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# Managing quality in projects: An empirical study

Ron Basu *

*Henley Business School, United Kingdom*
*SKEMA Business School, France*

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**Abstract**

The purpose of this paper is to establish the key role of quality in the 'iron triangle of cost, time and quality' and highlight the importance of implementing the people related 'organisation quality' amongst key stakeholders to deliver the success criteria of a project.

The field research design comprised three stages.

Stage 1: Semi-structured interviews
Stage 2: Questionnaire surveys followed by a conceptual research model. The research model was validated by Partial Least Squares (PLS) modelling
Stage 3: Case studies of two comparable large projects based organisations (Heathrow Terminal 5 and High Speed 1).

As a substantive contribution to knowledge the research defined project quality with three dimensions (viz. Design Quality, Process Quality and Organisation Quality) and identified the lack of attention to details to Organisation Quality. A mixed methodology of Partial Least Squares (PLS) and case studies was applied. The findings also helped to develop a simple but effective tool APEX (Assessing Process Excellence) to assess the key constructs of project quality and excellence. The paper also provides a summary of the best practices for managing quality.


*Keywords:* Project quality; Project excellence; Design quality; Process quality; Organisation quality; Project success criteria; Project success factors

## 1. Why project quality?

We all agree and accept that as an end user of a product or service we would like it 'as it says in the tin', when we want it and at good value for money. Being in a competitive world of consumer choice we also expect it to last. We understand it in a market driven economy and aim for the appropriate product and service quality. This is the domain of operations, services and supply chain management. And we define it as '*quality is what customer expects as a lasting experience*' (Basu, 2011). However in the field of project management the importance of quality is not so clear cut. Project managers appear to accept the 'iron triangle of cost, time and quality' (Atkinson, 1999) but focus more on 'on time and budget' delivery as the success criteria. Quality in projects is mostly relegated to a 'lip service' and to several documents with 'ticking boxes'. Project managers also appreciate the risk of a project because of its uniqueness, complexity and deliberate design details but appear not to prioritise the link between the outcomes of risks with the root causes underpinned by the dimensions of project quality. As a consequence we find many examples (as described later) of projects which were delivered on time and within budget but failed to meet the expectations of end users in the longer run.

* Little Maltmans, Maltmans Lane Gerrards Cross, UK, SL9 8RW. Tel.: +44 1753 886 701.
*E-mail address:* basurn@aol.com.
*URL:* http://www.perf-ex.co.uk.

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Therefore we need to ask 'how diligent are we in terms of project processes to deliver project objectives'? This is the minimum requirement of 'what it says in the tin'. Furthermore we should also investigate 'how good is our project management … as a vehicle for delivering the longer term outcomes and benefits as required by the sponsors and end users'. This is part of additional requirements of sustainable quality leading to project excellence. The relationship between project quality and project excellence will be discussed in more details later.

Let us now examine the current thinking and practices to address the above questions. The extant project management literature (Atkinson, 1999; Meredith and Mantel, 2003; Morris and Hough, 1997: Turner, 1999) identifies and supports three criteria or objectives for assessing the success of a project known as the 'iron triangle' of time, cost, and quality. The first two objectives are relatively simple to define and measure (Morris and Hough, 1997). Project quality as the third objective or dimension of the 'iron triangle' is more difficult to define and assess although it has received some attention in the academic literature (Heisler, 1990; Turner, 2002). Turner (2002) is amongst the few authors who attempts to more clearly define project quality comprising two dimensions as product quality and process quality. The guidelines for project quality in the project management bodies of knowledge (APM, 2007; PMI, 2008a; PRINCE2, 2009) also reflect procedures of design and process requirements. These definitions and guidelines appear to suffer from two important limitations, viz. a lack of clarity in the definition (Whitty and Schulz, 2005) and the exclusion of organisational learning practices. (Kotnour, 2000)

The lack of clarity around quality is often the source of project disputes and there are in fact more reports in the business world as illustrated below, documenting the link between inadequate attention to quality management and unsuccessful major projects.

Case example: The Millennium Dome

'The Millennium Dome project was one of the most controversial public works projects ever undertaken.' (National Audit Office, 2000). The National Audit Office report also stated that the New Millennium Experience Company experienced severe financial difficulties. The main cause of these difficulties was the failure to achieve the visitor numbers and other contributing factors included the quality of project delivery and the contents within the dome.

