its impact on the TQM index score. The results were also compared with the base run model.

Figure 7-32 shows that the TQM index score is most responsive to the Leadership enabler, a 10% increase in improving the Leadership enabler will reduce the time required to reach the 1000 TQM score from 19 years (in base run) to 13 years (leadership run). The impact of increasing the efforts in improving the Partnership and strategy, and People enablers is similar, both leading to the achievement of the highest score sometime in 15thand 16th years. Improving the Policies and stagey enabler will probably reduce this time by two years while increasing the effort to improve the Processes enabler by 10% will lead to a 1-year reduction in the time required to reach the highest TQM score.

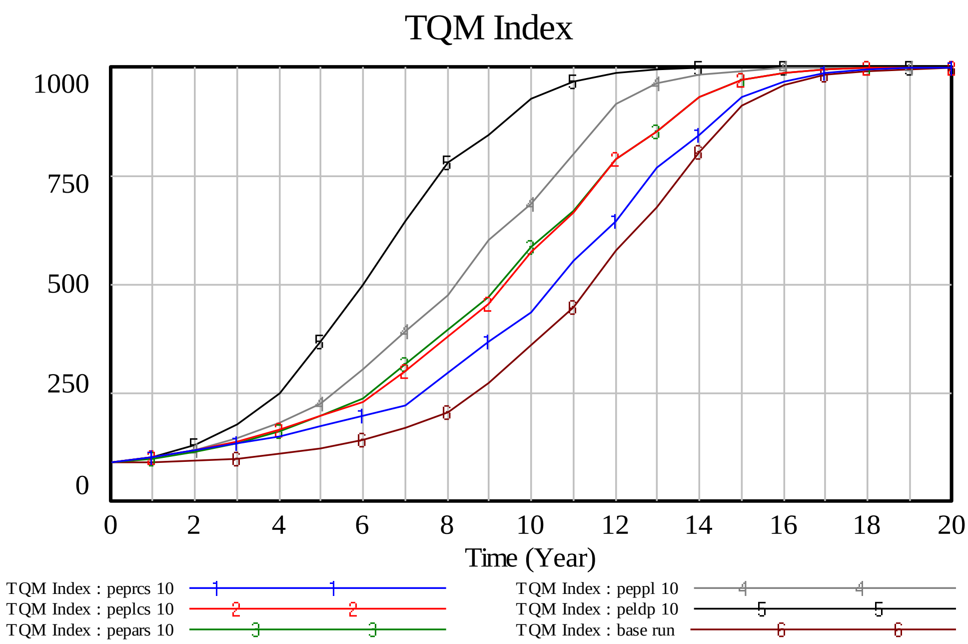


Figure 7-32: Comparative TQM index score chart when initial value of enabler is increased by 10%

It was tested whether increasing *peldp* further will have any impact on firms' ability to reach 5th level of TQM maturity any sooner. The initial value of *peldp* was increased to 0.2 and 0.3. This represents a 20% and 30% increase in the initial value of *peldp*. The remaining values were left and the simulation was run. Figure 7-33 indicates this increase is will improve the firm's ability to achieve the high TQM index score earlier but the improvements are not as dramatic as observed in the cases of initial value of the *peldp* from 0 to 10%. This can be explained by the fact that the Leadership enabler on its own does not achieve a high TQM score.

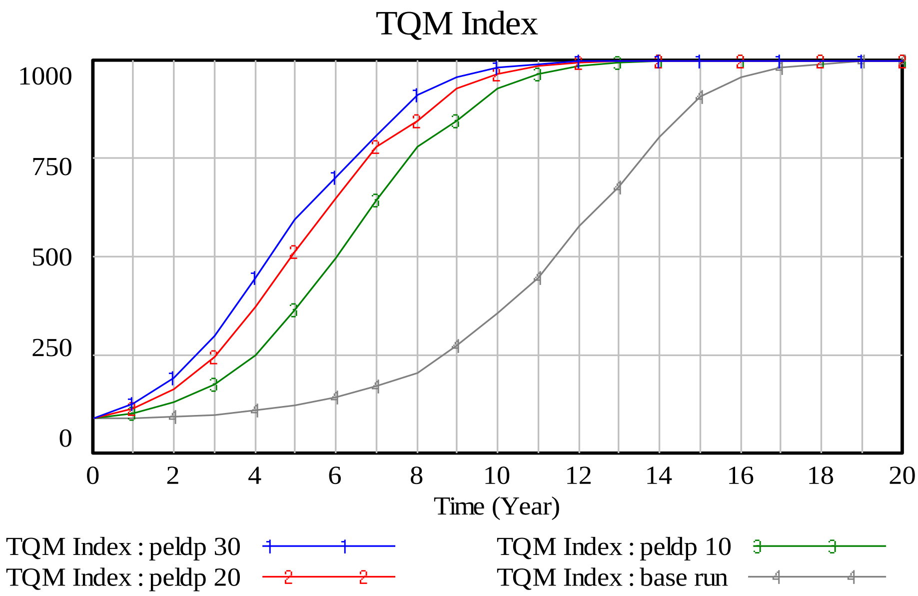


Figure 7-33: Responsiveness of TQM index score to *peldp* (the percentage of effort invested in improving leadership enabler)

Figure 7-34 shows the responsiveness of the TQM index to different leadership values. The sensitivity of the model was checked by varying the initial value of the leadership enabler in increments of 25% of the desired value. For example, Curve 3 refers to Initial value of leadership set at 25% of desired value i.e. 28 (25% of 112). The base run indicated the Initial value of leadership enabler as zero.

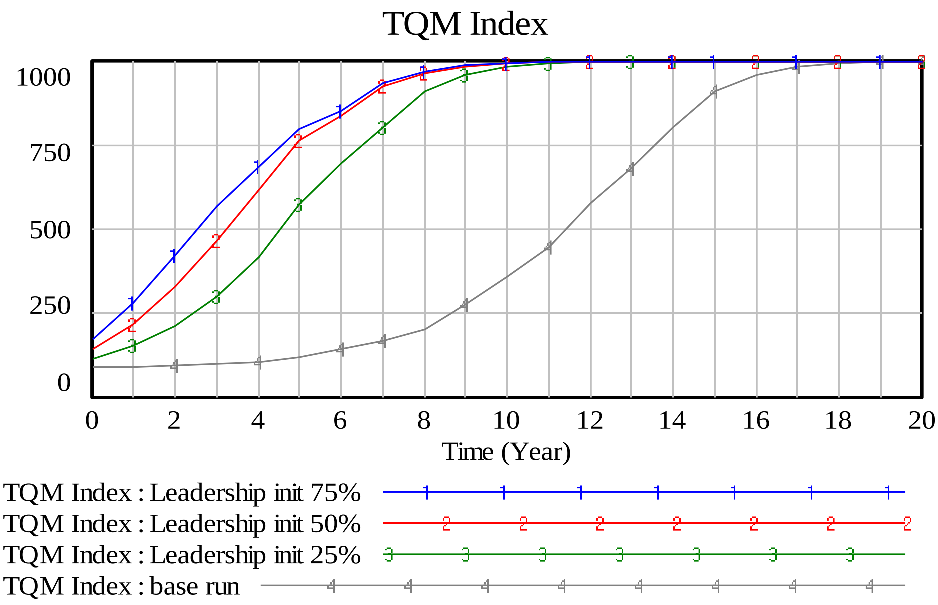


Figure 7-34 Chart depicting responsiveness of TQM index score trend line with initial value of leadership

Table 7-17: Table showing responsiveness of TQM index score to changes in initial value of leadership

Time (Year)	TQM Index			
	Leadership init 75%	Leadership init 50%	Leadership init 25%	Base run
0	173	145	117	89
1	279.903	216.672	153.441	90.21
2	420.3814	327.9061	209.7434	92.94248
3	566.7579	467.6592	300.3265	98.1892
4	683.9891	618.0584	415.2766	107.1513
5	799.3394	762.44	575.1564	121.167
6	853.5367	836.6918	694.5792	141.5174
7	932.1509	924.452	804.5578	169.071
8	968.5555	965.0164	909.7147	203.7912
9	985.4227	983.7882	958.2679	273.7421
10	993.2407	992.4833	980.6786	357.9021
11	996.8652	996.5134	991.0441	446.0474
12	998.5459	998.3823	995.8453	578.3344
13	999.3254	999.2492	998.0714	678.4655
14	999.687	999.6514	999.1043	802.7281
15	999.8547	999.8381	999.5837	909.2304
16	999.9326	999.9248	999.8065	958.196
17	999.9688	999.9651	999.91	980.681
18	999.9855	999.9838	999.9581	991.0494
19	999.9933	999.9925	999.9805	995.8457
20	999.9968	999.9965	999.991	998.0692

It can be clearly seen that a higher initial value of the leadership enabler will expedite the process of reaching the highest TQM score (Table 7-17). What this suggests is that firms with highly motivated and active leadership (in the context of quality management) will achieve the highest level of TQM maturity within just 7 years (Leadership initial value set to 25% of desired leadership value) while those where Leadership enabler is not sufficiently activated at the beginning might take up to 14 years to reach this score. This supports the case for strengthening the Leadership enabler. The high initial value of the Leadership enabler has more significant impact on the TQM index score than *peldp* (the percentage of effort invested in improving leadership enabler) as shown in Figure 7-33.

Figures 7-35 to 7-38 indicate that increasing the initial values of other four enablers will also have an impact in reducing the time required to achieve a high TQM score. This means that the firms which have initial high value of either of the enablers are likely to achieve the high TQM maturity levels much quicker compared to investing the efforts in improving these enablers later.

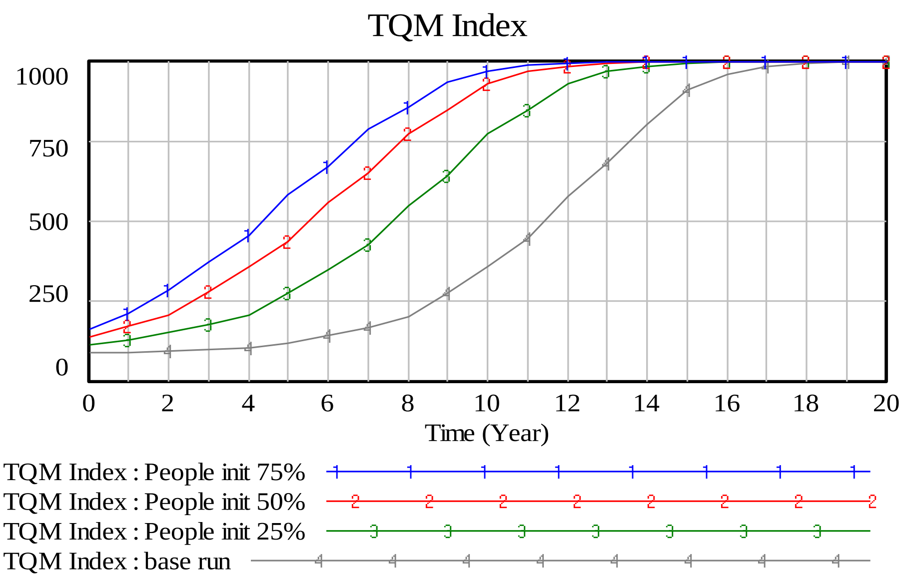


Figure 7-35: Changes in trends lines for TQM index score with initial value of People enabler score

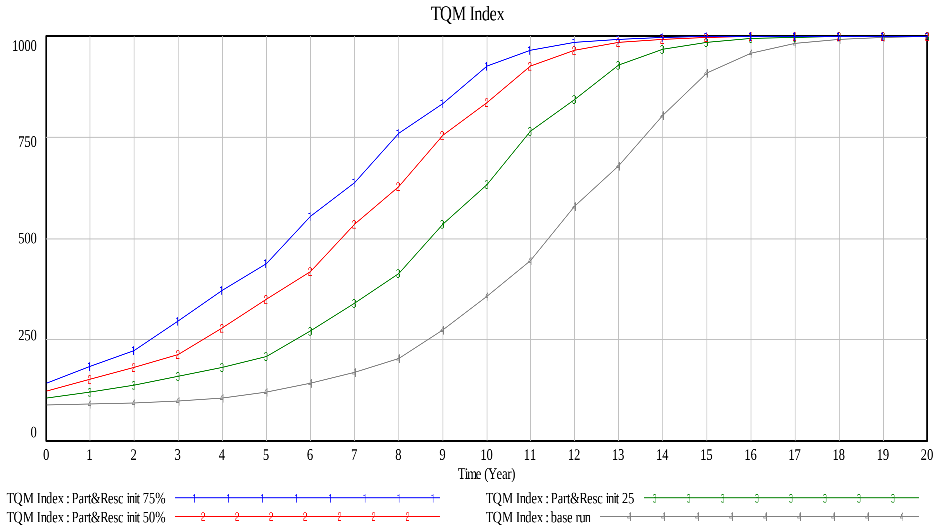


Figure 7-36: Changes in trends lines for TQM index score with initial value of Partnership & resources enabler score

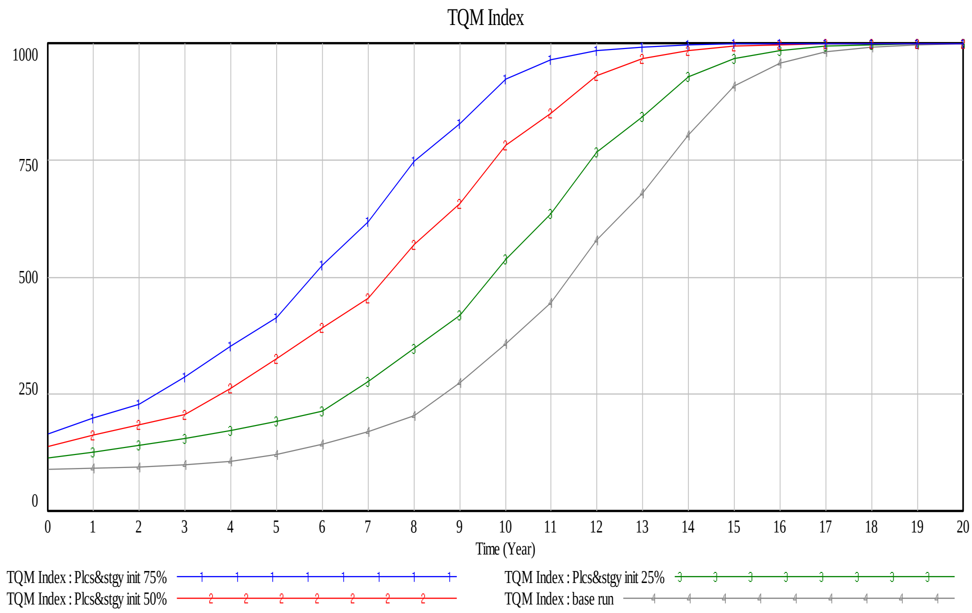


Figure 7-37: Changes in trends lines for TQM index score with initial value of Policy and Strategy enabler score

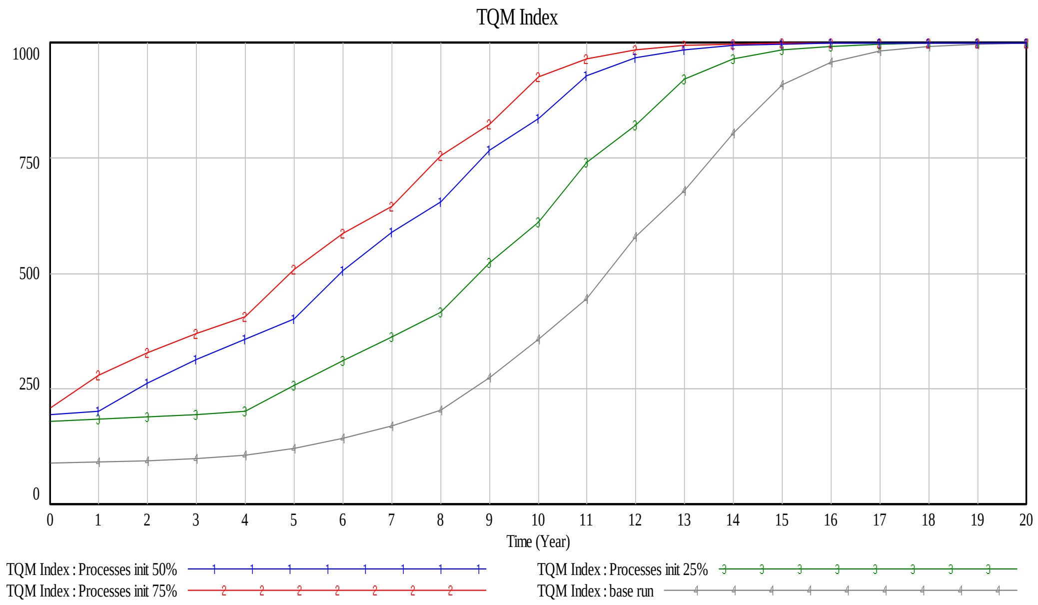


Figure 7-38: Changes in trends lines for TQM index score with initial value of Processes enabler score

Statistically speaking, by achieving 50% of initial value of any of the four enablers at the start of the system, it is possible for the organizations to achieve the highest TQM maturity level in year 8. However, if the organization begins with an initial value of 25% (of the desired value of the respective enabler) for any of these four enablers, it will reach its peak TQM maturity level by year 9. However, in cases of processes enabler the time require do reach the top TQM maturity level will be reduced to 9 years and 10 years when initial value is increased to 50% and 25% (of the desired Processes enabler value) respectively. This may be because processes enabler is last in the sequence of relationships. Improving processes enabler without improving preceding enablers will reverse the process and indicates that unless there is a change in all the enablers the system behaviour may not change. This indicates that the organizations looking to achieve higher TQM maturity level must adopt a systematic and strategic approach, improving enablers in sequence to maximise the impact of their efforts.

On the other hand, starting with a value of zero for all the enablers will take the organization 18-19 years to reach the top TQM maturity level. It is understandable because a higher starting value for any of the enablers shows that a firm already has achieved some level of TQM maturity. If the firm has crossed, or is on verge of crossing to the first TQM maturity level, then time reduction to reach top maturity level will be even higher because the first TQM maturity level takes maximum time to cross over.

7.6 Comparison between TQM enabler weights

Figure 7.39 shows the comparison of the TQM maturity chart of non-Saudi construction firms (identified by EFQM scores) and Saudi construction firms (identified by AHP scores) and relative quality management performance. The chart shows that non-Saudi construction firms are likely to perform marginally better than the Saudi construction firms, but the difference between the two is small. This shows that, despite the difference in characteristics, Saudi construction firms (as indicated by AHP analysis) are likely to perform similarly to the firms, which were used as a sample to derive EFQM score. A marginal difference between the two sets indicates that Saudi firms are slightly worse off due to unique cultural challenges. For example, the firms which were used as sample for deriving EFQM scores do not face the level of cultural diversity that the Saudi construction industry does.

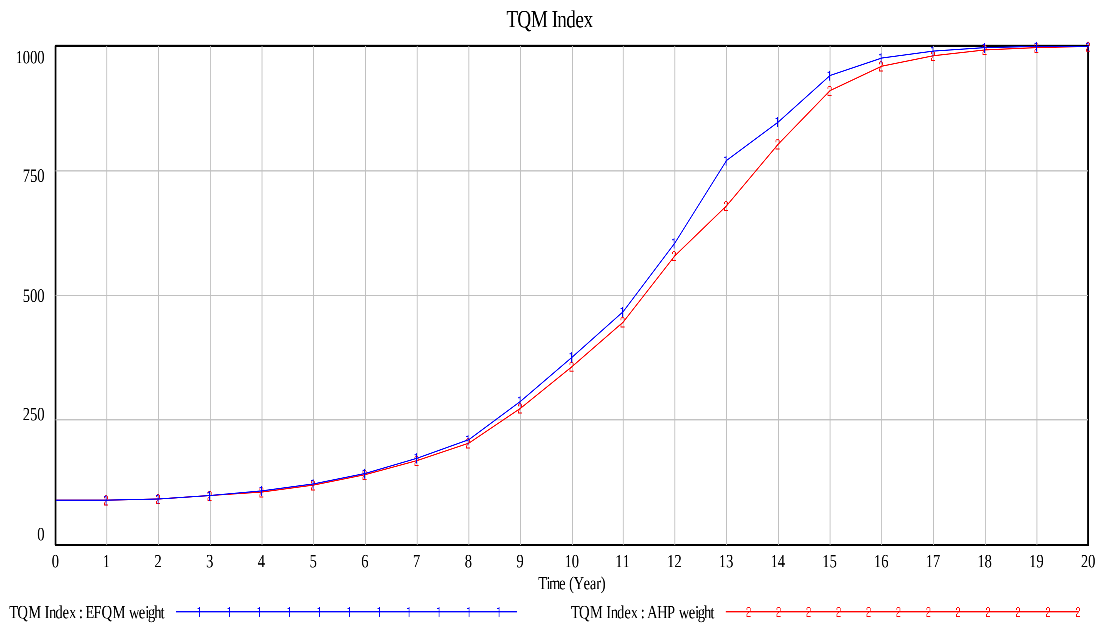


Figure 7-39: Comparison of TQM index scores for EFQM weights and weights obtained for Saudi construction industry with AHP

7.7 Chapter summary

This chapter presented two steps, namely the formulation of a simulation model and testing the system. The EFQM model validated in the previous chapter was tested using SDM. The SDM methodology was already explained in chapter 5. The equation explaining the various relationships and interdependencies were also presented in this chapter as well as the terminology used in the building of the SD model. Vensim software was used to formulate the system dynamics model and the simulations were run over a 20-year period to see how different enablers will affect the TQM maturity in Saudi construction firms.

The base run model developed shows the generalised TQM maturity model for the Saudi construction industry. It indicates that a firm starting from the beginning (i.e. TQM score of zero) will take around 19 years to reach the highest TQM score of 1000. However, it will reach the highest TQM maturity level (which begins at TQM index score of 800) in the14th year.

Sensitivity analysis was conducted to test the robustness of the model. The values for the different assumed values were tested for $\pm$10% and $\pm$25% variations in their base run values. In particular, the model was tested for sensitivity to the desired value of each enabler as well as for the path coefficients that determine the strength of relationships between different enablers and goals. The shape of the curve remains very similar under different scenarios, the only noticeable change being slight shift in the positioning of the curve. Based on the findings, the model is considered robust and valid.

Policy testing shows the impact of different policy decisions on TQM maturity in construction firms. The analysis indicates that firms' ability to achieve the higher TQM score is most responsive to the initial value of the Leadership enabler, followed by the initial value of the People enabler. The analysis indicates that it is possible to more than half the time required to achieve highest TQM index score by adopting the right policy decision.