Case example: Wembley Stadium

'The company that built the new Wembley Stadium, which opened after years of delays and almost tripling its cost, is suing the engineering consultants behind the project for £253 m, claiming that their services were unsatisfactory.' (The Observer, London, March 16, 2008). A preliminary search of legal cases (British and Irish Legal Information Institute, http://www.bailii.org, accessed 26/11/08) indicated several instances (2512 hits) of litigations because of 'poor quality' in projects. For example, in the recent Wembley Stadium project, there were eight major litigations related to project quality and three of these litigations were related to the *definitions* of project quality. In the case between Multiplex Construction Ltd and Honeywell Control Ltd (both being the contractors of Wembley Stadium) the dispute was to resolve the statement in the contract, "It will have extensive, high quality corporate hospitality facilities and a state of the art communications system (installed by Honeywell)." (Neutral Citation Number: 2007, EWHC 447, TCC, www.bailii.org, accessed 26/11/08).

Case example: West Coast Rail Upgrade

The rail line between Glasgow and London was undergoing an £8.6bn upgrade from 2003. The modernisation of the West Coast Main Line will deliver the following enhancements:

- 125 mph route capability for tilting trains delivering much faster journey times.
- Capacity for significantly more long distance passenger and freight trains than today.
- Better and more resilient performance in travel time and safety measures.

The National Audit Office said it might not be able to cope with current levels of growth beyond 2015. The auditors' report on the west coast line warned that electronic signaling equipment might become obsolete significantly earlier than expected. The auditors were also concerned about the ineffective communications between key stakeholders (Government, Network Rail, Rail Track and Virgin Trains). To sustain train operations, the line's operator, Virgin Trains, was paid £590 m more in subsidy in the period 2002–06 than envisaged in its franchise agreement, their report said. In January 2008, an over-run on work results in one of the worst delays yet. Network Rail is fined £14 m.

The above examples of major project failures appear to focus on the quality of design, the quality of execution processes and the quality of communications between stakeholders. Many papers and studies in 1990s (Belassi and Tukel, 1996; Kirby, 1996; Tam, 1999) highlighted project failures but the problems still exist (MPA, 2003). Recent academic publications (Abdelsalam and Gad, 2009; Jamieson and Morris, 2008; Ling et al., 2009; Zou et al., 2007) also suggest that causes of project failures include inadequate risk evaluation and quality management. These papers also highlight that there is a lack of clarity regarding the dimensions of project quality and its application with key stakeholders.

When we search the domain of operations management we may observe some proven paths to follow. The area of operations management enjoys some success stories, (along with failures) of the application of quality based operational excellence concepts such as Total Quality Management, Six Sigma, Lean and Supply Chain Management (Oakland, 2003). The application of operational excellence concepts are now extended to non-manufacturing processes. 'Firms such as Motorola, General Electric…successfully implemented Six Sigma. Motorola saved $15 billion in an 11 year period. General Electric saved $2 billion in 1999 alone.…Although Six Sigma initiatives have focussed primarily on improving the performance of manufacturing processes, the concepts are widely applied in non-manufacturing, administrative and service functions' (Weinstein et al., 2008). Even though operational excellence concepts (such as Six Sigma) are often driven by the objective of cost effectiveness the enablers of these concepts are rooted to the fundamentals of quality management (Oakland, 2003).

In the domain of operations management, the dimensions and definitions of quality have been identified by some authors (Garvin, 1984; Parasuraman et al., 1984). The early leaders of

Total Quality Management (TQM) (Deming, 1986; Feigenbaum, 1983; Juran, 1989) emphasised the importance of people related issues as a dimension of quality. On the other hand, the dimensions and definitions of quality appear to be wanting in publications related to project management. Project management standards (e.g. PMI, 2008b; PRINCE2, 2009) focus primarily on processes in the project life cycle with some references to quality management systems (Whitty and Schulz, 2005). Turner (2002) appears to agree with Wild's (2002) dimensions of product quality and process quality. Kotnour (2000) points out the lack of clarity in the definition of project quality and the role of organisational learning in project management. There are publications regarding the success criteria and success factors of projects (Grude et al., 1996; Pinto and Slevin, 1988) but their implications in the dimensions of project quality are not clear. The application of excellence models in projects appears to be limited (Hertogh et al., 2008; Westerveld, 2003). Unlike operations management, the tools and concepts of operations excellence (Basu, 2008), such as Lean and Six Sigma, are rarely being applied in project management (Pinch, 2005).

As summarised in Table 1, the publications for the manufacturing and service sectors are more focussed on the definitions of quality with distinctive dimensions and also encompass operational excellence concepts. The publications for the project management sector include success criteria and success factors but these in turn appear to show a gap with their link with the dimensions of project quality. There is also an apparent gap with the application operational excellence concepts in project management.

On the basis of the above summary there appears to be a knowledge gap in the environment of project management related to the benefits achieved by quality management in comparison to the manufacturing and service operations. This publication is an attempt that sets out to investigate the impact of all aspects of quality management in project management. The aim of this paper is to contribute to this knowledge gap in project management and take the status of the subject matters a step forward.

## 2. Research questions and propositions

The above preliminary review also indicates that there should be a clearer definition of project quality to establish some key dimensions. If you cannot define, you cannot measure, and if you cannot measure, you cannot control, assure or improve. First, what are the dimensions of project quality? Secondly, what tools or models can be effectively used in the quest for achieving and sustaining project excellence?

Thirdly, how can the successes of operational excellence concepts, such as supply chain management, Lean Thinking and Six Sigma, be gainfully deployed in enhancing project quality and excellence?

Following an extensive review of literature related to the research questions the following propositions were derived:

**Proposition 1**. *There exists a new dimension of quality in projects beyond the product and process quality and that is organisation quality.*

**Proposition 2**. *The organisation quality in projects spans across critical success factors and softer issues in project management leading to the sustainability of outcomes.*

**Proposition 3**. *The strategy of organisation quality in projects supported by periodic holistic assessments, operational excellence approaches and continuous training leads to project excellence.*

## 3 . Definition of project quality

It is generally accepted that the minimum success criteria of projects are that they should completed to time, to budget and to

Table 1
Classification of publications on quality and excellence.

| Publications | Dimensions and definitions of quality | | | Success criteria and success factors | Excellence models | Operational excellence concepts SCM/TQM/ 6Sigma | | Application sector |
|---|---|---|---|---|---|---|---|---|
| | Product | process | People | | | | | |
| Garvin (1984) | X [a] | | | | | | | Manufacturing |
| Parasuraman et al. (1984) | X | | | | | | | Service |
| Wild (2002) | X | X | X | | | | | Manufacturing |
| Deming (1986) | | X | X | | | | X | Manufacturing |
| Juran (1989) | | X | X | | | | X | Manufacturing |
| Feigenbaum (1983) | | X | X | | | | X | Manufacturing |
| Whitty and Schulz (2005) | | X | | | | | | Projects |
| PRINCE2 (2009) | | X | | | | | | Projects |
| Turner (2002) | X | X | | | | | | Projects |
| Kotnour (2000) | | | X | | | | | Projects |
| Pinto and Slevin (1988) | | | | X | | | | Projects |
| Grude et al. (1996) | | | | X | | | | Projects |
| Westerveld (2003). | | | | | X | | | Projects |
| Hertogh et al. (2008) | | | | | X | | | |
| **THIS PAPER** | X | X | X | X | X | X | X | **Projects** |

[a] X denotes the presence of the topic in the publication.

quality. However when one explores what is meant by quality the answers are often vague and variable. If someone talks about 'working on project quality', they may simply mean activities related to quality management systems recommended in bodies of knowledge (e.g. PMI, 2008b; PRINCE2, 2009) and they ensure the compliance to procedures by 'ticking boxes'. Quality in a broader context has many meanings depending on customers, ranging from luxury and merit to excellence, good value for money or convenience and even practicality. A generic definition of quality is simply 'meeting the customer requirements' but this has been expressed in many ways, e.g.;

- 'conformance to requirements' — Crosby (1992)
- 'fitness for use' — Juran (1989)
- 'Quality should be aimed the needs of the consumer' — Deming (1986)
- 'The total composite product and service characteristics of the organisation to meet the expectation by the customer' — Feigenbaum (1983)
- 'the totality of characteristics of an entity that bear on its ability to satisfy stated and implied need' — ISO 9000:2000

If we can't find a comprehensive definition of project quality we can't assess its efficacy and therefore we can't apply it effectively to deliver successful projects. Only Feigenbaum's definition seems to cover the 'total' concept of quality covering product, service (conformance) and organisation. However the consistency of conformance is not explicit here. Therefore the definition of quality should be rephrased as:

> *Quality is the consistent conformance to customer expectations.*

Basu (2004) proposes a three-dimensional model of quality is shown in diagrammatic form in Fig. 1.

When an organisation develops and defines its quality strategy, it is important to share a common definition of quality and each department within a company can work towards a common objective. The product quality should contain defined attributes of both numeric specifications and perceived dimensions.