CHAPTER 8 THE APPLICATION OF TQM DYNAMICS MODEL (CASE STUDIES ANALYSIS)

8.1 General overview

This Chapter considers the final step of the five-stage of System Dynamic Model (SDM) proposed by Sterman (2000), policy design and evaluation. This requires an understanding of the context of the organization to apply the learning of the SDM. Not all firms are at the same level/score for each enabler; some will have a high Leadership enabler score, while others may have a high Processes enabler score. The differences within organizations are investigated, with tests for the application of SDM results for organizations.

Two organizations are selected to demonstrate how changing the values of enablers affect a firm's ability to reach higher TQM maturity levels. Two organizations, referred to as organization A and organization B, were selected from the sample. The basis of selection was based upon their maturity levels (See step 5 in section 5.7). The selected organizations are at different TQM maturity levels based on their TQM enabler and goals scores: organization 'A' is in the second (Committed) level of maturity at the beginning of the experiment, and organization 'B' is in the third (Improver) maturity level at the beginning.

8.2 Policy design and analysis

Policy design here refers to the kind of TQM-related decisions that the decision-makers need to make in order to achieve the desired TQM-related goals. The impact of different policy decisions will be tested using system dynamic modelling to evaluate which policy decisions will be most effective. This research is aimed at benefiting these TQM-related policy/decision makers who can use this model to understand and evaluate the progress that the firm has made and identify ways of improving further. Such models can track firms' maturity towards higher quality performance levels allowing them to make strategic decisions at different stages to speed up their progression towards higher maturity levels. Five enablers in the EFQM model influence the TQM index score. Figure 8-1 shows the attributes of the enablers.

Enablers **Attributes**

Figure 8-1: Attributes of enablers in the TQM maturity model

Enablers comprise attributes, such as clear vision, communication, empowerment, and skilled human resources. Efforts to boost these attributes lead to an increase in the overall score of the enabler. It is possible to test the impact of specific interventions by looking at how it will boost specific enablers and then modelling the enabler's impact on the achievement of goals. However, it is beyond the scope of this research to test the impact of each factor/component on the enablers. Instead, this research is limited to testing the impact of overall changes in enablers.

Managers must work on the individual attributes to enhance the enablers. To improve leadership, leaders need commitment towards quality management systems/quality assurance/quality control, ensure effective communication towards quality goals, provide clear vision, act as role model, and engage in continuous development. Dealing with the reality of the situation in the Saudi construction sector is necessary, with the multi-cultural, multi-lingual, and poorly trained workforce, coupled with the hierarchical and bureaucratic approach to management. This focus will eventually enhance the influence of the enablers and the TQM index score.

The key goal of the SDM was to identify the policies (i.e. which enablers must be improved) that will lead to faster achievement of the highest TQM levels. The policies interventions help to identify the policy decisions for further improvement, by identifying which enabler will be improved by policy decisions, and how it will lead to change in the overall achievement (Saeed and Brooke, 1996).

The SDM base run analysis showed the current situation without any policy interventions. Policy interventions were implemented using SDM analysis to see how specific interventions might affect the overall achievement of goals. Section 8.3 describes the base run for both organizations (‘A’ and ‘B’).

8.3 TQM maturity model without policy intervention

8.3.1 **Base Run for Organization ‘A’**

The initial values of the five enablers and *Goals* of organization ‘A’ (referring to the questionnaire database) were:

Valldp = 26.13

Valppl = 19.80

Valpars = 25.20

Valplcs = 19.80

Valprcs = 44.57

Valgls= 175

For details on explanation of the process followed to estimate these values through the questionnaire responses (Appendix 7).

The sum of the scores of five enablers and the Goals gives the value of TQM index. Adding all the scores, the base value of the TQM index was 310.5. This means that firm A was in the second maturity stage (TQM index score between 200 and 400).

The initial values of the five enablers and goals in case A were included in the dynamic model to simulate the results for organization A. Figure 8-2 shows base run simulation of Case A compare to Base run when all initial values of enablers are zero in Sec.7.3.1.

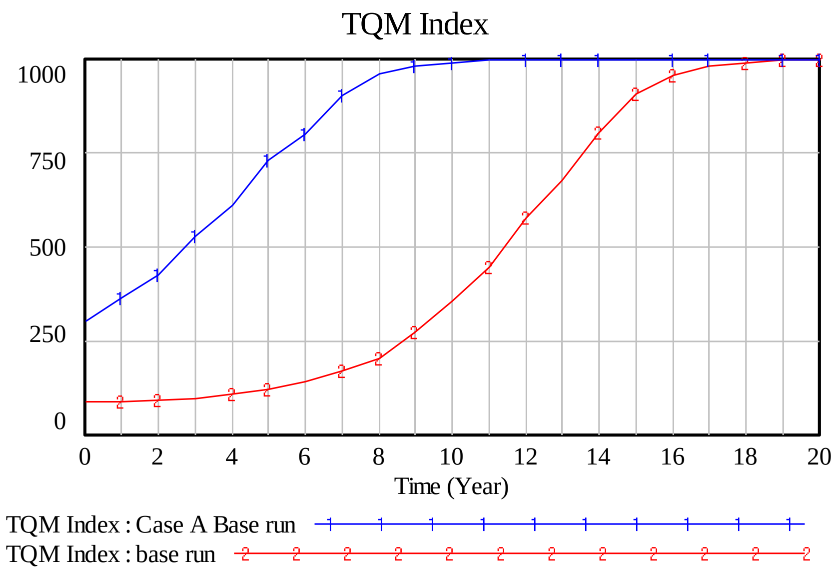


Figure 8-2: Comparison of TQM index maturity trend for organization A Vs Base Run.

Table 8-1 shows that Leadership gap will be reduced to zero by year 8, while most other enablers will be reduced to zero in the 9th or 10th years. Table 8-2 shows that organization A will cross over to the 3rd TQM maturity level within 2 years and will take another two years to move to 4th level. The organization will enter the 5th TQM maturity level in the sixth year. By the 9th year, Organization A will be close (TQM Index of 982) to the ultimate score (TQM score of 1000). It shows that the enablers ‘starting score was 135.5 and that it almost reached the maximum score of 500 by after year 9. In other words the gap between the desired and actual score of the enablers was 364.50 at the beginning, reducing to almost zero by year 12.

Table 8-1: Estimated values of five enablers for Organization A over 20 years

	Leadership		Partnership and resources		Policies and strategy		People		Processes	
Time (Year)	*Valldp*	*Gpldp*	*Valpars*	*Gppars*	*Valplcs*	*Gpplcs*	*Valppl*	*Gpppl*	*valprcs*	*gpprcs*
0	26.13	85.87	25.20	44.80	19.80	79.20	19.80	79.20	44.57	75.43
1	29.16	82.84	34.55	35.45	30.25	68.75	29.89	69.11	61.97	58.03
2	33.26	78.75	42.17	27.83	43.70	55.30	39.08	59.92	83.91	36.09
3	45.19	66.81	49.42	20.58	56.37	42.63	48.17	50.83	101.80	18.20
4	54.60	57.40	56.39	13.61	68.91	30.09	58.64	40.36	112.87	7.13
5	70.13	41.87	61.98	8.02	79.38	19.62	68.69	30.31	118.03	1.97
6	81.27	30.73	66.04	3.96	87.69	11.31	78.38	20.62	119.65	0.35
7	98.38	13.62	68.35	1.65	93.10	5.90	86.02	12.98	119.97	0.03
8	111.19	0.81	69.47	0.53	96.37	2.63	91.84	7.16	120.00	0.00
9	112.00	0.00	69.87	0.13	97.97	1.03	95.47	3.53	120.00	0.00
10	112.00	0.00	69.97	0.03	98.60	0.40	97.27	1.73	120.00	0.00
11	112.00	0.00	69.99	0.01	98.85	0.15	98.16	0.84	120.00	0.00
12	112.00	0.00	70.00	0.00	98.94	0.06	98.59	0.41	120.00	0.00
13	112.00	0.00	70.00	0.00	98.98	0.02	98.80	0.20	120.00	0.00
14	112.00	0.00	70.00	0.00	98.99	0.01	98.90	0.10	120.00	0.00
15	112.00	0.00	70.00	0.00	99.00	0.00	98.95	0.05	120.00	0.00
16	112.00	0.00	70.00	0.00	99.00	0.00	98.98	0.02	120.00	0.00
17	112.00	0.00	70.00	0.00	99.00	0.00	98.99	0.01	120.00	0.00
18	112.00	0.00	70.00	0.00	99.00	0.00	98.99	0.01	120.00	0.00
19	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00
20	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00

Table 8-2: Estimated values of enablers score, Goals score, Gaps and TQM index score for Organization A over 20 years

Time (Year)	Enablers score	Gap of Enablers	Goals score	Gap Goals	TQM Index score	TQM Level
0	135.5	364.5	175	325	310.5	2^{nd}
1	185.8167	314.1833	177.9724	322.0276	363.7891	2^{nd}
2	242.1056	257.8944	184.0739	315.9261	426.1795	3^{rd}
3	300.9457	199.0543	227.5531	272.4469	528.4988	3^{rd}
4	351.4103	148.5897	260.5186	239.4814	611.9289	4^{th}
5	398.2056	101.7944	330.891	169.109	729.0966	4^{th}
6	433.0389	66.9611	367.3529	132.6471	800.3918	5^{th}
7	465.8233	34.1767	438.2991	61.7009	904.1224	5^{th}
8	488.865	11.135	471.3866	28.6134	960.2516	5^{th}
9	495.3083	4.6917	486.7347	13.2653	982.043	5^{th}
10	497.8431	2.1569	493.8502	6.1498	991.6933	5^{th}
11	498.9935	1.0065	497.149	2.851	996.1425	5^{th}
12	499.5252	0.4748	498.6783	1.3217	998.2035	5^{th}
13	499.7742	0.2258	499.3872	0.6128	999.1615	5^{th}
14	499.892	0.108	499.7159	0.2841	999.6079	5^{th}
15	499.9481	0.0519	499.8683	0.1317	999.8164	5^{th}
16	499.975	0.025	499.9389	0.0611	999.9139	5^{th}
17	499.9879	0.0121	499.9717	0.0283	999.9596	5^{th}
18	499.9941	0.0059	499.9869	0.0131	999.981	5^{th}
19	499.9972	0.0028	499.9939	0.0061	999.9911	5^{th}
20	499.9986	0.0014	499.9972	0.0028	999.9958	5^{th}

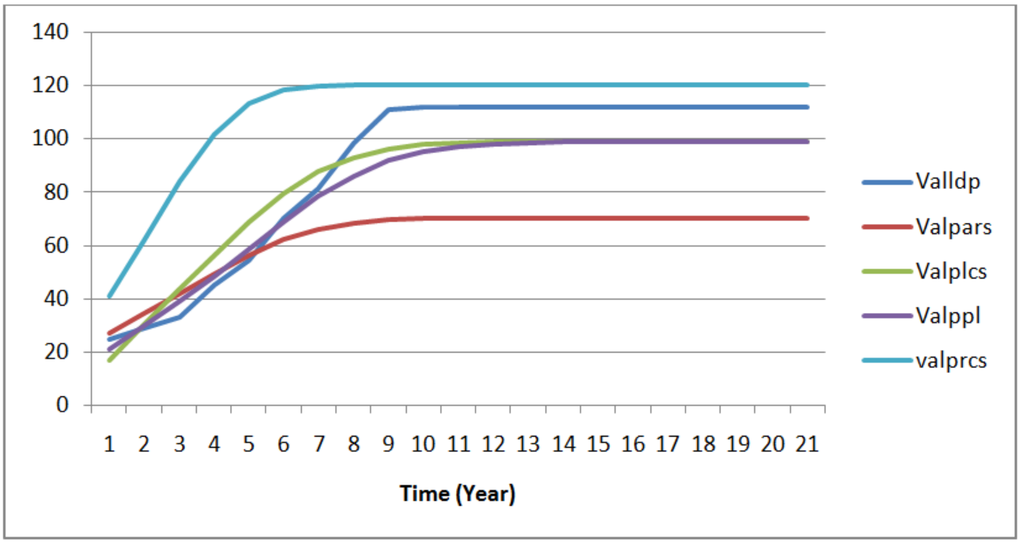


Figure 8-3: Trend lines for five enablers score for Organization A (Base run)

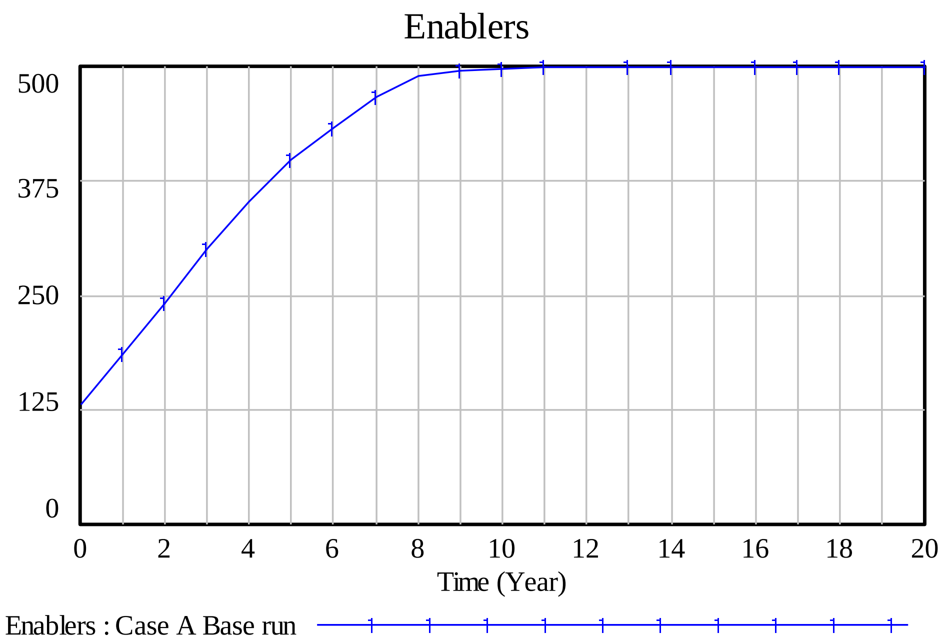


Figure 8-4: TQM enablers score trend chart for organization A

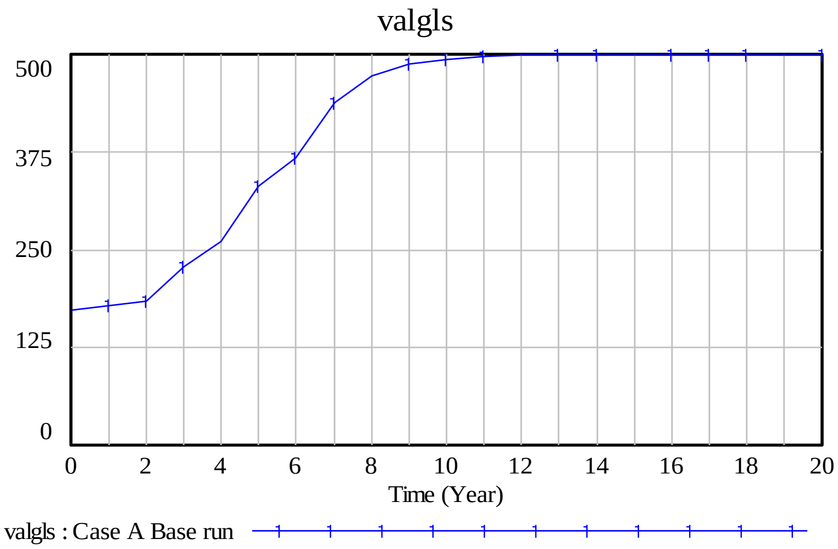


Figure 8-5 Trend line for Value of goals for organization A

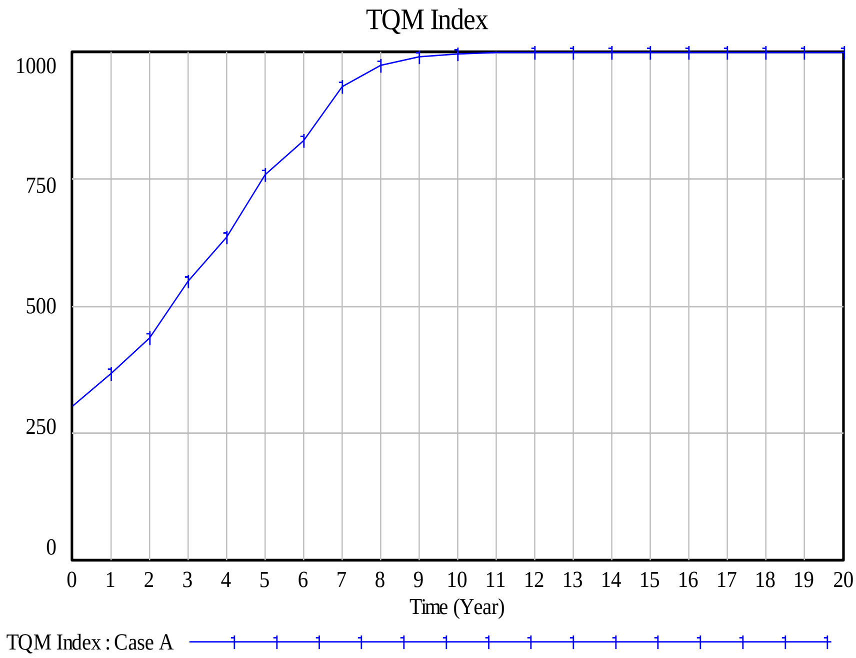


Figure 8-6: Trend line for TQM index score for organization A over time

The starting score of Goals was 175 (year 0), it almost reached the maximum score of 500 by the end of year 9 Table 8-2. The gap between the desired and actual score of Goals was 325 at the beginning, reducing to almost zero by year 9. Since both the Goals, and Enablers score almost reached their maximum level in year 9 TQM index score was maximised in the same year. The interesting observation in the base run simulation of Case A is that when the firm enters the fifth maturity level in 6th year, the gap in the Leadership and

People enablers is high while the gap in the other three enablers (Partnership and resources; Policies and strategy; Processes) is not so high. This means that firms need to put more effort into the Leadership and People enablers if they wish to speed up their progression to the fifth maturity level.

8.3.2 **Base Run for Organization 'B'**

The initial values of the five enablers and *Goals* of organization 'B' (referring to the questionnaire database) were:

Valldp = 48.53

Valppl = 36.77

Valpars = 39.20

Valplcs = 27.72

Valprcs = 58.29

Valgls = 208.33

The explanation of the process followed to estimate these values through the questionnaire responses is shown in Appendix 7.

The initial values of the five enablers and goals in case B were included in the dynamic model to simulate the results for organization B. Figure 8-7 shows base run simulation of Case B compare to Base run when all initial values of enablers are zero in Sec.7.3.1.

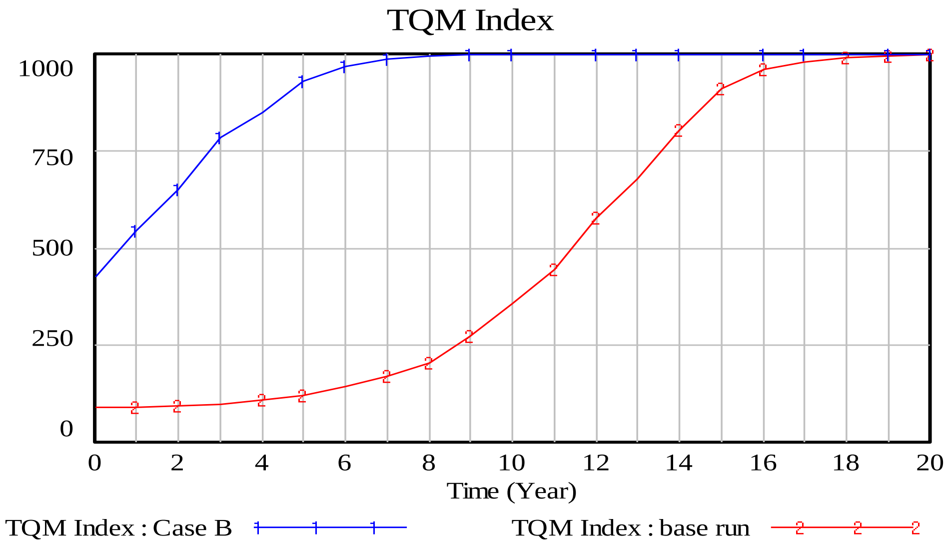


Figure 8-7: Comparison of TQM index maturity trend for organization B Vs Base run.

Table 8-3: Estimated values of five enablers for Organization B over 20 years

	Leadership		Partnership and resources		Policies and strategy		People		Processes	
Time (Year)	*Valldp*	*Gpldp*	*Valpars*	*Gppars*	*Valplcs*	*Gpplcs*	*Valppl*	*Gpppl*	*Valprcs*	*gpprcs*
0	48.53	63.47	39.2	30.80	27.72	71.28	36.77	62.23	58.29	61.71
1	60.04	51.96	50.27	19.73	49.58	49.42	50.85	48.15	84.61	35.39
2	70.12	41.88	58.34	11.66	67.21	31.79	64.04	34.97	105.71	14.29
3	87.01	24.99	64.08	5.92	80.43	18.57	75.21	23.79	116.36	3.64
4	99.92	12.08	67.62	2.38	89.67	9.33	84.65	14.35	119.49	0.51
5	112.00	0.00	69.24	0.76	94.88	4.12	91.19	7.81	119.97	0.03
6	112.00	0.00	69.81	0.19	97.40	1.60	95.18	3.82	120.00	0.00
7	112.00	0.00	69.96	0.04	98.38	0.62	97.13	1.87	120.00	0.00
8	112.00	0.00	69.99	0.01	98.76	0.24	98.09	0.91	120.00	0.00
9	112.00	0.00	70.00	0.00	98.91	0.09	98.55	0.45	120.00	0.00
10	112.00	0.00	70.00	0.00	98.96	0.04	98.78	0.22	120.00	0.00
11	112.00	0.00	70.00	0.00	98.99	0.01	98.89	0.11	120.00	0.00
12	112.00	0.00	70.00	0.00	98.99	0.01	98.95	0.05	120.00	0.00
13	112.00	0.00	70.00	0.00	99.00	0.00	98.97	0.03	120.00	0.00
14	112.00	0.00	70.00	0.00	99.00	0.00	98.99	0.01	120.00	0.00
15	112.00	0.00	70.00	0.00	99.00	0.00	98.99	0.01	120.00	0.00
16	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00
17	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00
18	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00
19	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00
20	112.00	0.00	70.00	0.00	99.00	0.00	99.00	0.00	120.00	0.00

Table 8-3 shows that the gap in the Leadership enabler is almost zero after year 4, while for the Partnership and resources and Policies and strategy and Processes enablers, the gap reduces to near zero after year 6. The People enabler reaches the desired level in year 7.

Table 8-4 shows the initial score of the five enablers was 210.51 reaching 494 in year 6, close to the top score of 500. The gap between the desired and actual level of the five enablers reduces from 289.5 to 5 in six years. Similarly, the starting score of Goals was 208.33, which reached 493.4 by year 7. The TQM index score was 418.84 at the beginning, reaching 990 by year 7.

Table 8-4: Estimated values of enablers score, Goals score and TQM index score for Organization B over 20 years

Time (Year)	Enablers score	Gap Enablers	Goals score	Gap Goals	TQM Index score	TQM level
0	210.51	289.5	208.33	291.67	418.84	3rd
1	302.7995	197.2005	234.0741	265.9259	536.8737	3rd
2	378.9179	121.0821	261.5373	238.4627	640.4551	4th
3	438.7985	61.2015	336.5599	163.4401	775.3584	4th
4	475.6297	24.3703	374.9301	125.0699	850.5598	5th
5	489.3055	10.6945	452.8454	47.1546	942.1509	5th
6	494.8902	5.1098	482.3476	17.65244	977.2378	5th
7	497.476	2.524	493.3944	6.60556	990.8705	5th
8	498.7196	1.2804	497.5282	2.4718	996.2478	5th
9	499.337	0.663	499.075	0.92496	998.412	5th
10	499.6515	0.3485	499.6539	0.34613	999.3054	5th
11	499.8149	0.1851	499.8705	0.12952	999.6854	5th
12	499.901	0.099	499.9515	0.04846	999.8525	5th
13	499.9468	0.0532	499.9819	0.01813	999.9287	5th
14	499.9713	0.0287	499.9932	0.00677	999.9645	5th
15	499.9845	0.0155	499.9975	0.00253	999.9819	5th
16	499.9916	0.0084	499.9991	0.00095	999.9906	5th
17	499.9954	0.0046	499.9996	0.00037	999.9951	5th
18	499.9975	0.0025	499.9999	0.00012	999.9974	5th
19	499.9987	0.0013	500	0	999.9987	5th
20	499.9993	0.0007	500	0	999.9993	5th

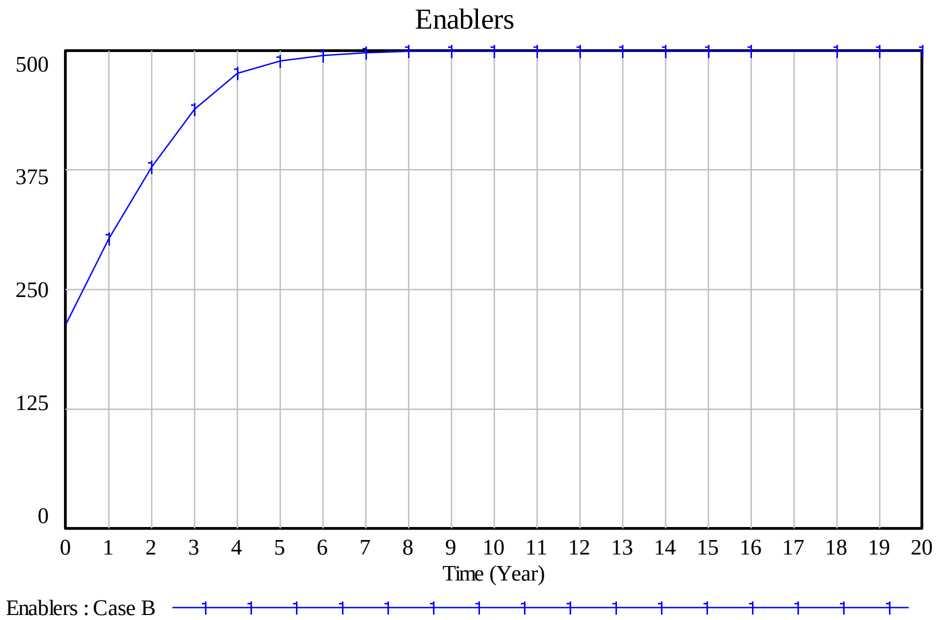


Figure 8-8 TQM enablers score trend chart for organization B

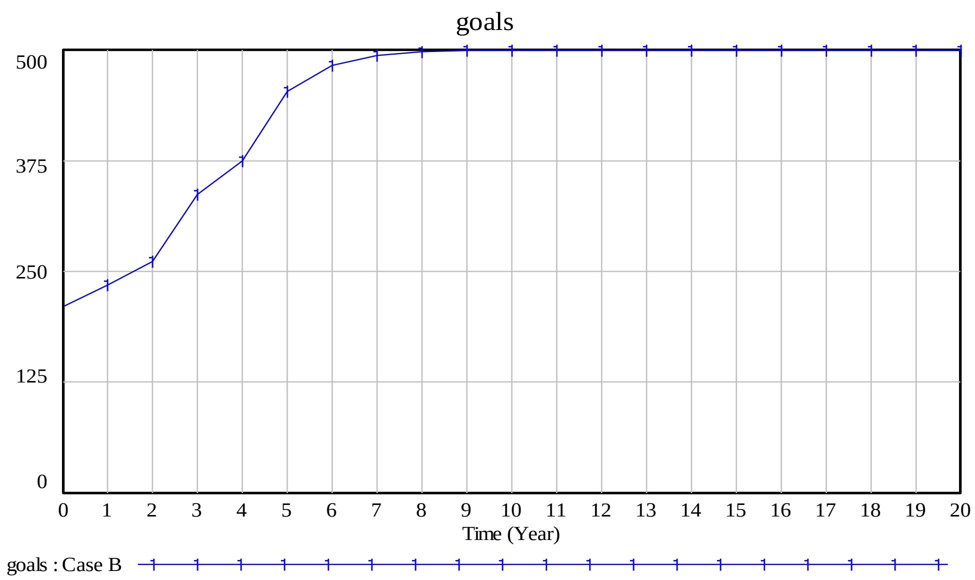


Figure 8-9: Trend line for Value of goals for organization B

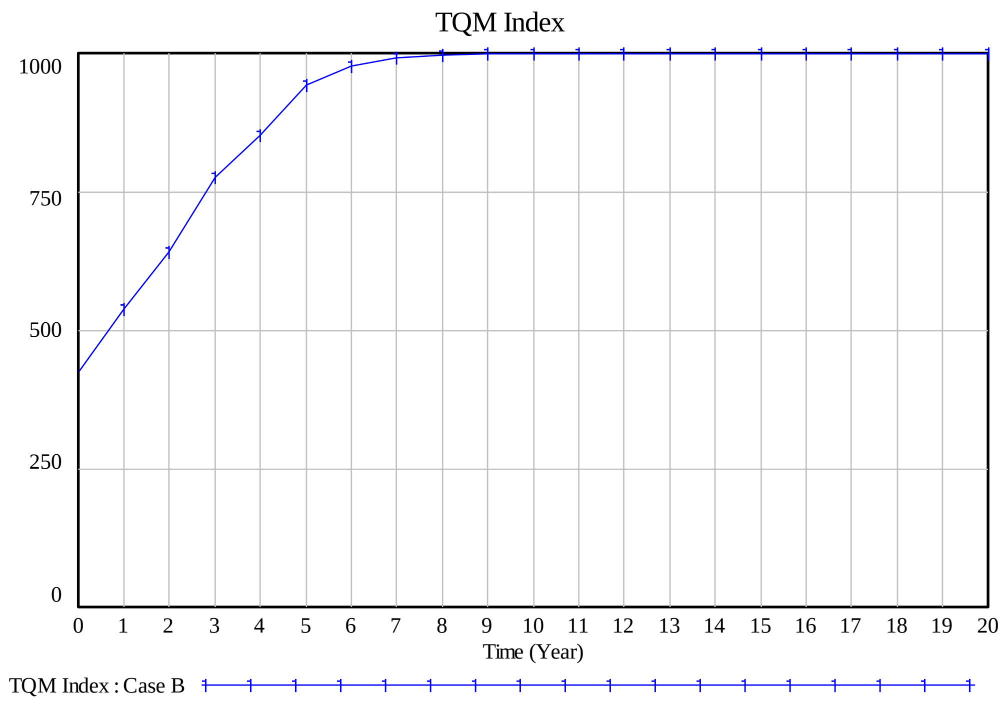


Figure 8-10: Trend line for TQM index score for organization B over time

Figure 8-10 shows that the organization B is in the 3rd TQM maturity level with a TQM index score of 418.84. Organization B will cross over to the 4th TQM maturity level in year 2 and the 5th TQM maturity level in year 4. By year 7 organization B will be close (TQM score of 990) to the ultimate score (TQM score of 1000).

The firm almost reaches the top score of 1000, four years after entering the 5th maturity level. When the firm enters the fifth maturity level in year 4, the gap in the Leadership and Processes enablers is close to zero while for the People enablers is high. The Partnership and resources; Policies and strategy is also not zero. The firm needs to put in more efforts into the People enabler if they wish to speed up their progression to the fifth maturity level.

8.4 Policy experiments using dynamic modelling

One of the key benefits of system dynamic modelling is that it allows decision-makers to evaluate the future impact of present policy decisions. This helps in identifying the policies that will yield the desired results in future. In this research, several experiments (scenarios) of policy decisions were tested to see how making policy changes would affect firms' performance of achieving the highest TQM maturity level. In other words, it will identify the policies (i.e. which enablers must be improved) that will lead to faster achievement of the highest TQM levels.

8.4.1 **Policy experiments for organization A**

Policy experiments were considered for organization A, which was expected to reach the fifth maturity level in the 6thyear, and the top maturity score of 1000 in year 9. The analysis shows the Leadership enabler and People enabler gap were much higher, compared to the gap in other enablers when organization A entered the fifth maturity level. The two main areas of focus for improving the chances of organization A reaching the fifth maturity level sooner, are the Leadership and People enablers. Hence, the policy experiments simulation was mainly focused on checking the impact on improving these two enablers.

The first test was with the Leadership enabler. Improving the Leadership enabler is likely to improve organization A's ability to achieve the TQM maturity level earlier. This can be achieved by improving the attributes attributed to leadership (e.g. Management commitment; Clear vision; Communication; Auditing; Role model; Continuous development). In order to improve the leadership score the initial value of *peldp* (percentage effort to improve leadership) was increased from 0 to 0.1. This represents a 10% increase in the initial value of *peldp*. The rest of the values were left and the simulation was run.

Comparison of the base run (organization A) and the policy intervention of raising *peldp* to 0.1 are shown in Table 8-5 below:

Table 8-5: Comparison of TQM maturity of organization A in base run case and case when *peldp* is increased by 10%

TQM maturity level	Base run (organization A)	*Peldp* = 0.1 (organization A)
2nd	Year 0	Year 0
3rd	Year 2	Year 2
4th	Year 4	Year 4
5th	Year 6	Year 6

The results in Table 8-5 show that organization A will be able to enter the fifth level of TQM maturity level in the same year in the base run, i.e. in 5th year, if the initial percentage of effort in improving leadership is increased from 0 to 0.1. However, TQM index in the 5th year was very close to the fifth level of TQM maturity level (i.e. 790).

The results shows that the Leadership enabler will achieve its highest value by the 6th year, which is 2 years less than the base run in which the leadership gap reduced to near zero in year 8. The leadership gap will be minimal when Organization A enters the fifth TQM maturity stage, while in the base case, the leadership gap was found to be highest at this stage. This means that increasing *peldp* from 0 to 0.1 will significantly boost leadership score and consequently organization A's ability to reach the fifth level of TQM maturity.

Table 8-6: Values of enablers for organization A with *peldp* = 0.1

	Leadership		Partnership and Resources		Policies and strategy		People		Processes	
Time (Year)	*Valldp*	*Gpldp*	*Valpars*	*Gppars*	*Valplcs*	*Gpplcs*	*Valppl*	*Gpppl*	*Valprcs*	*Gpprcs*
0	26.13	85.87	25.20	44.80	19.80	79.20	19.80	79.20	44.57	75.43
1	37.86	74.14	34.54918	35.45082	30.24806	68.75194	29.892	69.108	61.96743	58.03257
2	50.06501	61.93499	43.45227	26.54773	46.14359	52.85641	41.82292	57.17708	83.90598	36.09402
3	69.53779	42.46221	52.45882	17.54118	62.04255	36.95745	54.87624	44.12376	102.6841	17.31592
4	85.14278	26.85722	60.54857	9.45143	76.83823	22.16177	68.86755	30.13245	114.2307	5.7693
5	105.7754	6.22456	65.93506	4.06494	87.52122	11.47878	80.56651	18.43349	118.8933	1.10674
6	112	0	68.74983	1.25017	94.15984	4.84016	89.45764	9.54236	119.9043	0.09566
7	112	0	69.68264	0.31736	97.11242	1.88758	94.33112	4.66888	119.9983	0.00171
8	112	0	69.92426	0.07574	98.26777	0.73223	96.71561	2.28439	120	0
9	112	0	69.98249	0.01751	98.71634	0.28366	97.88229	1.11771	120	0
10	112	0	69.99602	0.00398	98.89015	0.10985	98.45313	0.54688	120	0
11	112	0	69.9991	0.0009	98.95747	0.04253	98.73242	0.26758	120	0
12	112	0	69.99979	0.00021	98.98353	0.01647	98.86908	0.13092	120	0
13	112	0	69.99995	0.00005	98.99362	0.00638	98.93594	0.06406	120	0
14	112	0	69.99999	0.00001	98.99753	0.00247	98.96866	0.03134	120	0
15	112	0	70	0	98.99905	0.00095	98.98466	0.01534	120	0
16	112	0	70	0	98.99963	0.00037	98.9925	0.0075	120	0
17	112	0	70	0	98.99986	0.00014	98.99633	0.00367	120	0
18	112	0	70	0	98.99995	0.00005	98.99821	0.00179	120	0
19	112	0	70	0	98.99998	0.00002	98.99912	0.00088	120	0
20	112	0	70	0	98.99999	0.00001	98.99957	0.00043	120	0

Table 8-7: Enablers score, Goals score and TQM index score of organization A with *peldp* = 0.1

Time (Year)	Enablers score	Goals score	TQM Index score	TQM maturity level
0	135.5	175	310.5	2nd
1	194.5167	177.9724	372.4891	2nd
2	265.3898	184.0739	449.4637	3rd
3	341.5995	227.5531	569.1526	3rd
4	405.6278	260.8061	666.4339	4th
5	458.6915	331.8801	790.5715	4th
6	484.2717	368.0826	852.3543	5th
7	493.1245	438.7867	931.9111	5th
8	496.9076	471.621	968.5287	5th
9	498.5811	486.8435	985.4246	5th
10	499.3393	493.9006	993.2399	5th
11	499.689	497.1723	996.8613	5th
12	499.8524	498.6891	998.5415	5th
13	499.9295	499.3923	999.3218	5th
14	499.9662	499.7183	999.6845	5th
15	499.9837	499.8694	999.8531	5th
16	499.9921	499.9395	999.9316	5th
17	499.9962	499.9719	999.9681	5th
18	499.9981	499.987	999.9851	5th
19	499.9991	499.994	999.993	5th
20	499.9996	499.9972	999.9968	5th

It was tested whether increasing *peldp* further will have any impact on organization A's ability to reach the 5th level of TQM maturity any sooner. The initial value of *peldp* (percentage effort to improve leadership) was increased to0.2. This represents a 20% increase in the initial value of *peldp*. The rest of the values were not changed and the simulation was run.

Comparison of the base run and the policy decision of raising *peldp* to 0.1 and 0.2 are shown in the Table 8-8:

Table 8-8: Organization A's ability to achieve higher TQM maturity level with improvement in leadership enabler

TQM maturity level	Base run (A)	*Peldp* = 0.1	*Peldp* = 0.2
2nd	Year 0	Year 0	Year 0
3rd	Year 2	Year 2	Year 2
4th	Year 4	Year 4	Year 3
5th	Year 6	Year 6	Year 5

The results also show that organization A will reach 4th level of TQM maturity one year sooner when *peldp* is increased to 0.2 instead of 0.1.This means that increasing *peldp* from 0 to 0.1, will not have any impact on firm's TQ maturity attainment, but increasing it to 0.2 will reduce the time required to reach highest TQM maturity level by 1 year.

Table 8-9 show that the Leadership enabler will achieve its highest value by the 4th year which is 4 years less than the base run of case A in which the leadership gap reduced to nearly zero in year 8. This is also 2 years less than the case when the initial value of *peldp* was set to 0.1.

Table 8-9: The value of five enablers for organization A with *peldp* = 0.2

	Leadership		Partnership and resources		Policies and strategy		People		Processes	
Year	*Valldp*	*Gpldp*	*Valpars*	*Gppars*	*valplcs*	*Gpplcs*	*Valppl*	*Gpppl*	*Valprcs*	*Gpprcs*
0	26.13	85.87	25.20	44.80	19.80	79.20	19.80	79.20	44.57	75.43
1	46.56	65.44	34.54918	35.45082	30.24806	68.75194	29.892	69.108	61.96743	58.03257
2	65.135	46.865	44.73839	25.26161	48.58999	50.41001	44.56457	54.43543	83.90598	36.09402
3	88.99289	23.00711	55.11218	14.88782	67.00346	31.99654	60.73274	38.26726	103.5719	16.42807
4	112	0	63.45809	6.54191	82.5467	16.4533	76.26189	22.73811	115.3662	4.6338
5	112	0	68.06998	1.93002	92.39108	6.60892	87.87469	11.12531	119.3909	0.60909
6	112	0	69.50053	0.49947	96.4127	2.5873	93.55661	5.44339	119.9798	0.02017
7	112	0	69.87959	0.12041	97.99529	1.00471	96.33665	2.66335	120	0
8	112	0	69.97202	0.02798	98.61069	0.38931	97.69688	1.30312	120	0
9	112	0	69.99361	0.00639	98.84923	0.15077	98.36241	0.63759	120	0
10	112	0	69.99856	0.00144	98.94161	0.05839	98.68804	0.31196	120	0
11	112	0	69.99967	0.00033	98.97739	0.02261	98.84737	0.15263	120	0
12	112	0	69.99992	0.00008	98.99125	0.00875	98.92532	0.07468	120	0
13	112	0	69.99998	0.00002	98.99661	0.00339	98.96346	0.03654	120	0
14	112	0	70	0	98.99869	0.00131	98.98212	0.01788	120	0
15	112	0	70	0	98.99949	0.00051	98.99125	0.00875	120	0
16	112	0	70	0	98.9998	0.0002	98.99572	0.00428	120	0
17	112	0	70	0	98.99992	0.00008	98.99791	0.00209	120	0
18	112	0	70	0	98.99997	0.00003	98.99898	0.00102	120	0
19	112	0	70	0	98.99998	0.00002	98.9995	0.0005	120	0
20	112	0	70	0	98.99999	0.00001	98.99976	0.00024	120	0

Table 8-10: Enablers score, Goals score and TQM index score of Organization A with *peldp*=0.2

Time (Year)	Enablers score	Goals score	TQM Index score	TQM level
0	135.5	175	310.5	2nd
1	205.36792	177.97243	383.34033	2nd
2	289.96167	184.59293	474.5546	3rd
3	378.3688	233.50227	611.87109	4th
4	447.81647	322.24243	770.0589	4th
5	477.61243	368.79071	846.40314	5th
6	489.87625	450.38251	940.25879	5th
7	495.15009	481.42334	976.57343	5th
8	497.59534	493.04858	990.64392	5th
9	498.77615	497.39877	996.17493	5th
10	499.36459	499.02661	998.39124	5th
11	499.66534	499.63577	999.30115	5th
12	499.82199	499.86371	999.68567	5th
13	499.90466	499.94901	999.85364	5th
14	499.94867	499.98093	999.92957	5th
15	499.97232	499.99286	999.96521	5th
16	499.98502	499.99731	999.9823	5th
17	499.99188	499.99899	999.99084	5th
18	499.99561	499.99963	999.99524	5th
19	499.99762	499.99988	999.9975	5th
20	499.99872	499.99997	999.99866	5th

The next policy decision tested was to alter the People enabler. This can be achieved by improving the attributes attributed to People (e.g. Training, Empowerment, Involvement, accessibility to Information, Rewards and recognition, Cross-functional team and Feedback survey). The initial value of *peppl* (percentage effort to improve People enablers) was increased to 0.1. This represents a 10% increase in the initial value of *peppl*. The rest of the values were unchanged for the simulation.

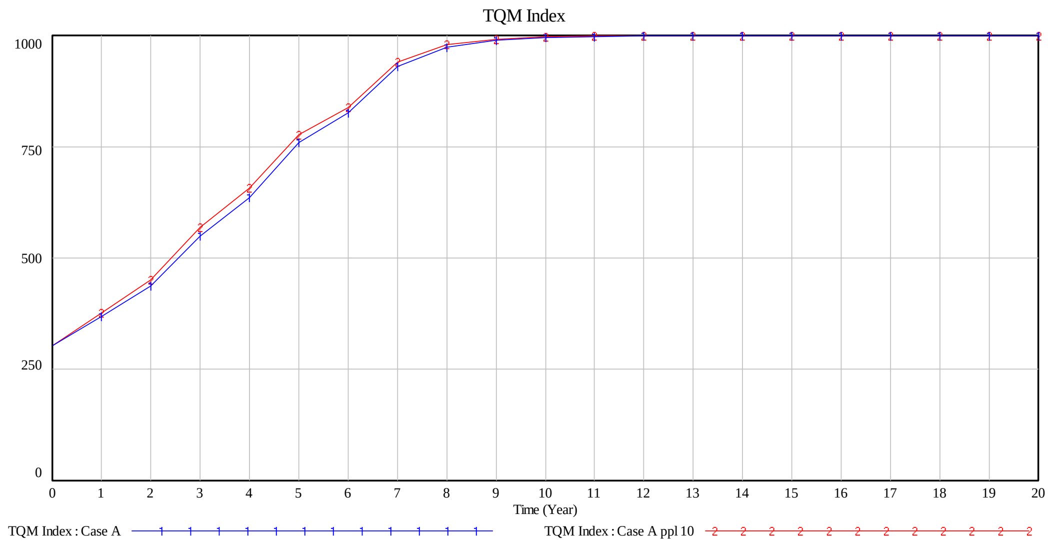


Figure 8-11: TQM index score trend line for organization A (base run) and when *peppl* = 0.1

Figure 8-11 shows that while increasing *peppl* from 0 to 0.1 has a marginal impact on the TQM index score of the firm; the overall impact is not that significant. This shows that improving the People enabler will not have the desired improvement needed to achieve a better TQM score; this must be combined with improvement in other enablers.

Thus, two further policy experiments were considered for organization A. the first test was by increasing both the Leadership and People enablers by 20% to investigate if it would give the desired impact on organization A's ability to reach TQM levels sooner was tested.

The second test was conducted by increasing percentage of efforts for all five enablers, *peldp*, *pepars*, *peprcs*, *pepelcs* and *peppl* all by 10%. Figures 8-12 and Figure 8-13, Tables 8-11 and 8-12 show the results.

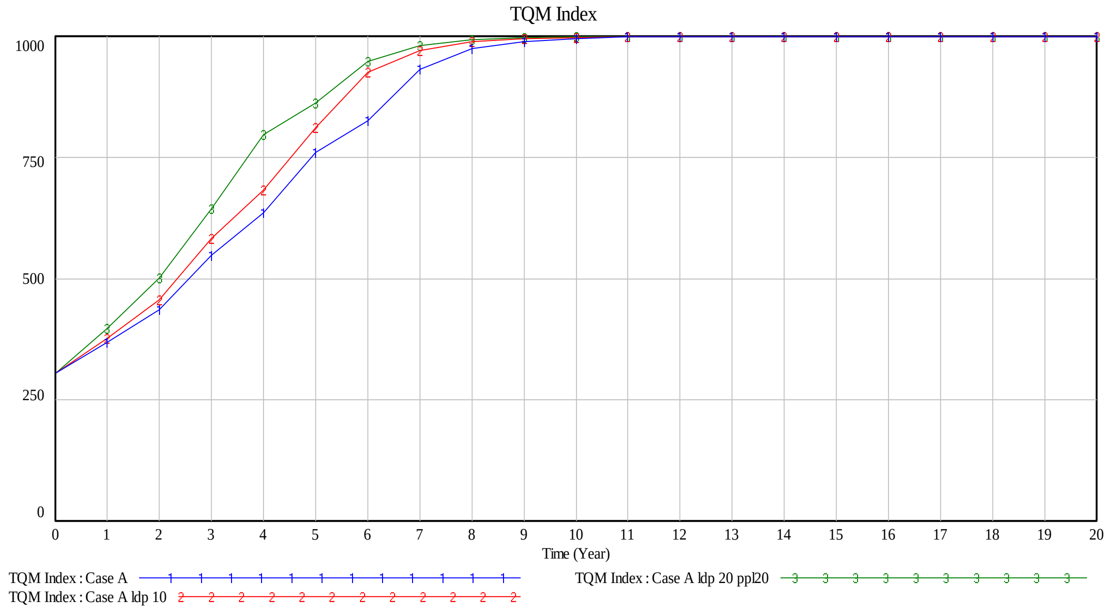


Figure 8-12: TQM index for organization A with change in leadership and people enablers

Table 8-11: Comparison of TQM index scores for organization A with varying values of *peldp* and *peppl*

Time (Year)	Case A Base run	Case A *peldp* 0.1	Case A *peldp*0.2	Case A *peldp* 0.2 *peppl*0.2
0	310.5	310.5	310.5	310.5
1	363.7891	372.4891	383.34033	397.14032
2	426.1795	449.4637	474.5546	500.72787
3	528.4988	569.1526	611.87109	642.94611
4	611.9289	666.4339	770.0589	796.45752
5	729.0966	790.5715	846.40314	861.33246
6	800.3918	852.3543	940.25879	948.17737
7	904.1224	931.9111	976.57343	980.64813
8	960.2516	968.5287	990.64392	992.76935
9	982.043	985.4246	996.17493	997.29675
10	991.6933	993.2399	998.39124	998.98877
11	996.1425	996.8613	999.30115	999.62158
12	998.2035	998.5415	999.68567	999.85828
13	999.1615	999.3218	999.85364	999.9469
14	999.6079	999.6845	999.92957	999.9801
15	999.8164	999.8531	999.96521	999.99255
16	999.9139	999.9316	999.9823	999.99719
17	999.9596	999.9681	999.99084	999.99896
18	999.981	999.9851	999.99524	999.99963
19	999.9911	999.993	999.9975	999.99988
20	999.9958	999.9968	999.99866	1000

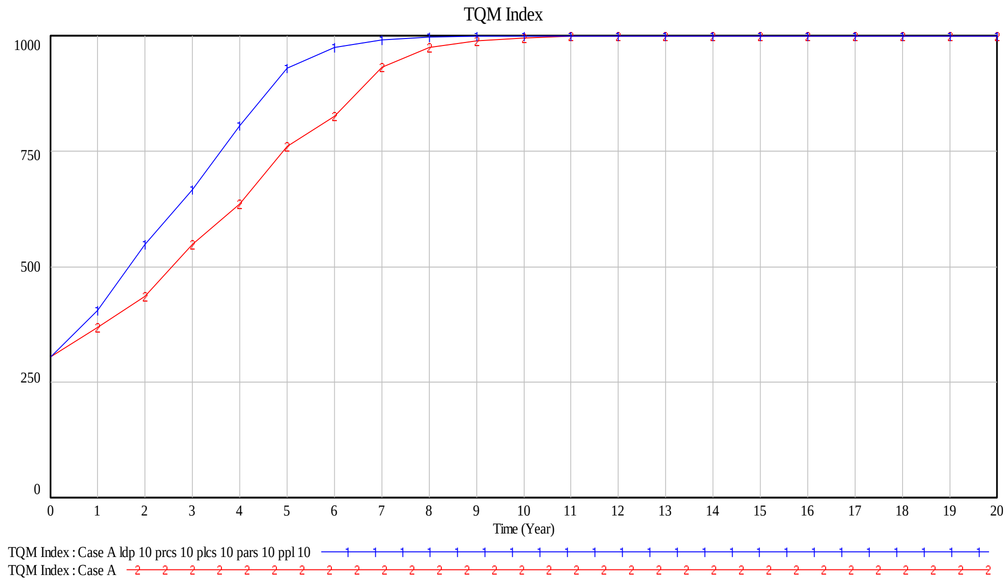


Figure 8-13: Trend lines for TQM index scores for organization A in base run and increasing all the enablers

Table 8-12: TQM index scores and the percentage of effort in improving all the five enablers is increased by 10%.

Time (Year)	Case A *peldp* 10 *peprcs* 10 *peplcs* 10 *pepars* 10 *peppl* 10	Base run
0	310.5	310.5
1	405.2003	363.7891
2	548.5888	426.1795
3	667.0531	528.4988
4	805.2562	611.9289
5	929.4744	729.0966
6	973.559	800.3918
7	990.0052	904.1224
8	996.1923	960.2516
9	998.5393	982.043
10	999.4359	991.6933
11	999.7809	996.1425
12	999.9143	998.2035
13	999.9663	999.1615
14	999.9866	999.6079
15	999.9947	999.8164
16	999.9979	999.9139
17	999.9992	999.9596
18	999.9996	999.981
19	999.9999	999.9911
20	999.9999	999.9958

Table 8.11 shows there is no significant difference between when *peldp* is increased by 20% to when both *peldp* and *peppl* is increased by 20% in term of achieving the fifth level of TQM maturity level. While there is some improvement in year-on-year rise in the TQM score when both *peldp* and *peppl* are increased, in both cases the firm reaches the fifth level of TQM index in the 5th year. Improving the Leadership enabler is the key to achieving higher TQM performance. This can be explained by the special characteristic of Saudi culture, which is top driven. Decisions taken at the top are likely to drive the organization towards better TQM performance, which will automatically generate a better People enabler. The only issue is that this impact will have a time lag; hence there is no significant improvement in improving only the Leadership enabler as compared to when both the Leadership and People enablers are improved. This also confirms the findings of SDM in base-run model, which indicated that improving the Leadership and People enablers is likely to have a more significant impact on TQM index score passed the TQM maturity level 2.

When the percentage of effort in improving all the five enablers is increased by 10% there is a noticeable change in the firm's ability to improve its TQM score Table 8-12. The firm will be able to reach the 5th level of TQM index within only 4 years, two years less than the base run of A, and 1 year less than the case when only *peldp* and *peppl* is increased. Having a holistic improvement in the enablers is likely to have a significant improvement in the firm's ability to achieve top level of TQM index sooner. However, this may involve significant costs. For example, money invested in improving the People (such as training, rewards) and, Partnership and resources (such as dedicating financial and other resources) enablers has cost implications.

8.4.2 **Policy experiments for organization B**

Experiments of policy were conducted for organization B. In the base run of case B; it began at TQM maturity level 3 and was expected to reach level five by the 4th year. The analysis showed that the People enabler gap was highest among all enablers when organization B entered the fifth maturity level. The Partnership & resources and Policies and strategy enabler gaps were also high.

The first test was with the leadership enabler. To improve the leadership, score the initial value of *peldp* (percentage effort to improve leadership) was increased from 0 to 0.1. This represents a 10% increase in the initial value of *peldp*. The remaining values were left and the simulation was run.

The results in Table 8-14 show that the Leadership enabler in this increase will achieve its highest value by the 4th year which is 1 year less than the base run for case B in which the leadership gap reduced to zero in year 5.

Comparison of the base run and the policy decision of raising *peldp* to 0.1 are shown in Table 8-13 below:

Table 8-13: TQM maturity level of organization B with leadership enabler (*peldp*=0.1)

TQM maturity level	Base case	*Peldp* = 0.1
3rd	Year 0	Year 0
4th	Year 2	Year 2
5th	Year 4	Year 4

Organization B will enter fifth maturity level in year 4 even when *peldp* is increased by 0.1 confirming the previous assumption that increasing leadership will not have noticeable impact on firm B's ability to reach TQM maturity level 5any sooner as the gap was slightly low in base run of case B.

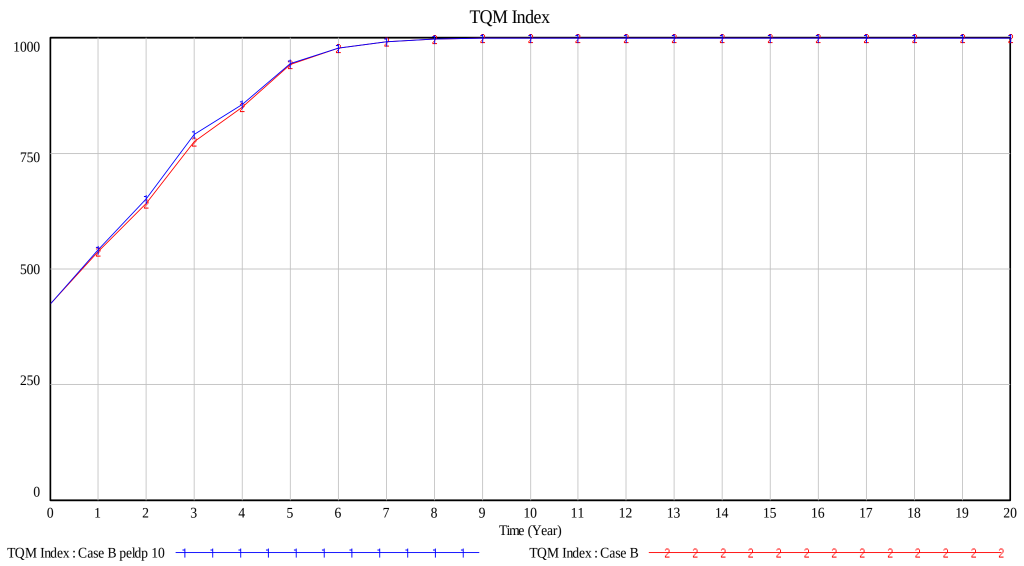


Figure 8-14: TQM index score of case B in base run and when *peldp* is increased

Table 8-14: TQM score for organization B with leadership enabler

Time (Year)	Case B *peldp* 10	Case B (base run)
0	418.84	418.84
1	541.97363	536.87366
2	651.86487	640.45514
3	791.57867	775.3584
4	856.14563	850.55981
5	944.33759	942.15088
6	978.25696	977.23779
7	991.36072	990.87048
8	996.49109	996.2478
9	998.53589	998.41199
10	999.36969	999.30542
11	999.71924	999.68536
12	999.87054	999.85254
13	999.93823	999.92865
14	999.96967	999.96448
15	999.98474	999.98193
16	999.99219	999.9906
17	999.99585	999.99506
18	999.99786	999.99744
19	999.9989	999.99866
20	999.99939	999.99927

Table 8-15: Score of five enablers for organization B with 10% change in *peldp*

	Leadership		Partnership and Resources		Policies and strategy		People		Processes	
Year	*Valldp*	*gpldp*	*Valpars*	*Gppars*	*Valplcs*	*gpplcs*	*Valppl*	*gpppl*	*valprcs*	*Gpprcs*
0	48.53	63.47	39.2	30.80	27.72	71.28	36.77	62.23	58.29	61.71
1	66.34	45.66	50.27333	19.72667	49.58409	49.41591	50.85328	48.14672	84.6099	35.3901
2	81.48727	30.51273	58.86035	11.13965	68.48244	30.51756	65.41816	33.58184	105.7079	14.29208
3	102.3369	9.66309	64.91928	5.08072	82.62319	16.37681	77.89657	21.10343	116.5292	3.4708
4	112	0	68.32226	1.67774	91.82744	7.17256	87.74462	11.25538	119.5881	0.41193
5	112	0	69.56513	0.43487	96.19604	2.80396	93.49297	5.50703	119.9858	0.01421
6	112	0	69.89508	0.10492	97.91156	1.08844	96.30552	2.69448	120	0
7	112	0	69.97561	0.02439	98.57829	0.42171	97.68164	1.31836	120	0
8	112	0	69.99443	0.00557	98.83668	0.16332	98.35495	0.64505	120	0
9	112	0	69.99874	0.00126	98.93676	0.06324	98.68439	0.31561	120	0
10	112	0	69.99972	0.00028	98.97551	0.02449	98.84557	0.15443	120	0
11	112	0	69.99994	0.00006	98.99052	0.00948	98.92444	0.07556	120	0
12	112	0	69.99998	0.00002	98.99633	0.00367	98.96303	0.03697	120	0
13	112	0	70	0	98.99858	0.00142	98.98191	0.01809	120	0
14	112	0	70	0	98.99945	0.00055	98.99115	0.00885	120	0
15	112	0	70	0	98.99979	0.00021	98.99567	0.00433	120	0
16	112	0	70	0	98.99992	0.00008	98.99788	0.00212	120	0
17	112	0	70	0	98.99997	0.00003	98.99896	0.00104	120	0
18	112	0	70	0	98.99998	0.00002	98.99949	0.00051	120	0
19	112	0	70	0	98.99999	0.00001	98.99975	0.00025	120	0
20	112	0	70	0	99	0	98.99988	0.00012	120	0

Table 8-16: Enablers, goals and TQM score of organization B with change in *peldp*.

Time (Year)	Enablers (case B)			Goals (case B)			TQM Index (case B)		
	peldp 0.2	*peldp* 0.1	Base	*peldp* 0.2	*peldp* 0.1	Base	*peldp* 0.2	*peldp* 0.1	Base
0	210.51	210.51	210.51	208.33	208.33	208.33	418.84	418.84	418.84
1	312.9995	307.8995	302.7995	234.0741	234.0741	234.0741	547.0737	541.9736	536.8737
2	400.7175	390.3276	378.9179	261.5373	261.5373	261.5373	662.2548	651.8649	640.4551
3	460.3404	455.0188	438.7985	336.5599	336.5599	336.5599	796.9003	791.5787	775.3584
4	483.2578	481.1653	475.6297	375.0305	374.9803	374.9301	858.2883	856.1456	850.5598
5	492.356	491.4186	489.3055	452.9847	452.919	452.8454	945.3408	944.3376	942.1509
6	496.3179	495.8789	494.8902	482.4041	482.3781	482.3476	978.7219	978.257	977.2378
7	498.1682	497.9549	497.476	493.4156	493.4059	493.3944	991.5839	991.3607	990.8705
8	499.0655	498.9586	498.7196	497.5361	497.5325	497.5282	996.6016	996.4911	996.2478
9	499.514	499.4592	499.337	499.078	499.0767	499.075	998.592	998.5359	998.412
10	499.7438	499.7152	499.6515	499.655	499.6545	499.6539	999.3988	999.3697	999.3054
11	499.8637	499.8486	499.8149	499.8709	499.8707	499.8705	999.7346	999.7192	999.6854
12	499.927	499.9189	499.901	499.9517	499.9516	499.9515	999.8787	999.8705	999.8525
13	499.9607	499.9564	499.9468	499.9819	499.9819	499.9819	999.9426	999.9382	999.9287
14	499.9788	499.9764	499.9713	499.9932	499.9932	499.9932	999.972	999.9697	999.9645
15	499.9885	499.9872	499.9845	499.9975	499.9975	499.9975	999.986	999.9847	999.9819
16	499.9938	499.9931	499.9916	499.9991	499.9991	499.9991	999.9928	999.9922	999.9906
17	499.9966	499.9963	499.9954	499.9996	499.9996	499.9996	999.9962	999.9959	999.9951
18	499.9982	499.998	499.9975	499.9999	499.9999	499.9999	999.9981	999.9979	999.9974
19	499.999	499.9989	499.9987	500	500	500	999.999	999.9989	999.9987
20	499.9995	499.9994	499.9993	500	500	500	999.9995	999.9994	999.9993

It was the tested whether increasing *peldp* further would have any impact on organization B's ability to reach 5th level of TQM maturity any sooner. The results indicate that the Leadership enabler in this case (*peldp* = 0.2) would achieve its highest value by the 4thyear which is same as when *peldp* is 0.1. Comparison of the base run and the policy decision of raising *peldp* to 0.1 and 0.2 are shown in Table 8-17.

Table 8-17: Organization B with improving in leadership enabler (*Peldp).*

TQM maturity level	Base run(Case B)	*Peldp* = 0.1	*Peldp* = 0.2
3rd	Year 0	Year 0	Year 0
4th	Year 2	Year 2	Year 2
5th	Year 4	Year 4	Year 4

Organization B will enter fifth maturity level in year 4 even when *peldp* is increased by 0.2 confirming the previous assumption that increasing leadership will not have noticeable impact on firm B's ability to reach TQM maturity level 5any sooner as the gap was slightly low in base run of case B.

The next policy decision tested was to alter the People enabler. The gap of people enabler was high in the base run (of case B) at the time when organization B reaches the fifth maturity level. New test was created in which percentage of effort to improve people enabler (*peppl*) was increased from 0 to 0.1 (10%).

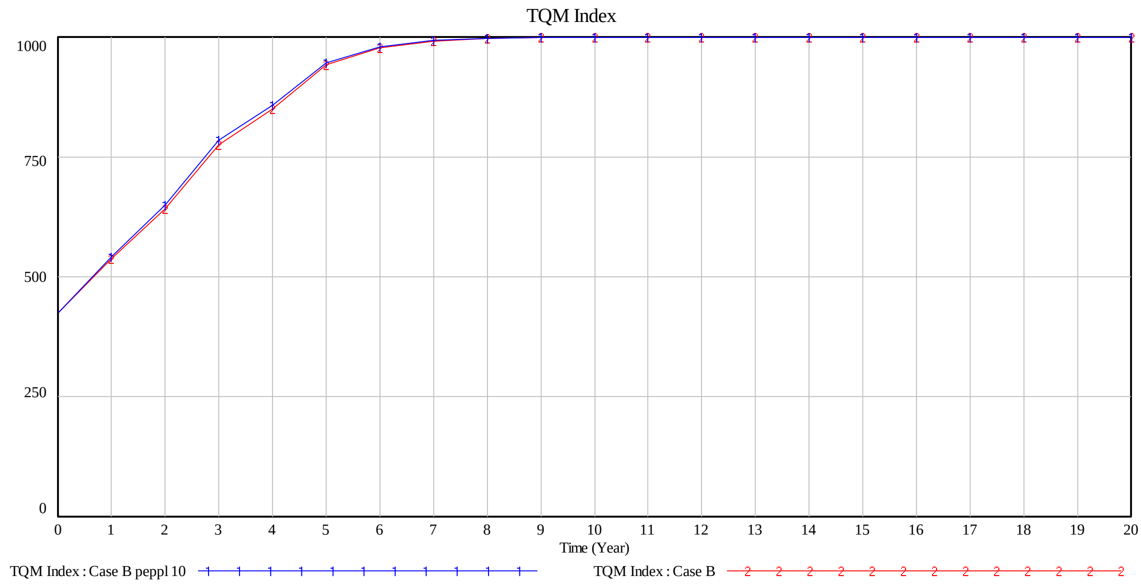


Figure 8-15: TQM index of Organization B with 10% change in *peppl*

Figures 8-15 show that, while increasing *peppl* from 0 to 0.1 has a marginal impact on the TQM index score of the firm, the overall impact is not that significant. Improving the People enabler will not have the desired improvement in achievement of TQM score and this must be combined with improvement in other enablers. The next policy decision tested was whether improving both the Leadership and People enablers by 20% would have the desired impact on organization B's ability to reach TQM levels sooner. Another test was conducted increasing the percentage of efforts for all five enablers, *peldp*, *pepars*, *peprcs*, *pepelcs* and *peppl* all by 10%.

Table 8-18: Organization B's TQM score with change in *Peppl*.

Time (Year)	TQM Index (Case B)		
	Peppl 0.2 *Peldp* 0.2	*Peppl* 0.1	Base run
0	418.84	418.84	418.84
1	557.6737	541.9736	536.8737
2	678.3752	651.8649	640.4551
3	811.438	791.5787	775.3584
4	928.3848	856.1456	850.5598
5	973.3318	944.3376	942.1509
6	990.0581	978.257	977.2378
7	996.29	991.3607	990.8705
8	998.6142	996.4911	996.2478
9	999.4819	998.5359	998.412
10	999.8062	999.3697	999.3054
11	999.9274	999.7192	999.6854
12	999.9728	999.8705	999.8525
13	999.9899	999.9382	999.9287
14	999.9962	999.9697	999.9645
15	999.9985	999.9847	999.9819
16	999.9995	999.9922	999.9906
17	999.9998	999.9959	999.9951
18	999.9999	999.9979	999.9974
19	1000	999.9989	999.9987
20	1000	999.9994	999.9993

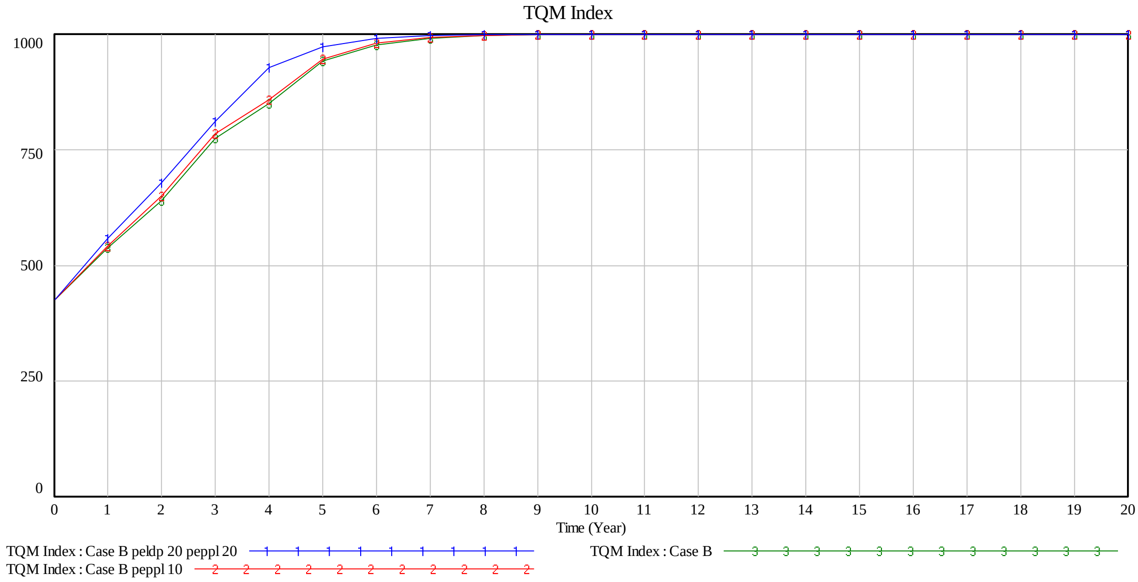


Figure 8-16: TQM index of organization B with change in People enabler

Table 8-18 indicates that when both the People and Leadership enablers are improved by increasing *peldp* and *peppl* by 0.2, the time taken by Organization B to reach TQM maturity level 5 is reduced by 1 year. As opposed to the base run (of Case B) when the organization will reach the top TQM maturity level in 4 years; if *peldp* and *peppl* are increased by 0.2 organization B will reach the top TQM maturity level within 3 years. This means that instead of improving either *peppl* or *peldp* the better option is to improve both *peldp* and *peppl*.

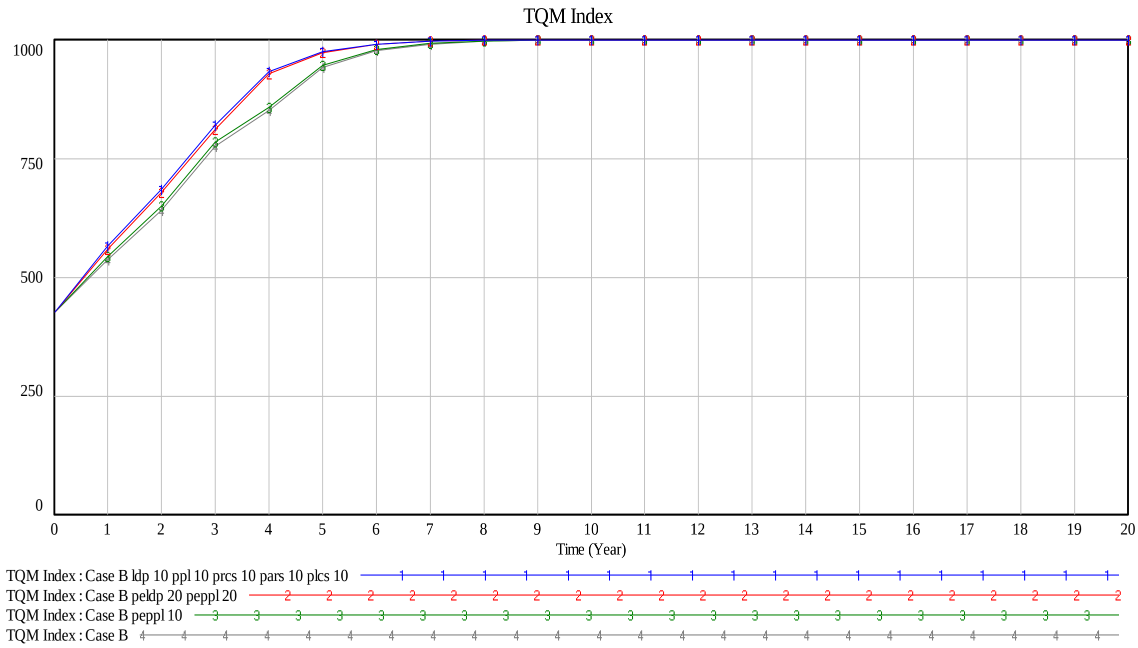


Figure 8-17: TQM index of Organization B with different enablers

Table 8-19: Organization B's TQM index score with change in different enablers

Time (Year)	TQM Index (Case B)			
	peldp 10 *peppl* 10 *peprcs* 10 *pepars* 10 *peplcs* 10	*peldp* 20 *peppl* 20	*peppl* 10	Base run
0	418.84	418.84	418.84	418.84
1	565.4437	557.6737	541.9736	536.8737
2	683.7094	678.3752	651.8649	640.4551
3	818.7014	811.438	791.5787	775.3584
4	932.6743	928.3848	856.1456	850.5598
5	974.7708	973.3318	944.3376	942.1509
6	990.4836	990.0581	978.257	977.2378
7	996.389	996.29	991.3607	990.8705
8	998.6224	998.6142	996.4911	996.2478
9	999.4718	999.4819	998.5359	998.412
10	999.7964	999.8062	999.3697	999.3054
11	999.9211	999.9274	999.7192	999.6854
12	999.9692	999.9728	999.8705	999.8525
13	999.9879	999.9899	999.9382	999.9287
14	999.9952	999.9962	999.9697	999.9645
15	999.9981	999.9985	999.9847	999.9819
16	999.9993	999.9995	999.9922	999.9906
17	999.9997	999.9998	999.9959	999.9951
18	999.9999	999.9999	999.9979	999.9974
19	999.9999	1000	999.9989	999.9987
20	1000	1000	999.9994	999.9993

Similarly when the percentage of effort in improving all five enablers is increased by 10% then there is a noticeable change in the firm’s ability to improve its TQM scores (Table 8-19 and Figure 8-17). In this case the firm will be able to reach the 5th level of TQM index within only 3 years which is one year less than the base run and same as when both *peldp* and *peppl* is increased by 0.2. This means that achieving a holistic improvement in all of the enablers is likely to have a significant and noticeable improvement in firm's ability to achieve top level of TQM index sooner. However, the results indicate that by just improving the Leadership and People enablers will yield the desired results and hence firms can save costs by focusing on these two enablers simultaneously.

8.5 Chapter summary

This chapter aimed to apply the TQM maturity model to specific cases and analyse how policy decisions can be used by organizations to accelerate their progress towards higher

TQM maturity levels. The two cases considered here were at different maturity levels to begin with: organization 'A' is in the second (Committed) level of maturity at the beginning of the experiment, and organization 'B' is in the third (Improver) maturity level at the beginning.

Analysis indicates that organization A in the base run, will enter the 5th TQM maturity level in the sixth year and also be able to push forward its movement towards the highest TQM index score by focusing on the Leadership and People enablers. Policy testing through sensitivity analysis also indicates that organization A can reduce the time to reach the highest maturity level from year 6 to year 4 by having a holistic improvement in all enablers.

Organization B starts in the 3rd TQM maturity level and was expected to reach stage five by 4th year in the base run model. Unlike organization A, boosting the Leadership enabler has no noticeable impact on organization B's ability to reach higher TQM maturity levels. However, when both the People and Leadership enablers are boosted it leads to a reduction of 1 year in the time required by organization B to reach the highest TQM maturity level for. Thus, the results indicate that improving the Leadership and People enablers will yield the desired results and hence firms can save costs by focusing on these two enablers simultaneously.

CHAPTER 9 FINDINGS AND DISCUSSION

9.1 Introduction

This chapter discusses the findings of data analysis and the systems dynamics analysis of TQM maturity in Saudi construction firms. The first section discusses the general findings, while the remaining sections discuss the findings related to specific enablers.

9.2 General findings

There is a focus on improvement in the construction industry, due to the high rates of project failures and poor performance, accidents and quality issues (Mahmood, 2008). Quality management has emerged as one of the most critical issues for the sector (Harrington *et al.* 2012; Hoonakker *et al.*, 2010). These issues are more common and more persistent in developing countries that have comparatively weak legal and institutional system.

The literature review considered research that investigated the causes of project failures in the Saudi construction industry. It found that many of the failures relate to quality issues (Assaf and Al-Hejji 2006; Arain *et al.* 2006; Al-Kharashi and Skitmore, 2009; Alghonamy, 2015). Poor quality culture is one of the key issues affecting the Saudi construction industry. The Saudi government is paying more attention to quality issues as well as other stakeholders because of this.

The review of the context of Saudi construction industry in chapter 4 confirmed that the Saudi construction industry is has special characteristics which embody culture, implementation of any strategy/philosophy requires contextualisation; otherwise, there is a high risk of failure. The market, cultural and institutional context within Saudi Arabia has historically not supported pursuing the quality improvement strategy. However, it is argued that the recent changes within the context of Saudi construction industry warrants rethinking the strategy for pursuing a quality focused strategy.

TQM is a quality management approach, with the potential to resolve many issues that the Saudi construction industry faces. One of the problems has been its poor implementation as the complexity and scale of the construction industry creates challenges in implementing quality management across such a borad and diverse industry. It is important to examine TQM applications and transferability of the techniques for the advancement of the Saudi construction industry (Albayoudh, 2003). The Saudi government announced the King Abdul Aziz Quality Award (KAQA) to maximize quality, efficiency and productivity in different sectors within the Kingdom, which highlights the increasing recognition and attention paid to quality in Saudi Arabia. Due to the link with crude oil prices and the dependency upon public sector work, the annual output of the Saudi construction industry is extremely volatile. This creates the risk-averse nature of the industry and a lack of investment in innovation.

Saudi contractors often fail to meet the high-quality expectations of their project sponsors (Alhammadi *et al.* 2016). This research confirms the views of Abusa and Gibson (2013), Griffith (2011) that quality management has a positive and significant impact on the achievement of high performance and maintaining competitive advantage for construction firms. With increased global competition, construction firms have been compelled to focus on improving quality as a solution to survive and grow (Oakland and Marosszeky, 2006). Quality reputation is fast becoming one of the key determinants of a firm's success because many project sponsors are considering quality not as a distinguishing criterion, but as a selection criterion for project bidders (Griffith, 2011).

It was argued in Chapter four that the Saudi construction industry is a dichotomy between a mature industry with large complex megaprojects undertaken mainly by a small number of local and foreign contractors using sophisticated management techniques and project management systems, and an immature and developing local market where projects are undertaken by indigenous small and medium sized Saudi registered contractors. The latter frequently fail to meet the quality expectations of the client. In addition, foreign contractors are obliged to outsource at least 30% of the project work to local players, giving the local players some degree of protection. This creates an environment of complacency in which the local players tend to rely on contractual obligations of foreign contractors, rather than their own performance in winning projects. To achieve their quality objectives, firms adopt several approaches such as ISO9001 certification, TQM etc. (Georgiev and Ohtaki, 2016). There is no one particular approach preferred by all organizations, it depends on the context in which they operate. For example, ISO9001 certification is globally recognised and following this quality management approach provides more quality credibility.

This research confirms the research findings that the Saudi construction industry has been slow in adopting TQM (Hafeez *et al.*, 2006; Aichouni*et al*, 2014). However, the focus on quality has started to change, evidenced by the rising number of organizations achieving ISO9001 certification. However, many of these firms fail to maintain their ISO9001 certified status; they find it difficult to sustain their quality performance.

A TQM maturity model is needed for construction companies to maintain continuous improvement in their quality standards. TQM proposes long-term, continuous and holistic improvement in quality performance. ISO9001 is the first step in achieving TQM. The findings show that many Saudi construction firms consider ISO9001 as the destination for their quality efforts, rather than the start of a journey. Considering the interests of the stakeholders as well as the customers, will have wider and positive implications for firms.

The literature review indicates that the concept of quality has evolved. Quality was mainly defined as an ability to meet customer expectations. However, the focus has shifted from customers to the wider stakeholder community. Quality in construction refers to meeting stakeholder expectations; organizational outcome is not dependent on customer satisfaction alone. Quality management in the industry is particularly challenging because of the number of stakeholders with diverse objectives (Harrington*et al.*, 2012). The problem is complex because the stakeholders will have conflicting interests; for example, investors will want construction firms to minimise costs, while other stakeholders may be more interested in speed of delivery focused upon meeting the minimum acceptable standards. Other stakeholders such as clients, shareholders, employees, partners, competitors, local government, media and the public further complicate this. Thus, it is a challenge for construction firms to determine on which aspects of quality they should concentrate. For example, improving the environmental performance may increase short-term costs, which may affect shareholders adversely, but ignoring the environmental performance may hurt society in the long run.

TQM implementation can be useful in improving the quality performance of Saudi construction firms, but to implement it construction firms need to take long term approach to quality improvement. Therefore, the research adopted the TQM maturity model, which requires firms to take incremental steps moving from one stage of TQM maturity to another, as they improve their quality performance. To achieve this, firms need to alter the factors that contribute to improvement in their quality performance, and change their quality culture. This alteration in factors cannot be achieved overnight; for example, changing the quality culture of the organization takes time and need to be done in several stages.

9.3 Findings from the surveys

There were key findings from the quantitative data analysis. This research finds that most construction companies consider that exceeding customer expectations is the most significant measure of quality; "exceeding customer expectations" received an average score of 4.27 on a scale of 1 to 5. This was followed by "providing best value for money for the customers," with an average score of 3.91. However, the government is the main procurer in the Saudi construction industry and with multiple decision-makers in the public sector; there are frequent interventions from public sector employees. This leads to frequent design changes and delayed discovery of certain issues (such as problems in permission from certain government departments), which leads to project delays. For example, the procuring Ministry may approve the design, but the Ministry of Finance may raise objections to certain aspects of projects and not allocate the funds. This is one of the primary reasons why most public sector projects fail to meet "the iron triangle" criteria of project success.

Customer satisfaction from public sector infrastructure depends not solely on the construction contractor, but on the entities involved in the supply chain and in facilities management. With public sector infrastructure, what really matters is how it is managed over a time period that determines customer (end users) satisfaction. The problem with the procurement and tendering in Saudi Arabia, especially in projects funded by the government, is that the focus is mainly on cost, where the lowest price is the only determinant for the project award in the bidding process. To secure work, the contractor will bid low with a low profit margin; quality is not the highest priority. There is a mind-set where procurers, especially in the public sector, take quality for granted, or assume that, irrespective of the price, all bidders will provide the same quality. Quality is not the main selection criterion for winning tenders in the public sector; contractors do not feel obliged to follow the quality concept.

Another interesting observation was the difference in weights of as obtained from the EFQM model and the AHP analysis. Researchers such as Algahtany*et al.* (2016) argue that the Saudi construction industry is different from the construction industry in western countries. The high-power distance culture is likely to increase the role of leadership in the implementation of quality management strategy; this should reflect in higher weight being allocated to leadership enabler. Similarly, high degree of collectivism will reflect in higher allocation to People enabler weight. AHP weights were calculated for Saudi Arabia and results indicate that the weights for Saudi construction industry are different from the EFQM weights. Particularly noticeable was the higher score attributed to the Leadership enabler, and lower score attributed to the Processes enabler. This shows that the Saudi construction industry is different from other Saudi industries such as manufacturing, and even from construction industries in other countries. This supports the argument that the EFQM model needs contextualisation when applying it in different contexts.

The EFQM model was contextualised for the Saudi construction industry; especially in terms of goals they target very specific goals using a quality management strategy. An AHP process revealed that the weights to be allocated to the five enablers for Saudi construction industry should be different from the weights allocated to the five enablers in the EFQM model. The noticeable aspects were the higher weights allocated to the Leadership, People and Policy& Strategy enablers in the Saudi context. For example, leadership enabler is allocated weight 100 under EFQM, but 112 under Saudi construction industry (as estimated through AHP), while the Processes enabler is allocated weight 140 under EFQM, but only 120 under Saudi construction industry (as estimated through AHP). This could be explained through cultural perspectives, for example, Saudi's high power distance culture means that decision-making is centralized and top-driven which explains the higher weight of the Leadership enabler.

The People enabler is critical because of the highly social nature of Saudi society as exemplified under the high collectivism score for Saudi Arabian culture in Hofstede's index. Policy and strategy is also critical because people tend to follow the rules verbatim. It is thus essential to have a clear, unambiguous and easy to understand set of policies and strategy.

9.4 Findings from System Dynamic Modelling (SDM)

The research utilized the System Dynamic Modelling (SDM) technique to analyse how Saudi construction firms are likely to achieve higher TQM maturity levels. SDM is used to understand and identify how different environmental, economic, social, and other factors affect a particular system in a complex way. One of the key factors in analysing firms' achievement of higher TQM maturity levels is the cyclical process in which the firms' TQM system learns from past experiences and inputs from different enablers and proceeds towards intended goals (i.e. higher TQM maturity levels). SDM is useful because it can model this process using the feedback loops which replicate the continuous improvement in quality management cycle.

A system dynamic model was constructed based on the EFQM model, the model is useful in helping to identify the factors that will support the organizations in achieving higher TQM. The EFQM model was contextualized in terms of allocation of weights for each of the enablers as well as the constituent aspects that comprised each aspect (the five enablers and goals) of the EFQM model. SDM was designed with the weights obtained from the AHP analysis, so that the system tried to fill any gaps in the desired and actual value of each enabler as well as goals. The Partial Least Squares Analysis helped to identify which enablers had a causal relationship with other enablers and goals. Using the PLS analysis, the nature of the relationship was also identified along with identifying whether or not the relationship was statistically significant. When a factor is positively affected another factor, there will be a positively enforcing loop between the variables. In cases when the relationship between the two variables is causal, negative and statistically significant, the loop between the two will be negatively reinforcing.

The TQM maturity score is organised on a scale of 0 to 1000 with five TQM maturity levels, each comprising a TQM maturity score interval of 200. The first base simulation exercise (Base run) shows that if Saudi construction firm, which has a zero score for its enablers i.e. no existing quality management policy, it will take around 19 years to reach the top score of 1000. However, the top level of TQM maturity levels has a starting point of 800, which can be reached in the 14thyear. This means that the organization will achieve its top TQM maturity level within the 14thyear but the absolute top score will be reached only somewhere around the 19thyear. Most of the curves obtained using SDM were *S* shaped which indicates that firms should spend considerable time rising from the bottom to the3rd maturity levels. Thereafter, they can progress quickly through 3rd and 4thmaturity stages before spending considerable time in the 5thmaturity level and reaching the highest TQM score. This is evident from the results that indicate that in the base run, the organization will take 7 years to cross over from the1st TQM maturity stage into the2nd and a further three years to cross from the 2ndto the 3rdmaturity stage. However, it will take only 2 years to cross over from third to fourth, and 1 year to cross over from fourth to fifth stages. However, after this the organization will spend 6 years within the fifth maturity stage before it almost reaches the highest TQM maturity score of 1000. This means that firms who want to achieve the higher TQM maturity levels quicker must focus on shortening the time spent in the first to fifth maturity stages. This can be identified by tracking the progression of the enablers over the time period.

An observation in the base run simulation is that the goals score does not start to rise considerably until year 8. Then it rises sharply between years 9 and 17. This indicates that firms looking to achieve high TQM score may not see much improvement in results initially; they need to be persistent with quality efforts because quality focused strategy is not short-term. This has been one of the biggest barriers in pushing for a quality-focused strategy in construction companies where management is often under pressure to meet yearly performance goals. This also shows that management need to support the quality initiatives at early stages because the lack of improvement in goals will put pressure on the organization to abandon their quality efforts. In countries like Saudi Arabia, where decision-making is centralised and top driven, management's support is quite useful in persevering with a quality strategy despite few realised benefits. This supports the earlier observation that the Leadership enabler is one of the most critical drivers in achieving higher TQM maturity levels.

In the base model, the trend line of the people and goals scores. It shows that the rise in goals score lags behind the people score by one year. This means that improvement in the people score this year is likely to show improvement in the goals score the following year. The year-on-year similarity in the trend lines of goals and people scores indicates that one of the significant contributors in the goals score is people (including training, empowerment, reward management etc.); one of the most significant aspects of quality strategy is to achieve a higher people enabler score. This supports the view that a change in organizational culture is a prerequisite for achieving quality goals and objectives. Therefore, it takes time for firms to start realising the benefits; developing a quality culture in an organization is a process, which takes time and requires persistence. Unless this is achieved it will be difficult for the firm to realise its quality goals. Other enablers such as leadership affect several aspects of the People enabler such as training, feedback, and reward system and information accessibility. This supports the choice of SDM methodology for this research because it takes into consideration the dynamic impact of variables on each other over time using the feedback loops.

The sensitivity analysis conducted for the base run by altering the desired values of enablers and path coefficients between different enablers and goals suggest that the model is robust and reliable. The $\pm$10% and $\pm$25% variation in the base run values of these variables did not have significant impact on the behaviour of the system. This means that the system is robust up to at least 25% variation it the assumed values.

Policy testing was conducted for the base run model. it was tested whether certain policies adopted by organisations, such as investing more effort into improving any particular enabler is likely to lead to any significant improvement in the performance of the organisation in terms of achieving its TQM maturity. According to the findings of this research, all the enablers are useful in achieving higher TQM maturity levels and its subsequent organization goals, but the most critical of these enablers are the Leadership and People enablers. These two enablers drive other enablers (Dale *et al.,* 2007); they act as triggers for the TQM performance improvement cycle. This makes sense from a Saudi culture perspective because most of the organizational efforts are driven by the management's vision. Setting quality focused policies and strategy, such as a quality-linked performance evaluation system, can contribute to the development of an overall quality-focused culture. TQM supports holistic quality management, achieved through the development of a quality-focused culture within the organization; which highlights the significance of the People enabler. Paying attention to the satisfaction of people such as employees is critical for achieving the TQM implementation goals.

Another noticeable finding from the results is that marginal changes in certain enablers produce significant improvement in a firm's ability to reach higher TQM levels sooner. For example, when the initial value of *peldp* (percentage effort to improve leadership enabler) is increased from 0 to 10%, it reduces the time required to reach highest TQM maturity levels by 6 years (from 14 to 8 years). Similarly, the time required to reach the highest TQM score is also reduced by 7 years (from 19to 12 years).

Further reductions in time require reaching higher TQM maturity levels, it can be achieved by increasing the initial value of the *peldp* by 20 and 30%, but these improvements are not as dramatic as observed in the case of initial value of the *peldp* increasing from 0 to 10%. This can be explained because the Leadership enabler on its own does not achieve a high TQM score. What is required is a strong and committed leadership followed by improvement in other enablers beginning with the People enabler and ending with the Processes enabler. This improvement in other enablers takes time to happen. For example, any change in the People enabler takes time, as it requires changes in the mind-set and culture of people.

Increasing the initial value of leadership by 25% will reduce the time required to achieve the fifth TQM maturity level by 7 years meaning the firm will achieve the highest TQM maturity level in this case (when initial value of leadership is set at 25%) in 7th year. The comparison of sensitivity charts for initial value of leadership and *peldp* (percentage of effort in improving leadership enabler) indicates that the firms' ability to achieve higher TQM maturity levels is more sensitive to the initial value of leadership than *peldp*. This is because the initial value of leadership indicates existence of a quality-focused leadership, which means that such firms might have a head start in quality culture improvement over firms who are just beginning to improve their efforts towards quality management as is indicated by *peldp*.

Improvement in the initial value of other enablers also provides improvements in a firms' ability to achieve higher TQM levels within short time spans. The results indicate that improving the initial value of any enabler by 25% (of the desired value) will reduce the time required to reach highest TMQ maturity levels to around 8 years. However, to interpret these results correctly, the sequences in which the improvements occur in an organization as highlighted by EFQM model need to be noted. The EFQM model the sequence begins with the Leadership enabler and so improving this is essential before improvement in the People enabler can be expected; the results are only interpreting a firm's rise towards higher TQM maturity levels.

The discussion reveals two things:

1) An improvement in firms' ability to reach higher TQM levels requires a change in all the enablers. Just focusing on the People or leadership enablers will provide limited benefits.
2) Any improvement in enablers is interdependent, hence will occur only over a time period. There needs to be persistent efforts towards achieving higher TQM levels. This will lead to a cycle of improvement in the enablers pushing the firm higher and higher towards the top TQM maturity levels.

This research investigated the simulation results for two cases. In both cases the initial value of the enablers was more than zero and the initial goals score was also high. This is understandable because of the choice of organizations for this research, which included ISO9001-certified companies which indicate that firms had already got a quality focused strategy. Looking at organization A, which had been ISO9001-certified for last three years, it is still only at the second stage of TQM maturity. This indicates that ISO9001 certification is merely the beginning of the journey towards TQM maturity. Although firm A began at the second TQM maturity stage, as opposed to the base run firm with an initial value of any enabler around 20 (the beginning of the first TQM maturity stage), the time required to reach the highest maturity stage was 6 years and the time required to reach the highest TQM maturity score would be 9 years. This confirms the findings of the previous model that increasing the initial value of all the enablers to 25% (of the desired value) will reduce the time to reach the highest TQM maturity level to 6 years and reduce the time to reach the highest TQM maturity score to 8 years. However, a remarkable difference is seen in organization B where the time to reach the highest maturity level is reduced to four years although the time required to reach the highest maturity score remains 8 years.

The next sections discuss the findings related to specific enablers in the model.

9.5 Leadership enabler

The results indicate that the Leadership enabler is quite significant for an organization as it contributes the most to the enabler score barring Processes enabler. This could be because the Leadership enabler affects all other enablers directly or indirectly. The TQM maturity model is initiated by the Leadership variable, which indicates that TQM adoption is not possible without leadership and commitment. Increasing the *peldp* value from 0% to 25% at the beginning will halve the time taken to reach the top TQM maturity level from 14 years to 7 years. From the results presented in the Table 7-10, it can be seen that within the first year Leadership enabler is the only contributor to the TQM index. This indicates that Leadership enabler acts as the key which kick-starts the process of achieving TQM maturity.

This research confirms the findings of researchers, Chin and Choi (2003), Haupt and Whiteman (2004), Pheng and Teo (2004) and Gharehbaghi and McManus (2003) who commented that one of the most significant predictors of the successful implementation of TQM principles was the commitment of top management. The Leadership enabler has been highlighted as a key enabler not only under EFQM (2014) but also under other TQM models (e.g. MBNQA, KAQA). This is because quality is mainly policy and strategy-driven and both these are decided at the top.

The Leadership enabler is critical because it help set the values and goals (Oakland and Marosszeky, 2006) and have a significant bearing on the path that the organization chooses to achieve these goals and objectives. Since the Leadership enabler has been found to be acritical influencer of TQM maturity, it is essential that leaders remain engaged in TQM maturity efforts throughout the cycle. In this respect, management commitment aspects of the Leadership enabler play a role in continuously motivating organizational resources and efforts towards the achievement of TQM maturity objectives. This confirms the views of Calvo-Mora *et al.* (2006) and Lewis, Pun and Lalla (2006a) who suggested that management commitment ensures that the organization does not abandon its TQM maturity drive despite setbacks but rather continues to learn and improve until it achieves its objectives.

Leaders play a vital role in not only setting policies and strategy but also taking practical steps such as rewards management, training and management (Jacobs and Suckling, 2007). This is evident from the PLS results which indicate that Leadership enabler has a statistically significant causal impact on three enablers; People, Policies & Strategy, Partnership & resources. All these create a push for a quality-focused culture within the organization which is the single most critical ingredient in achieving higher TQM maturity levels. Mazher *et al.* (2015) also suggested that a rewards-based strategy is a useful strategy in the Saudi construction industry's case due to the high rewards focus of migrant employees who constitute the majority of the construction workforce.

Not only top leadership but also middle level management plays a critical role in implementing TQM strategy as they bridge the gap between strategic planning and execution of quality strategy (Oakland and Marosszeky, 2006). Management's clear vision about TQM needs to be evident in the policies and strategy they make and also in their interaction with team members. This is quite a challenge in the Saudi construction industry where the interaction between top management and front line employees is quite limited. Leaders should encourage employee participation.

Poor orientation of the Leadership enabler towards TQM maturity can be one of the key inhibitors to its attainment in the Saudi construction sector. Researchers such as Scott-Jackson (2008) and Obeidat *et al.* (2016b) have also confirmed that the Arabic management style is more centralised with lower management level individuals barely participating in decision-making. Whilst quality can be conceptualised at the top, to achieve it requires concerted efforts of the site employees. The Saudi culture of high power distance is a barrier in achieving higher TQM maturity levels.

Most managers in the Saudi construction industry still follow some principles of management, which may not always be in line with TQM philosophy (Mazher *et al.* 2015;

Alotaibi *et al.* 2013). For example, favouritism or nepotism prevails in Saudi Arabia, which is believed to be both normal and beneficial (Building and Construction Authority, 2013). Also, managers may ignore some mistakes made by the employees in the name of compassion and sympathy but such ignorance may thus gradually become ingrained in the culture leading to development of a poor quality culture. Nevertheless, the Saudi management style remains significantly influenced by Islamic principles and Saudi culture (Alyousif *et al.* 2010). What is required is that the leaders provide a clear vision and guidance and exhibit solidarity within a quality strategy. They need to reward good performance and also take punitive action towards poor performance as the tolerance for poor quality may result in a culture of complacency. However, before doing so, management needs to do everything possible to support the employees in improving their quality performance. Leaders need to understand that quality is implemented by people and so should be done through people.

In summary, the **Leadership** enabler:

- Is significant as it contributes significantly to the enabler score.
- Helps set the values and the goals.
- Is the most critical influencer of TQM maturity by continuously motivating organizational resources and effort.
- Plays a significant role in setting policy and taking practical steps such as rewards and training.

9.6 People enabler

One of the main explanations for poor TQM performance of Saudi firms can be mainly attributed to people issues. Most of the workforce in the industry is poorly-trained and uneducated foreign workers who possess limited knowledge and understanding of the significance of quality in construction (Mazher *et al.* 2015). Many of these individuals come from cultural backgrounds where an emphasis on quality is poor. Influencing and altering the culturally-driven behaviour of an individual is difficult to achieve. However, implementation of TQM requires the changing of organizational culture to a quality-focused culture. This explains why Saudi construction firms may take longer to achieve higher TQM maturity levels, as altering the organizational culture in Saudi construction firms is not easy.

EFQM and most quality-based models suggest that the path to improvement in quality standards goes through improvement in human resources by developing and improving quality culture in organizations (Gómez, *et al*. 2011). As discussed in the base run model, the People enabler is the second enabler in the sequence of enablers that start the TQM maturity cycle. It is essential for People enabler to get affected, in order for other enablers to rise and consequently affect the TQM index score. In this research as the model reveals that the People enabler is one of the key enablers in terms of improving TQM maturity performance of organizations. Despite the known problems of a reliance on foreign unskilled workers, the industry has continued to rely on these workers due to lack of an available alternative (Alsamari, 2010). Researchers have talked about the issues caused by an unskilled workforce who lacks knowledge of quality culture both in terms of its usefulness and implementation (Albayoudh, 2003). Due to these issues and despite the top-level efforts, quality culture remains elusive for many Saudi construction firms. Past researchers (see, for example, Yurdakul and Ozturkcan, 2014) have also noted that the Saudi people support others in this social network and individuals may also disregard competency when offering favours. This leads to an environment which allows organizations to be complacent and yet remain competitive.

This research confirms the past findings that the difference in languages spoken makes it difficult for the managers to communicate with the front-line employees who do the manual labour work. Quality-related issues cannot be communicated in a one-off session, but requires a continuous flow of information and dialogue between all parties. Since there is a communication gap, caused mainly by language (Albayoudh, 2003), it is very difficult to develop the same level of communication regarding quality. As a result, the implementation of quality strategy remains a challenge. Middle managers play a key role in the implementation of a quality strategy so they must be adequately trained in both soft and hard skills. Soft skills here refer to interpersonal skills, while hard skills are the technical skills required in implementing a quality strategy

According to researchers such as Piesse *et al.* (2012), Yurdakul and Ozturkcan (2014), high levels of uncertainty avoidance in Saudi culture have a negative impact on the level of innovation and creativity in the industry. Quality management often involves change management because it requires the finding of new and innovative ways of improving quality. However, due to the high uncertainty avoidance culture of Saudi Arabia (Hofstede, 2011), there is often lack of willingness to disrupt the status quo. Therefore, there is a lack of interest among Saudi construction firms in adopting new and novel ways of boosting quality. This is especially true in the case of adopting new technology for quality improvement and to implement radical changes. This makes TQM even more relevant in the Saudi context because it proposes gradual and incremental improvement in quality performance and not a one-off radical change.

In terms of the People enabler, development of a quality-focused culture is critical in achieving higher TQM maturity level. Studies that investigated continuous improvement, which is widely acknowledged as being crucial for the successful implementation of TQM, found that the requirements were not met by most organizations (Alhwairini and Foley, 2012). The reason for this may have been that Arab culture is very distinct from Western culture and therefore it is expected to have a major impact on TQM Practices (Islam *et al.* 2013). Studies which focused on the efforts taken by of some organizations in the public sector to implement TQM found that organizational and social factors in Saudi Arabia hindered successful implementation (Al-Qahtani and Al-Methheb, 1999). This view has been asserted by other studies which considered organizational culture as a key factor in implementing TQM in construction firms (Mazher *et al.* 2015, Albayoudh, 2003).

In summary, the **People** enabler:

- Is key in improving TQM maturity performance of organizations.
- Is more efficient if there is better communication and greater skills in the workforce.
- Feeds off of innovation – the Saudi industry has a high uncertainty avoidance culture.
- Requires the development of a quality-focused culture.

9.7 Policies and strategy enabler

One of the ways in which management can develop a specific kind of culture is through developing and implementing a desired type of policies and strategy which leads to formation of specific culture within the organization. Such policies help in many ways such as the allocation of resources, due attention being paid to critical issues, generation of cooperation of all internal and external project partners etc. (Davies and Mackenzie, 2014).

The People and Strategy enablers have a significant impact on the Processes enabler which in turn affects the ability of firms to achieve its quality goals. In this respect, it can play a useful role in assisting firms in achieving their TQM objectives. This is especially true for Saudi construction industry as Saudi culture of following the rules verbatim without questioning means that individual quality efforts can be driven by the organization's stated policy/ strategy towards quality.

This research supports the views of Olian, and Rynes (1991), Thiagarajan and Zairi, (1997) that quality policies are useful in implementing quality initiatives and that they ensure a consistency in an organization's efforts towards TQM implementation. Interestingly, the contribution of the Policies and strategy enabler remains similar throughout the growth curve after achieving a certain level (refer to figure 7.12), indicating that the firm needs to have the right set of policies and strategy and persist with these unless some new piece of information warrants change in either of them.

The uniformity in the impact graph can be explained in that setting policies and strategy has a significant impact, but there is a limit to which this will affect a firm's ability to achieve its TQM objectives. Since strategy and policy remains constant, the impact cannot go beyond a specific level unlike the People and Leadership enabler where there is a lot of scope for improvement leading a constantly-upward scaling relationship. Policies and strategy can only affect the TQM maturity attainment to a saturation level, beyond that it is through the Leadership and People enablers that an organization can continue its progression to higher TQM maturity levels. This is because organizational culture is more than just follow what is stated in the policy/ strategy. For a firm to achieve highest level of TQM, people need to go further and embrace quality as the key outcome of their activities.

Consistency of strategy and policy is critical so that other resources including human resources can be channelled in a specific direction to achieve the objectives. Firms pursuing high TQM maturity scores need to adopt and maintain consistency in quality-related strategy and policies. This is critical because constantly changing policies and strategy causes confusion among implementers and leads to a lack of focus and attention. This is also critical because quality policy and strategy affects quality processes within the organization. It takes time for various components of the system to adapt to new processes. Frequent disruption to the policy and strategy will reflect in frequent disruptions to quality processes, which will affect system learning and consequently may result in failure in following the procedures as intended.

Policy and strategy of an organization determines how the organizational resources are developed and even the internal and external partnerships are managed. Leaders manage people resources as well as other resources through setting and implementing adequate policies and strategy (Bou-Llusar *et al.* 2005). These resources do not start to yield desirable results instantly, but need to be developed, nurtured and utilised over time. As these resources develop, firms achieve higher TQM maturity levels. In this respect, the impact of policies and strategy may not be direct but through the way in which they affect the other enablers.

In terms of quality, the policy and strategy should be both externally and internally driven (Martín-Castilla*et al.*, 2008). Knowledge management within the organization can help diffuse the knowledge that each individual holds about their environment. This can help them make informed decisions about how to manage quality in their roles. This can be done through a policy of knowledge management within the organization. It means that policies and strategy work in a cyclical fashion where the future policies and strategy itself are driven by the effectiveness of past policies and strategy.

By establishing a quality-related policy and strategy, the management is signalling its interest in quality management (George et al., 2003). This provides legitimacy to quality managers and processes which are quality focused. Once an organization's policy and strategy is quality-focused, it facilitates cooperation and coordination among different entities generating their interest in quality management. This supports the views of Civcisa (2007) who commented that what the management does best is setting the strategy, which acts as a guide for the rest of the organization to follow.

One of the key policies in this regard is rewards management. Since the migrant workers, as well as the local workers, recognise monetary rewards more than any other form of reward, it is essential to develop a comprehensive quality-linked compensation policy. The policies and strategy should be driven based on the knowledge and information collected from all internal and external resources.

Management's job does not end with setting of policies and strategy but requires continuous monitoring of whether these are being implemented adequately or not (Bou-Llusar *et al.* 2005). As Aichouni *et al.* (2014) recommended quality policy cannot be static; it should be dynamic and progressive to be effective. For this the management need to continuously monitor the performance of the organization and revise the quality policy and strategy as required. This again is linked to continuous management commitment which was emphasised in section 9.5 as one of the key ingredients of TQM maturity attainment.

Greater participation of middle level managers in this regard is useful because they will translate the organizational policy and strategy into divisional policy and strategy and thereafter monitor its implementation. Delegation of responsibilities is thus critical in the case of quality management in Saudi construction industry.

In summary, the **Policies and strategy** enabler:

- Has a significant impact on the Processes enabler which in turn affects the ability of firms to achieve its quality goals.
- Remains similar throughout the growth curve after achieving a certain level; it can only affect the TQM maturity attainment to a saturation level.
- Relies upon consistent policies and strategies to reach high TQM maturity.
- Should be internally and externally driven and involve knowledge management.

9.8 Partnership and resources

With a very long and complex supply chain, the performance of construction industry players depends not only on their own work but also that of their partners. Partnership management can be a useful strategy in this regard (Davies, 2008). Building partnership and resources is a long-term approach towards achieving a long-term strategy. Firms often get confused by short-term objectives and lose focus on long-term strategy. This research finds that building partnership and resources with an aim to supporting a long-term quality strategy is a critical contributor to firms' attainment of higher TQM maturity levels.

This research confirms the findings of Oakland (2014) that use of resources is critical for the achievement of quality goals. Management and all individuals need to play their role in managing quality. TQM is about managing quality in the best possible way and in every aspect of business. This is only possible if the people involved utilise the resources to achieve quality goals. For example, employees can use technology to streamline production, making the supply chain more efficient, communicate and share information etc. Resources should be utilised not only efficiently but also smartly in order to ensure that the quality goals and objectives are achieved.

Firms use their resources in order to achieve their objectives (Bou-Llusar, *et al.* 2005). In case the firm does not have a particular resource, it needs to acquire that resource. In terms of quality in construction industry, the most critical resource is the information and knowledge of what quality is and how it can be achieved in context of each and every process. This is often held by the individuals who undertake these tasks and activities.

Management of resources is critical but this research finds the most critical resource to be managed is people. It is almost impossible to achieve TQM objectives without adequate participation of people. In case of the Saudi construction industry, it is even more critical because a lot of the work is manual and most quality control is in the hands of the individuals undertaking the tasks. Technological resources also play a key role in quality management in any industry (Bou-Llusar, *et al.* 2005) including construction. However, in the Saudi construction industry the usage of technology is comparatively low compared to that in western countries. Comparatively lower costs, poor professional training and relative ease of obtaining manual labour create disincentives to the adoption of new technology. Also, the high uncertainty intolerance makes Saudis less likely to adapt to new technology and ways of doing things. However, highly centralised power system means that top management can create a push for utilisation of new technologies and resources to achieve organizational quality goals.

Management of partnerships is critical because most of the projects involve a number of partners (subcontractors, suppliers etc.). It is difficult to develop a cooperative- and coordination-based approach with new partners. For this reason long-term and strategic thinking with a key focus on quality is required. With time, an organization and its partners can come to the same level of understanding regarding quality issues. For this it is essential that contractors consider subcontractors as their partners and not suppliers and maintain a quality-focused relationship rather than a cost-focused one. This aspect is strategy and policy driven and hence should be initiated by top management. In cases where partner is not able to maintain the quality standards of the organization it is advisable to work with that partner to bring up its level of quality rather than abandoning them and looking for a new partner. This is because developing a cooperative relationship requires a lot of time and effort. In terms of considering suppliers as partners, one more aspect that needs to be looked at is information exchange and skills development. Through proper communication, contractors can develop the knowledge of quality issues, expectations and risks across whole of its value chain. Unless there is consistency in this knowledge, it is almost impossible to achieve the quality objectives.

In summary, the **Partnership and resources** enabler:

- Resources is a long-term approach towards achieving a long-term strategy.
- Requires strategic thinking.
- Should be managed and adequate resources provided.

9.9 Processes enabler

Everything that construction firms do is organised in the form of processes with each process consisting of several sub-processes. Quality management is essentially done through looking at each process in turn and managing them so that they yield better quality. Since processes are often sequential, disruption in one process will likely cause disruption in subsequent processes. It is essential that processes are managed so possible disruptions and mitigations are planned, which can lead to improvement in processes and consequently improvement in overall quality (Bou-Llusar, *et al.* 2005).

The research finds that process improvement has a critical and positive impact on firms' attainment of a higher TQM maturity level. There are various ways in which process management is critical for quality management. For example, scheduling of processes ensures that material and resource unavailability does not cause problems in achieving quality goals (Rusjan, 2005). One of the key aspects in this regard is knowledge management, to ensure that all the involved parties have all process-related information and knowledge they require. Castka*et al.* (2004) recommend that using internal and external benchmarks to identify ways of improving further. This is, however, only possible with an existing channel of information sharing. This is related to policy and strategy as leaders need to adopt this as a long-term strategy rather than a short-term one. This will require top management to adopt a broader vision of future growth and development rather a short-term goal of survival. This is similar to the recommendations of Idrisand Zairi (2006) and Dale and Lascelles (1997b) who recommended systematic, periodic and continuous process improvement in order to identify the problem areas and weaknesses and to address them with specific solution-based remedies.

Process optimisation is required to ensure that organization can meet all its quality goals. This can be done through incremental optimisation of the processes; identifying issues at different stages and then continuing to improve those. In this respect, involvement of all individuals is required because their inputs are useful and, in some cases essential to finding ways of improving processes. Jacobs and Suckling (2007) and Castilla and Ruiz (2008) recommend improving the processes with the ultimate objective of customer satisfaction. However, the problem is that sometimes customers' interests may be contrary to those of other key stakeholders and achieving objectives of one stakeholder at the cost of other stakeholders is a sub-optimal solution. In such situations prioritisation may be required.

Furthermore, processes improvements should be institutionalised through dissemination of quality improvement-related knowledge across the organization. Davies (2008) suggested that this will ensure that processes are designed to achieve the same goals and that processes are optimised to achieve these objectives.

In summary, the **Process improvement** enabler:

- Has a critical and positive impact on firms' attainment of a higher TQM maturity level.
- Relies on knowledge management, to ensure that all parties involved have the process-related information and knowledge they require.
- Should be institutionalised through dissemination of quality improvement-related knowledge across the organization

9.10 Implications of the research

The research results indicate that there is no magic approach to reaching highest TQM maturity scores quickly and firms will require, irrespective of anything, a certain time period to reach them. The assumption of the EFQM model is that improvement in quality performance is a sequential process in which organizations improve through a chain process improving each enabler in a recurring cycle till they reach the desired levels. This research confirms this opinion. What it also suggests is that firms need to use it as a cyclical process, learning, adopting and improving in recurring cycles. None of the enablers can be improved from the bottom level to the top level in just one cycle as improvement in each enabler is based on the feedback loop. Loops work in an iterative/ incremental manner bringing in gradual improvements leading up to the highest TQM maturity scores over a period of time.

Persistence with a TQM strategy is critical for any firm looking to achieve quality goals. There are several implications of these findings:

- Since the Leadership enabler affects all other enablers directly or indirectly it is essential that this enabler is activated as soon as the firm realises a need for greater quality focus. Without management support and commitment, the quality strategy cannot be implemented. This is especially true for countries like Saudi Arabia which have a centralised top-down decision-making structure due to their high-power distance culture.
- The second enabler that is found to be critical is the People enabler. Just like the Leadership enabler the People enabler also affects all other enablers directly or indirectly. This means that following any focus on the Leadership enabler the next step should be on improving different aspects of the People enabler. Identifying the need for training and findings ways to empower and involve people in quality-related decision making can provide a strong boost to a firm's quality performance. Saudi Arabian society is a collectivist society which makes it essential to use the people approach to implementing initiatives such as TQM. In a collectivist society, the influence has to be done at a group (or higher) level instead of at an individual level. It is also essential because the people context of Saudi construction industry is one of the key factors that add complexity to the industry's quality initiatives. In particular, the high proportion of migrant, unskilled workers who come from different cultural backgrounds and speak different languages notwithstanding the different perspectives on quality issues makes it one of the key enablers for TQM initiatives.
- Firms need to persist with their quality efforts as a quality strategy is likely to yield long-term benefits. In this respect, the quality strategy is best driven from the top because top management will have comparatively fewer performance pressures. Furthermore, top management is in continuous communication with owners and stakeholders so it is easier for them to convince all relevant parties on the adoption of a long-term strategy. Lower management is best utilised for implementing the quality strategy. A top-driven quality strategy is also useful because it ensures consistency in an organization's approach as a whole. Unless the efforts to improve quality, performance are undertaken across the organization, and unless there is organization wide coordination and cooperation, it is impossible to reach high TQM maturity levels.

CHAPTER 10 CONCLUSIONS

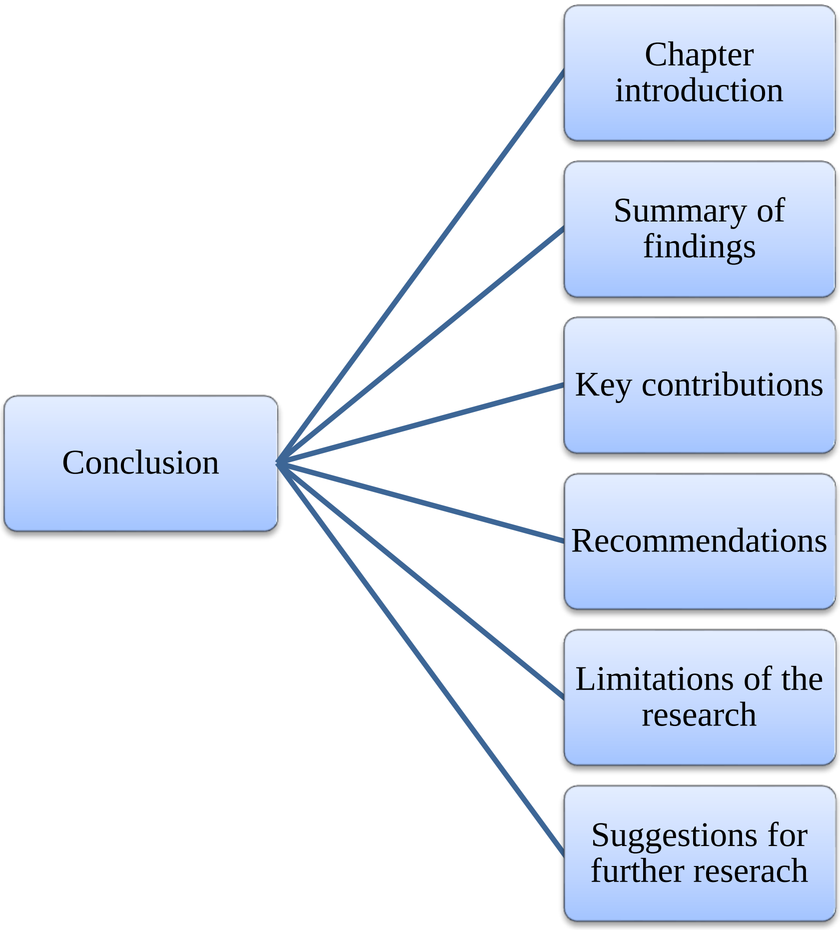


Figure 10-1: Structure of the Chapter

10.1 Introduction

The research advances the concept of TQM maturity model for the Saudi construction industry, with the view that achieving higher TQM maturity levels requires long-term sustained efforts. This requires a holistic approach to consider how different TQM enablers affect the progression of firms across different TQM maturity levels over a time-period. A contextual case of construction firms in Saudi Arabia was used as an example. Research looked at how Saudi construction firms can achieve improved TQM maturity levels. To achieve this objective the research identified key factors that affect Saudi construction firms' ability to reach higher TQM maturity levels. This research will make a meaningful contribution towards improving quality management practices in Saudi construction industry.

The first survey used a questionnaire survey with Saudi construction industry professionals with in-depth knowledge of their organization's quality strategy. Cronbach's alpha test confirmed the reliability of the questionnaire. A PLS regression test considered the statistical significance of the causal relationship between different variables. The relationships explain how changes in one enabler will affect another enabler, so forming a chain of variations, which eventually leads to a shift in the state of the system. The second survey used 20 experienced individuals to rank the enablers of TQM. The analytical Hierarchy Process (AHP) method evaluated the survey data. System dynamics modelling was formulated and tested to simulate the development of TQM maturity in the Saudi construction firms. Two case studies of the Saudi industry were selected to apply the simulation and to investigate different policy decision interventions. This Chapter looks at the findings, achievements and contributions of this research, its limitations as well as suggestions at how this research can be further expanded.

10.2 Findings

The adoption of TQM philosophy is a natural way of progression for Saudi construction firms, the challenge is to contextualise its adoption, Saudi construction differ significantly from western construction industries. AHP analysis confirms the assumption that weights assigned to different enablers in the EFQM model is different from Saudi Arabia from the standardised weights published in other research. This supports the assumption that generalisation of the TQM approach is not suitable; firms must contextualise their TQM implementation. Firms should expand their perspective and look at wider stakeholder interests rather than the interests of the customers alone.

The TQM maturity model is based on the perspective that quality management involves continuous development. The S shaped curves of TQM score attainment indicates that firms will progress slowly in the beginning (TQM levels 1 and 2) followed by a rapid progression in the middle phases (TQM levels 3 and 4) followed by a slowing down towards the end. This means that the time taken for completing levels 1 and 2 is significantly more than completing levels 3 and 4and for completing level 5.

When the firm has done the basic work, the progression through TQM maturity is quite rapid. The problem with long initial stages is that due to lack of realised benefits, many managers may abandon TQM efforts in the early stages. This has two implications; firstly, it suggests that when firms decide to adopt a quality-focused strategy they must be patient to see the results/benefits of this strategy as these may not be immediately visible. Results indicate that the goals score starts to rise noticeably only after two years when the first TQM maturity level is crossed. Secondly, the results indicate that it needs to focus on speeding up the first to third maturity stages in order to reduce the overall time required to achieve higher TQM maturity levels.

Sensitivity results indicate that firms' progression to higher TQM maturity level is most sensitive to the Leadership enabler followed by the People, Partnership & resources, Policies and strategy, and Processes enablers in that order. Focussing on Leadership and People enablers will shorten the longest stage and consequently speed up a firm's progression towards higher TQM maturity levels. The Leadership and People enablers are strongly linked with Saudi culture, which is characterised by high power distance and high collective social behaviour index. The collectivism aspect indicates that people work together as a team and hence a people-based approach is required. Achieving a higher people enabler score i.e. investing in people for quality initiatives is likely to have a significantly positive impact on a Saudi construction firm's ability to reach higher TQM maturity levels. The time required to develop the People enabler may be one of the reasons why quality goals and objective are not achieved in a shorter time in the TQM maturity cycle. Management can improve the People enabler score by investing in aspects such as people empowerment/involvement, as well as people's training, reward management etc. This also indicates that firms will not be able to generate the desired benefits from its TQM initiatives unless it has invested in people and quality culture development.

In terms of policy and strategy, it is critical to maintain a consistently progressive TQM-related policy and strategy. This will instil confidence among the employees and partners and will make sure that the firm improves its TQM performance year on year. The need for a quality-focused culture is evident from the strong relationship between people enabler and goals score. In Saudi culture, people tend to follow written rules more than informal rules and hence a reference to quality in the organization policy and strategy documents is critical. People need to be given clear direction on how the quality policy/strategy of the organization translates in terms of their role; this will help individuals in understanding their responsibility towards achieving the organization's quality objectives.

Improving enablers, such as leadership and people, enablers can reduce the time required to reach higher TQM maturity levels. However, the impact of these enablers only works to a certain extent; improving them beyond that level shows no marked improvement in firms' progression towards higher TQM maturity levels. Strong and committed leadership alone will not improve a firm's ability to reach high TQM levels unless it translates this into improvement in other enablers. Improvement in the initial value of other enablers also provides significant improvements in the firms' ability to achieve higher TQM levels within shorter time spans.

Results indicate there is no magic approach to reaching the highest TQM maturity scores quickly and firms will require, a certain time to reach these scores. This is underpinned by the assumption of the EFQM model that improvement in quality performance is a sequential process where organizations improve through a chain process improving each enabler in a recurring cycle until they reach the desired levels. Firms need to make it a cyclical process, learning, adopting and improving in recurring cycles. None of the enablers can be improved from the bottom level to top level in just one cycle as improvement in each enabler is based on the feedback loop. Loops work in an iterative/incremental manner bringing in gradual improvements leading up to the highest TQM maturity scores.

10.3 Achievement of objectives

This research aimed at the development of a maturity model of TQM in Saudi construction firms using a system dynamics approach. It investigated the interactions and causal relationships between the enablers and their consequences over time on organizational goals. The following are the findings of the research objectives.

Objective1: To investigate the characteristics of the Saudi construction environment and how this influence quality management in construction firms.

Saudi construction firms have special characteristics shaped by the construction environment (Chapter four). The climate is harsh, and there is over reliance on foreign workers on job sites. The industry is very fragmented with low barriers to entry. Different cultural aspects have a significant impact on the culture within Saudi construction industry in general. The industry lacks a deep-rooted culture of delivering quality caused by the heterogeneous structure of the industry; there is the need for quality improvement systems such as TQM. The Saudi public sector is the major procurer for the construction sector, because of the requirement to award projects on the lowest cost, there is a lack of focus on quality. The public sector has the desire for high quality, as evidenced by quality awards, but its purchasing procedures do not reflect the desire. Cost is the most critical selection criteria to win projects. Contractors and specialty contractors often compromise on quality aspects in order to minims' costs. The Saudi culture is characterised by high power distance, which makes it difficult to implement quality initiatives that require wider participation and decentralised decision making. Implementation of TQM requires changes in organization and attitude, but the high uncertainty avoidance culture of Saudi Arabia is an obstacle. Saudi Arabia has many bureaucratic procedures and compliance, with the emphasis on complying with the initial procedure, rather than checking and ensuring compliance with the procedure. Organizations follow quality management approaches that provide them with certification such as ISO 9001, but many fail to maintain their ISO 9001 certification indicating failure to continuously improve.

Objective 2: To find an appropriate assessment framework for TQM and identify the enablers and goals of TQM and how they relate to Saudi construction firms.

Different TQM Assessment Models/Frameworks were evaluated in Section 2.9. The EFQM model was identified as the most relevant assessment framework of TQM for the reasons stated in Section 2.10. EFQM was selected because it is simple, holistic, dynamic, and flexible and has been extensively used by other researchers in TQM related research. Chapter three explained the five key enablers of EFQM framework and its components. The five enablers in the EFQM framework are: leadership, people, policies and strategy, partnership and resources, processes, for quality management in Saudi construction industry. For organizational issues, the key goals are project goals which involve meeting client satisfaction within the time and budget targets. Additional goals are people, society and business. People goals involve meeting the expectations of employees, personal or otherwise. Society goals are becoming more relevant, society is taking an increasingly active interest in how the activities of construction firms affect their lives. Firms have to ensure that they have good quality image/reputation to ensure that they are considered favourably when bidding for projects. In terms of business goals, the construction industry should achieve profits, while also building a good quality reputation, which in turn will enhance its competitiveness.

The EFQM model of TQM maturity was adapted for the Saudi construction industry. The key step in this adoption was recalculation of the weights of the five enablers in context of Saudi construction industry. This was done using AHP analysis which is explained in Section 6.6. The maturity index score was scaled from zero to 1000, with 0 representing the firm with no prior quality score and 1000 representing the highest quality TQM score.

The scale was divided into five levels of maturity with each maturity level comprising an interval of 200 points on the TQM index scale.

Objective 3: To identify the causal relationships between enablers and goals and their interdependencies.

Partial least squared (PLS) regression analysis was carried out to test the causal relationship between different aspects of the EFQM model (refer to Section 6.6. for PLS results). Leadership has a positive and statistically significant impact on people, policies and strategy, partnership and resources. The People enabler has a positive and significant impact on Partnership and resources, which affects Policy and Strategy. These three enablers affect processes that affect the quality goals. The feedback processes were identified and accommodated in the system dynamic model.

Objective 4: To build a system dynamics model to understand the complexity of dynamic interactions among enablers and goals on a long-term basis.

Chapter 7 described in detail how the System Dynamic Model for TQM maturity in Saudi construction industry was developed. The model has been built on causal loop feedback, the stock and flow principles in system dynamics modelling. The dynamics model presented in chapter seven represent all the dependencies and interactions of each component of TQM maturity model. The system was projected over a 20-year period and a firm's attainment of higher TQM maturity levels was observed. Vensim software was used to build the dynamic model because of the simplicity in its use of a graphical interface. The dynamic model has been validated through an internal and external validation process. The main validation of the system behaviour was carried out by a behavioural sensitivity analysis, which indicated the model sufficiently robust and valid.

Objective 5: To identify the policy implications through the application of TQM maturity model for Saudi construction firms.

Chapter 8 discussed the impact of policy decisions in TQM maturity attainment of Saudi construction firms. For the application of the model, two case studies were tested and results used to identify the relevance of different enablers in achieving higher TQM maturity levels. The base case was followed by specific changes in which the initial efforts to improve different enablers were tested. This research finds that the Leadership enabler is one of the key ingredients in stepping up firms' ability to achieve higher TQM levels. The impact of the Leadership enabler is enhanced if the People enabler is increased. The other enablers are dependent on the People and Leadership enablers and consequently the impact of increasing other enablers alone without increasing those two is not significant. The focus should be on improving the Leadership and People enablers at the beginning, while other enablers should be focused upon in subsequent stages.

10.4 Key contribution

The most important contribution is that this research goes beyond existing research on TQM in construction. Research has focused on the adoption of TQM, whilst ignoring that quality management is not a one-step process, but a process of continuous improvement. In the static models, the interactions of the different aspects of the complex quality systems over time were ignored. This research takes this into consideration and attempts to model the complexity in implementing TQM. The need to contextualise quality management efforts is highlighted. The pick and choose approach is not suitable because quality management involves highly contextual aspects, such as people and resources. Therefore, a model representing system dynamics analysis of Saudi Arabian construction firms' TQM maturity strategy was the main contribution of this research.

This contribution to the academic research is by into looking at ways of improving quality management, rather than merely identifying the factors that may affect adoption of TQM. TQM is an approach that includes processes and continuous improvement, which needs to be put into practice. Research has focused on how firms can adopt the approach but this research goes beyond that and looks at how to operationalise the principles of TQM and achieve maximum benefits out of it.

This research has practical benefits. Chapter 4, highlights the poor Saudi construction performance on quality matters, there is a need to improve quality. This research provides guidance for practitioners and managers in Saudi construction firms on how to improve quality by implementing TQM. It goes onto provide guidance on the factors that may play a key role in Saudi construction firms' attainment to higher TQM maturity levels. It highlights the need to achieve higher quality management levels and to sustain it through continuous improvement. The process of developing the TQM maturity model using system dynamics approach provides an alternative approach for Saudi contractors to identify area of improvements and to benchmark in their continuous improvement journeys.

This research presents a case for adopting TQM for the Saudi construction industry. It links TQM with organizational goals that matter to all the stakeholders, by providing a framework for a more holistic benefit for Saudi firms. This model is a good starting point in generating more support for focus on quality.

10.5 Recommendations

Recommendations for Saudi construction firms are:

- TQM implementation should be undertaken from a long-term perspective rather than as a one-off step. Management needs a carefully-planned strategy of gradual and incremental improvement in quality management.
- Persistence and adherence to the quality strategy is critical. Firms need to be realistic in their expectations regarding the benefits of a quality strategy. It is likely to provide long-term benefits; short-term benefits may not be evident immediately. A building a firm's quality image/reputation will take time, but once built, it will provide long-lasting benefits.
- Achievement of the highest level of TQM is not the end. Firms must have a strategy and mechanism in place to maintain the high standards of quality management achieved. Institutionalisation of policies, processes and practices can help maintain a quality culture.
- Achieving high levels of TQM requires holistic efforts across all enablers. Firms must have a comprehensive approach to achieving and sustaining the highest levels of TQM.
- Firms should constantly review their TQM strategy and its impacts to see whether they need to alter it. Quality management is contextual, depending on several factors such as nature of work, client type, partners and competition, financial constraints, composition of workforce etc. Thus, firms must adopt both an internal and external approach to quality management. Externally they need to see which perspective of quality is most critical for stakeholders and to learn from the competition. Internally, it must see how it can employ its resources and capabilities to achieve their goals.
- The focus should be on people because ultimately, they are the ones who will operationalise the quality strategy. Generating awareness and motivating these people through incentives and other strategies is critical.

10.6 Limitations of the research

The data for this research was collected using a self-administered questionnaire survey. Self-administration was useful to protect respondents' identity and to minimise inconvenience in data collection. However, it also meant that the researcher did not interact directly with respondents during data collection. The lack of interaction meant that respondents had no chance of clarifying doubts; this meant that some of the respondents could have given inaccurate responses to the questions. The researcher tried to minimise this limitation by refining the questionnaire using a pilot study and by using easy-to-understand language.

Due to the guarantee of anonymity, personal information about the respondents or their employing organization was not included in the survey. This also meant that the researcher could not clarify the number of organizations represented in the sample. Therefore, there is a possibility of organizational bias in the sample. On the positive, side the guarantee of anonymity is likely to have raised the response rate as well as the reliability of the responses provided.

The data were collected only from senior managers because this research looked at the top-level perspective of quality management. Research could be conducted accommodating middle and lower management perspectives, there could be issues known to middle managers but not to top managers, especially in terms of implementation.

The data was collected from ISO9001-certified companies only. This was considered essential because this research is not looking at adoption of TQM but rather at a TQM maturity model. However, this sampling strategy has excluded companies, which have not had their ISO9001 certificate for at least last three years. This may have affected the generalisation of the findings of this research.

The research began with EFQM as the base model, hence does not develop new framework, but builds upon an existing framework. However, although this model was modified for the Saudi construction industry context, there is a possibility that some factor may have been overlooked.

10.7 Suggestions for Further Research

The research can be extended in multiple ways, especially in terms of methodology. This research can be extended into a mixed methods research, which can investigate the findings of system dynamic modelling using qualitative methods such as interview. By conducting a mixed method research, the existing framework could be refined and developed using some qualitative technique before system dynamic modelling is conducted.

Research can also be conducted using two sets of samples: ISO9001-certified companies and non-certified companies. This will help draw comparisons between the TQM maturity attainments of these different companies.

Research can be conducted in other countries, industry sectors or even cross-industry level to see if the findings of this research can be generalized. Comparisons can be made into how different cultural and institutional contexts may affect firms' ability to achieve high TQM maturity levels.

This research can further be advanced to see the link between TQM strategy and a specific set of goals. In this research, five categories of goals were combined under one. Research can be carried out to reassess the weight between different goals and the achievement of these goals independently.

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APPENDICES

Appendix 1: Information and consent form

Questionnaire survey on the assessment of Total Quality Management (TQM) in the Saudi construction firms

I am Sultan Algithami, a PhD Candidate in the School of Construction Management and Engineering at the University of Reading. As part of my PhD research I am investigating total quality management (TQM) in construction firms in Saudi Arabia. My research aims to develop a maturity model of total quality management for Saudi construction firms. This model would help organizations in identifying strength, weakness and areas for improvement in the quest of improving quality performance. As a senior manager, quality director, or quality manager you are invited to participate in this study.

You can find the survey by clicking on the link below.

Your participation is voluntary; you can stop at any time. Only completed responses will be accepted in the research so kindly try to complete the questionnaire. It will not take more than 10 minutes of your valuable time. Responses will be kept anonymous and confidential. None of the information collected can be used to identify you or your employer so you will remain completely anonymous. The only persons to see the questionnaire will be me and my supervisors.

By completing and returning this questionnaire you understand that you are giving consent for your responses to be used for the purposes of this research project.

If you have any questions or concerns about this research, please contact Sultan Mosfer S. Algithami at (*s.m.s.algithami@pgr.reading.ac.uk*) or my supervisor Professor Roger Flanagan at (*r.flanagan@reading.ac.uk)*

Appendix 2: The questionnaire

SECTION I: BACKGROUND

Question 1: Designation of respondent

- ☐ CEO/General Manager
- ☐ Managing Director
- ☐ Quality Director
- ☐ TQM Manager
- ☐ Others. ………

Question 2: Number of years you have been working with your present employer

☐ Less than 5 years ☐ 5-10 years ☐ 11-20 years ☐ More than 20 years

Question 3: Number of fulltime employees in your organization?

☐ Less than 500 ☐ 500-1000 ☐ 1000 -5000 ☐ More than 5000

Question 4: The number of years the firm had been in existence

☐ Less than 10 years ☐10-20 years ☐ 21-30 years ☐ More than 30 years

Question 5: The main project type in your firm (Please tick one box)

- ☐ Building
- ☐ Infrastructure
- ☐ Transport
- ☐ Hydraulic structure
- ☐ Industrial building
- ☐ Other…………

Question 6: Which of the following is the most accurate description of quality for your organization? Please rank in order (1 – least accurate.......5- most accurate)

	Description	1	2	3	4	5
	Exceeding customer expectations					
	Provide best value for money					
	Conform to specifications					
	Visual appearance					
	Cost minimisation					

Question 7: Roughly what proportion of your organization's annual budget is spent on improving quality management (for example, training, rewards, quality checking, control, management, assurance etc.)**?**

………………%

Question 8: What are the most critical project goals for your organization? Please rank in order. (1- least critical……5- most critical)

	Description	1	2	3	4	5
	Time compliance					
	Cost compliance					
	Quality compliance					
	Customer satisfaction					
	Safety performance (incidents of safety)					

Question 9: To what extent do you think your organization implements TQM principles?

- ☐ Not implemented at all
- ☐ Partially implemented
- ☐ Fully implemented

SECTION II: TQM PRACTICES AND GOALS

Question 10: This question includes statements that aim to explore the level of TQM practices in your organization and consequences of quality management. Please tick the box that most reflects your observations:

Scale	Very Low 1	Low 2	Moderate 3	High 4	Very High 5

	LEADERSHIP	1	2	3	4	5
LD1	Top management committed towards quality (allocates adequate time and resources for quality management)					
LD2	Top management (managers) share a clear vision and mission toward quality with all employees.					
LD3	Top management communicating and discussing quality issues with employees					
LD4	Managers review continuous quality improvement through the					

	organization.					
LD5	Leaders act as role models towards quality (Engage, direct and support)					
LD6	Managers continuously acquire and update their knowledge that is valuable for improving quality.					
	Policy and Strategy	1	2	3	4	5
PS1	Company's values, vision and mission reflect the quality concept.					
PS2	Management review and upgrade quality policy on a regular basis.					
PS3	In our organization, quality is an essential part in formulating our business strategy and goals					
PS4	In our policy, quality holds the same priority as production.					
PS5	In our organization the most Important strategy is to achieve customer satisfaction.					
	PEOPLE	1	2	3	4	5
PL1	Employees have authority in their positions to take necessary actions when required.					
PL2	The organization puts avenues where employees can suggest their ideas for quality improvement					
PL3	Company offers continuous improvement training for all employees in their daily work.					
PL4	Easy access to relevant quality information for employees.					
PL5	Cross-functional team are used to solve quality problems					
PL6	A regular survey to gain feedback and employees' perceptions (process)					
PL7	The organization has formulate a suitable reward and recognition system for quality improvement					
	PARTNERSHIP AND RESOURCES	1	2	3	4	5
PR1	Supplier and subcontractors are categorized based on quality improvement.					
PR2	Regular inspection of the quality standard of materials and workmanship of suppliers and subcontractors.					
PR3	In our organization, financial resources are adequately provided to support the implementation of our quality policy					
PR4	Our organization endeavours to have skilled human resources to achieve targeted quality performance					
PR5	Our organization has sufficient necessary material and equipment for quality standard work in job site.					
	PROCESSES	1	2	3	4	5
PC1	In our organization, there is systematic management and regular improvement of the company processes.					
PC2	Processes are designed to meet customer expectations and needs.					
CF3	We apply self-assessment tools to identify performance gaps and improve the effectiveness of the process, system, and practices.					
PC4	Benchmarking to compare with other construction organizations is applied to establish the need for change.					
PC5	Innovation and creativity are encouraged in order to improve processes performance.					
PC6	Company uses quality tools (e.g., control chart, histograms, etc.) to evaluate and find causes of quality problems.					
PC7	Regular feedback provided to employees regarding issues and					

	improvement of their work quality.					
	GOALS	1	2	3	4	5
GL1	The way we manage our quality has decreased construction time.					
GL2	The way we manage our quality has decreased construction cost.					
GL3	The way we currently manage quality in our organization helps us reduce the number of defects and rework					
GL4	The way we manage our quality has improved safety in job site					
GL5	Our customers are satisfied with our service and product quality					
GL6	Our current quality management helps us to decrease customer/client's complaints					
GL7	Our employees are satisfied in the way we manage our quality.					
GL8	The way we manage our quality has increased Number of received useful suggestions from employee					
GL9	The way we manage our quality has improved our quality image in society perception.					
GL10	The way we manage our quality has increased our market share.					
GL11	The way we currently manage our quality helps us to enhance our competitiveness.					
GL12	The way we manage our quality has increased our profitability.					

Comments:

Please make any comments or raise any points that you think were not covered by this survey.

……………………………………………………………………………………………

……………………………………………………………………………………………
……………………………………………………………………………………………

Please provide your contact details if you are interested in participating in a follow-up survey. The follow up survey will be very short asking you to prioritise /rank the enablers of TQM.

Name: ………………………………………………………… (Optional)

Email: ……………………………………………………….. (Required)

Phone: ………………………………………………………… (Optional)

Alternatively, please send me an email at *s.m.s.algithami@pgr.reading.ac.uk* to confirm your consent to participate in the follow up survey.

Thank you for your participation.

Appendix 3: Analytical Hierarchy Process Survey

Analytical Hierarchy Process Method (AHP) is a mathematical method that has been used in this research to weigh TQM enablers for Saudi construction firms. Table 1 presents the 1 -9 scale values, which can be used to compare two enablers.

Table1: Scale for Importance of TQM enablers

Value of aij	Definition	Explanation
1	Criteria i and j are equal importance	Two activities contribute equally
3	Criteria i is just more important than criteria j	There is evidence suggesting one activity is little more important than another
5	Criteria i is much more important than criteria j	Good evidence and logical criteria exist to demonstrate that one is more important
7	Criteria i is demonstrably more important than criteria j	Conclusive evidence show the importance of one activity over another
9	Criteria i is Absolutely more important than criteria j	The evidence favouring one activity over another is absolute
2, 4, 6, 8	Intermediate values between the two adjacent judgements	e.g. a value of 8 is midway between demonstrably and absolutely evident

Please indicate the importance of each factor in compare to others in terms of improving total quality management:

More important *Equal* *More important*

Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Strategy & Policy**

Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**People**

Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Partnerships & Resources**

Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Processes**

Strategy & Policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**People**

Strategy & Policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Partnerships & Resources**

Strategy & Policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Processes**

People	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Partnerships & Resources**

People	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Processes**

Partnerships & Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Processes**

Note: this research used the scale of relative importance for pairwise comparison, proposed by Saaty and Sodenkamp (2010). By assigning values ranging from 1 to 9 to the alternatives, the scale determines, for example, the relative importance of alternative *I* with regard to alternative *j* and, reciprocally, the alternative *j* with regard to alternative.

scale	Numerical assessment (a*ij*) (*i* in relation to j)	Reciprocal (1/a*ij*) (*j* in relation to *i*)
Extremely importance	9	1/9
Very to extremely strongly importance	8	1/8
Very strongly importance	7	1/7
Strongly to Very strongly importance	6	1/6
Strongly importance	5	1/5
Moderate to Strongly importance	4	1/4
Moderately importance	3	1/3
Equally to Moderately importance	2	1/2
Equally importance	1	1

Appendix 4: Reliability test outputs

Scale: Leadership

Case Processing Summary

		N	%
Cases	Valid	87	100.0
	Excluded[a]	0	.0
	Total	87	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.862	6

RELIABILITY

/VARIABLES=Quality_vision Reviewing_and_Upgrade_Policy Quality_as_strategy Priority_of_quality
Customer_Satisfaction_Strategy

Scale: Policy and Strategy

Case Processing Summary

		N	%
Cases	Valid	87	100.0
	Excluded[a]	0	.0
	Total	87	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.811	5

RELIABILITY

/VARIABLES=Empowerment Involvement Training Information Accessibility, Crossfunctional_team, Feedback_Survey Rewards_and_recognition

Scale: People

Case Processing Summary

		N	%
Cases	Valid	87	100.0
	Excluded[a]	0	.0
	Total	87	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.776	7

RELIABILITY

/VARIABLES=Quality_based_classification Quality_Standards_Inspection Financial_resources Skilled_human_resources Material_and_equipment

Scale: Partnership and resources

Case Processing Summary

		N	%
Cases	Valid	87	100.0
	Excluded[a]	0	.0
	Total	87	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.894	5

RELIABILITY

/VARIABLES=Processes_improvement Customer_focus Performance_measurement Benchmarking Innovation_and_creativity Quality_tools Dissemination_of_quality_improvement

Scale: Processes

Case Processing Summary

		N	%
Cases	Valid	87	100.0
	Excluded[a]	0	.0
	Total	87	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.815	7

RELIABILITY

/VARIABLES=Time Cost Defects_rework Safety Customer_satisfaction Customer_complaints
Employee_satisfaction Useful_suggestions Quality_reputation Market_share Competitiveness Profits

Scale: Goals

Case Processing Summary

		N	%
Cases	Valid	87	100.0
	Excluded[a]	0	.0
	Total	87	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.875	12

DESCRIPTIVES VARIABLES=Management_commitment Clear_vision Communication Auditing Role_model Continuous_development Quality_vision Reviewing_and_Upgrade_Policy Quality_as_strategy Priority_of_quality Customer_Satisfaction_Strategy Empowerment Involvement Training Information_Accessibility Crossfunctional_team Feedback_Survey Rewards_and_recognition Quality_based_classification Quality_Standards_Inspection Financial_resources Skilled_human_resources Material_and_equipment Processes_improvement Customer_focus Performance_measurement Benchmarking Innovation_and_creativity Quality_tools Dissemination_of_quality_improvement Time Cost Defects_rework Safety Customer_satisfaction Customer_complaints Employee_satisfaction Useful_suggestions Quality_reputation Market_share Competitiveness Profits

Appendix 5: Regression results

Appendix 5.1 PLS regression model between Leadership (independent) and people (dependent) enabler

Proportion of Variance Explained

	Statistics				
Latent Factors	X Variance	Cumulative X Variance	Y Variance	Cumulative Y Variance (R-square)	Adjusted R-square
1	1.000	1.000	.585	.585	.580

Parameters

	Dependent Variables
Independent Variables	People
(Constant)	1.688
Leadership	.466

Variable Importance in the Projection

	Latent Factors
Variables	1
Leadership	1.000

Cumulative Variable Importance

Weights

	Latent Factors
Variables	1
Leadership	1.000
People	.456

Loadings

	Latent Factors
Variables	1
Leadership	1.000
People	1.000

Appendix 5.2 PLS regression model between People, Leadership (independent) and Partnership & resources (dependent) enabler

Proportion of Variance Explained

	Statistics				
Latent Factors	X Variance	Cumulative X Variance	Y Variance	Cumulative Y Variance (R-square)	Adjusted R-square
1	.725	.725	.715	.715	.712
2	.275	1.000	.004	.193	.174

Parameters

Independent Variables	Dependent Variables Partnership_Resources
(Constant)	1.285
Leadership	.458
People	.200

Variable Importance in the Projection

	Latent Factors	
Variables	1	2
Leadership	1.132	1.129
People	.848	.852

Cumulative Variable Importance

Weights

	Latent Factors	
Variables	1	2
Leadership	.417	.671
People	.312	-.747
Partnership_Resources	.362	.085

Loadings

	Latent Factors	
Variables	1	2
Leadership	.447	.599
People	.327	-.800
Partnership_Resources	1.000	1.000

Variable Importance in the Projection indicates the relative impact of variables – variables higher in importance have higher impact on the dependent variable.

Latent variables are the variables that may explain the relationship between the variables. Latent variable are the variables not included in the equation but are underlying variables that may explain the impact of independent variable on the dependent variable.

Loading shows the impact of the dependent variable son the latent variables. Higher loading means higher the impact of the dependent variable on the latent variable.

Appendix 5.3 PLS regression model between Partnership & resources, Leadership (independent) and Policy & Strategy (dependent) enabler

Proportion of Variance Explained

	Statistics				
Latent Factors	X Variance	Cumulative X Variance	Y Variance	Cumulative Y Variance (R-square)	Adjusted R-square
1	.694	.694	.776	.776	.773
2	.306	1.000	.010	.171	.151

Parameters

	Dependent Variables
Independent Variables	Policy_Strategy
(Constant)	1.261
Leadership	.492
Partnership_Resources	.059

Variable Importance in the Projection

	Latent Factors	
Variables	1	2
Leadership	1.245	1.226
Partnership_Resources	.671	.707

Cumulative Variable Importance

Weights

	Latent Factors	
Variables	1	2
Leadership	.409	.624
Partnership_Resources	.221	-.800
Policy_Strategy	.345	.129

Loadings

	Latent Factors	
Variables	1	2
Leadership	.423	.221
Partnership_Resources	.218	-.409
Policy_Strategy	1.000	1.000

Appendix 5.4 PLS regression model between Processes (dependent) enabler and People, Partnership & Resources, Policy & Strategy (independent) enablers

Proportion of Variance Explained

	Statistics				
Latent Factors	X Variance	Cumulative X Variance	Y Variance	Cumulative Y Variance (R-square)	Adjusted R-square
1	.536	.536	.644	.644	.64
2	.245	.781	.009	.311	.295
3	.219	1.000	.000	.311	.286

Parameters

Independent Variables	Dependent Variables Processes
(Constant)	1.887
Partnership_Resources	.264
Policy_Strategy	.173
People	.118

Variable Importance in the Projection

	Latent Factors		
Variables	1	2	3
Partnership_Resources	1.176	1.180	1.179
Policy_Strategy	.938	.924	.925
People	.859	.869	.869

Cumulative Variable Importance

Weights

	Latent Factors		
Variables	1	2	3
Partnership_Resources	.470	.141	-.213
Policy_Strategy	.374	-.095	.812
People	.343	-.675	-.561
Processes	.376	.113	.018

Loadings

	Latent Factors		
Variables	1	2	3
Partnership_Resources	.449	.107	-.319
Policy_Strategy	.389	-.276	.826
People	.339	-.667	-.466
Processes	1.000	1.000	1.000

Appendix 5.5 PLS regression model between Goals (dependent) and Processes (independent) enablers

Proportion of Variance Explained

	Statistics				
Latent Factors	X Variance	Cumulative X Variance	Y Variance	Cumulative Y Variance (R-square)	Adjusted R-square
1	1.000	1.000	.551	.551	.548

Parameters

	Dependent Variables
Independent Variables	Goals
(Constant)	2.206
Processes	.371

Variable Importance in the Projection

	Latent Factors
Variables	1
Processes	1.000

Cumulative Variable Importance

Weights

	Latent Factors
Variables	1
Processes	1.000
Goals	.447

Loadings

	Latent Factors
Variables	1
Processes	1.000
Goals	1.000

Appendix 5.6: Linear regression model between Goals (dependent) and total enabler score (independent).

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Enablers[b]	.	Enter

a. Dependent Variable: Goals

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.662[a]	.438	.427	.6077

a. Predictors: (Constant), Enablers

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5.279	1	5.279	16.818	.000[b]
	Residual	19.825	85	.254		
	Total	23.215	86			

a. Dependent Variable: Goals

b. Predictors: (Constant), Enablers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	89	23.113	121.013	2.687	.001
	Enablers	.47	.121	.602	3.884	.000

a. Dependent Variable: Goals

Appendix 6: Skewness and Kurtosis of responses

	Skewness		Kurtosis	
	Statistic	Statistic/std. Error	Statistic	Statistic/std. Error
Management commitment	0.289	1.117	-0.838	-1.639
Clear vision	-0.556	-2.154	0.066	0.128
Communication	-0.118	-0.456	-0.706	-1.38
Auditing	0.12	0.467	-0.638	-1.248
Role model	0.067	0.258	-0.285	-0.558
Continuous development	-0.497	-1.923	0.015	0.029
Quality vision	0.217	0.841	-0.028	-0.055
Reviewing and Upgrade Policy	-0.308	-1.193	-0.781	-1.528
Quality as strategy	0.181	0.701	-0.639	-1.25
Priority of quality	-0.139	-0.538	-0.268	-0.525
Customer Satisfaction Strategy	0.024	0.093	-0.271	-0.53
Empowerment	0.074	0.288	-0.688	-1.346
Involvement	-0.319	-1.234	-0.231	-0.451
Training	0.952	3.688	0.406	0.795
Information Accessibility	0.547	2.118	-0.183	-0.359
Cross-functional team	-0.057	-0.219	-0.626	-1.225
Feedback Survey	0.26	1.006	-0.617	-1.208
Rewards and recognition	0.153	0.591	-0.536	-1.049
Quality based classification	0.06	0.233	-0.76	-1.487
Quality Standards Inspection	-0.064	-0.247	-0.456	-0.893
Financial resources	-0.052	-0.201	-0.175	-0.343
Skilled human resources	-0.788	-3.053	0.791	1.548
Material and equipment	-0.159	-0.614	-0.125	-0.245
Processes improvement	0.009	0.037	-0.472	-0.924
Customer focus	-0.04	-0.156	-0.739	-1.445
Performance measurement	-0.43	-1.666	-0.527	-1.031
Benchmarking	0.232	0.899	-1.072	-2.097
Innovation and creativity	0.117	0.454	-0.412	-0.805
Quality tools	0.134	0.517	-0.976	-1.909
Dissemination of quality improvement	-0.288	-1.117	-0.779	-1.524
Time	0.73	2.825	-0.411	-0.803
Cost	-0.233	-0.902	-0.081	-0.158
Defects rework	-0.116	-0.449	-0.897	-1.755
Safety	-0.168	-0.651	-0.964	-1.886
Customer satisfaction	-0.201	-0.779	-0.127	-0.248
Customer complaints	0.199	0.772	-0.498	-0.975
Employee satisfaction	0.185	0.716	-0.434	-0.849
Useful suggestions	-0.462	-1.79	-0.387	-0.757
Quality reputation	0.021	0.081	-0.471	-0.923

Market share	-0.94	-3.641	1.38	2.7
Competitiveness	0.49	1.896	-0.295	-0.577
Profits	0.103	0.4	-0.666	-1.304

One of the key assumptions of any regression analysis is that the data is normally distributed (Sekaran and Bougie, 2006). For testing that the data is normally distributed, Tatham et al. (2006) stated that skewness and kurtosis levels should fall between -2.00 and +2.00. The table above indicates that values of Skewness and Kurtosis (Statistic) for all the variables is between +2 and -2 confirming the assunption that the data is normally distributed.

Appendix 7: Vensim guide for users of the model

The model developed in this research can be contextualised by any Saudi construction company. Below are the steps that the organisations intending to use the model in this research need to follow in order to obtain their own TQM maturity curve.

Step 1: Answer all the questions in the questionnaire survey give in Appendix 2.

Step 2: Calculate the current value of each enabler for their organisation using the following equation:

$$Current\ value = \frac{\sum_{i=1}^{n} Score}{n * 5} * Desval$$

Score: is the score of each question from 1 to 5.

Desval: the desired value of the enabler (Table 6-10)

n; is the number of (items) questions for each enabler

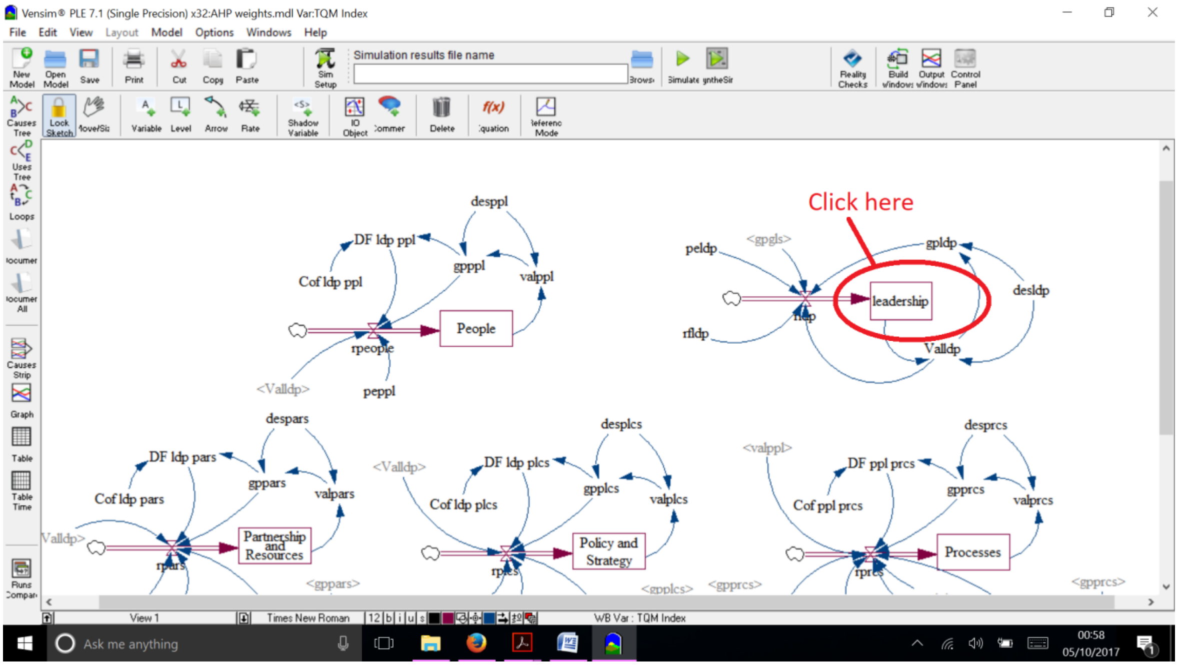
5 is the maximum score for each (item) question

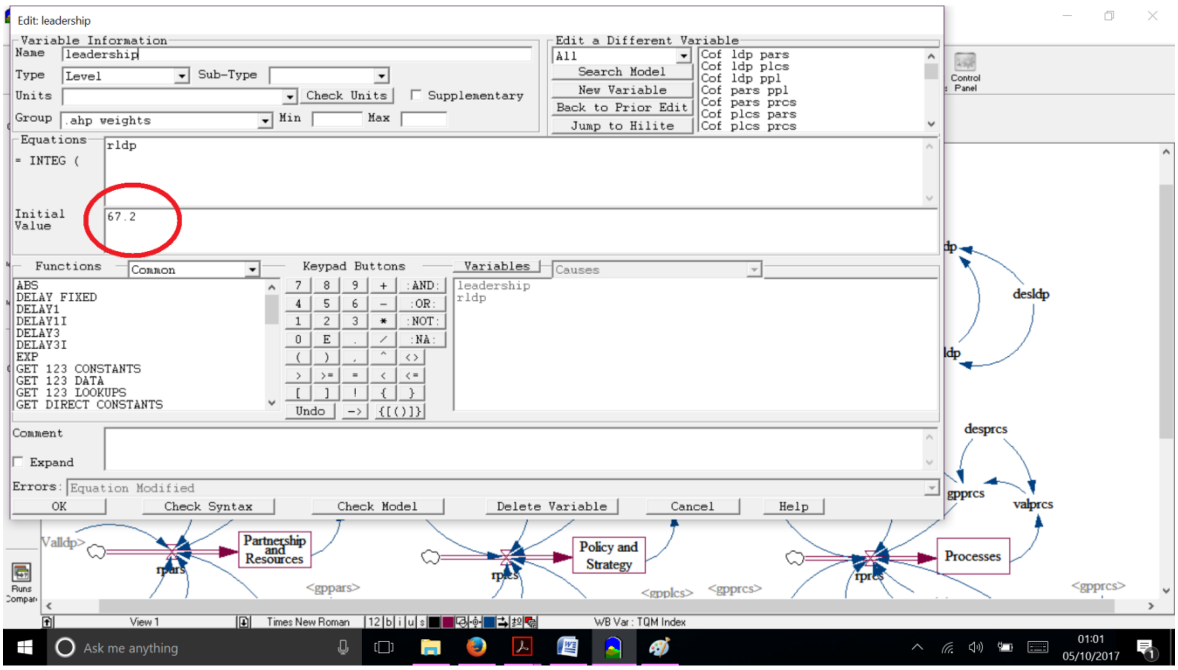
For example, the score given to the six questions under Leadership enabler are 2,3,3,4,5,1

And because *desldp* = 112. Therefore,

Current value = (2+3+3+4+5+1)*112/ 6*5 = 18*112/30 = 67.2

Once the current value of all the enablers is calculated these values are to be updated in the Stock flow diagram. The figure below shows example for leadership enabler:





Once all the values have been updated, simulation could be run and desired results be obtained.

If the organisation would like to forecast the likely impact of some policy decisions, they need to change relevant values. For example, if the policy decision is to increase the effort allocated towards development of people enabler to 20% then the same process as shown in images need to be followed for changing the value of *peppl* from 0 to 0.2.

Simulations can be run and graphs indicating curves representing different policy decisions can be obtained.