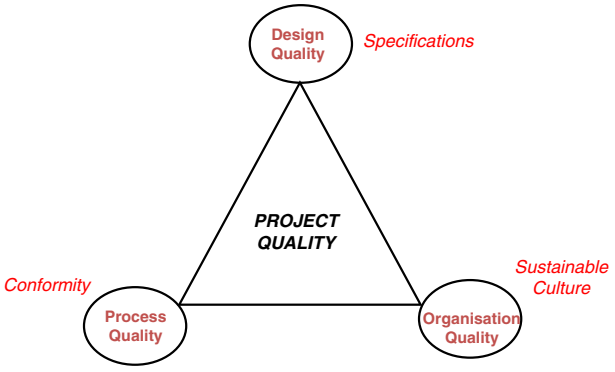


Fig. 1. Three dimensions of quality.

The process quality, whether it relates to manufacturing or service operations, should also contain some defined criteria of acceptable service level so that the conformity of the output can be validated against these criteria. Perhaps the most important determinant of how we perceive sustainable quality is the functional and holistic role we fulfill within the organisation. It is only when an organisation begins to change its approach to a holistic culture emphasising a single set of numbers based on transparent measurement with senior management commitment that the 'organisation quality' germinates. We have compiled (see Table 2) a set of key organisation quality dimensions following semi-structured interviews with 16 senior members of the Major Projects Association, UK (MPA).

*Top Management Commitment* means that organisational quality cannot exist without the total commitment of the top executive team.

*Sales and Operations Planning* is a monthly senior management review process to align strategic objectives with operation tasks.

*Single Set of Numbers* provides the common business data for all functions in the company.

*Using Tools and Techniques* relates to the fact that without the effective application of tools and techniques, the speed of improvement will not be assured.

*Performance Management* includes the selection, measurement, monitoring and application of key Performance Indicators.

*Knowledge Management* includes education, training and development of employees, sharing of best practice and communication media.

*Teamwork Culture* requires that communications and teamwork should be practiced in cross functional teams to encourage a borderless organisation.

*Self-assessment* enables a regular health check of all aspects of the organisation against a checklist or accepted assessment process such as EFQM.

## 4. Field research design

The major components of field research comprised semi-structure interviews, a questionnaire survey, a Partial Least Squares (PLS) modelling (Chin, 1998) and case studies. From this research it became apparent that there were many different perspectives on this multi-dimensional issue ranging from (but without limitation to) the definition and dimensions of quality in project management, application of quality in projects, the impact of the critical criteria and factors relating to the success of projects, the role of project

Table 2
Basu's organisation quality dimensions.

- Top management Commitment
- Sales and Operations Planning
- Single Set of Numbers
- Skills of using Tools and Techniques
- Performance Management
- Knowledge Management and continuous learning
- Communication and teamwork Culture
- Self-assessment

excellence and maturity models to the application of operational excellence approaches in project management. These perspectives and issues need to be tested by practical data. The field research design was influenced by the review of literature both on the research topic and the published methods of research and comprised three stages.

Stage 1: Semi-structured interviews with 16 senior project and programme managers selected from the members of the Major Projects Association, UK (MPA).
Stage 2: Questionnaire surveys to members of the Association of Project Management (APM) and the Chartered Quality Institute (CQI) followed by a conceptual research model. The research model was validated by Partial Least Squares (PLS) modelling (Basu, 2010).
Stage 3: Case studies of two comparable large projects based organisations (Heathrow Terminal 5 and High Speed 1) and the validation of results by adapting the case study approach of Yin (2003) and Eisenhardt (1989).

The field research started with sixteen senior project and programme managers in the Major Projects Association (MPA). The semi-structured interviews not only helped to refine the questionnaires for the second wave of field survey they also provided some useful pointers for continuing research in project quality and excellence. The pilot survey with APM (Association of Project Management) members served as the useful and necessary field test before finalising the questionnaire for on-line survey. The refined questionnaire was then transcribed to an online format by using 'www.hostedsurvey.com' facility (see Appendix 1). The population of the survey was members of Chartered Quality Institute (CQI), Major Projects Association (MPA) and Association for Project Management (APM) who had access to internet and who could be contacted by e-mail. It also facilitated initial data validation for missing and incorrect data. The actual survey responses (73 valid responses) were collected on-line on the server itself and later downloaded in text or Excel format for further analysis.

## 5. Summary results

The data from Excel were formatted for data compression and regression analysis by SPSS and then in causal modelling by using Partial Least Squares (PLS) originally developed by Wold (1985), Hulland (1999) and Chin (1998) recommend the PLS technique for predictive causal modelling to deal with small data samples. The data for exogenous constructs for the inner model (see Fig. 2) were derived from the measures in the data base extracted from the online questionnaire. As shown in the model there are five exogenous constructs (viz. Quality Strategy & Procedures, Quality Audits & Measures, Organisation Effectiveness, Operational Excellence Concepts and Self-Assessment &Knowledge Management) and two endogenous constructs (viz. Project Quality and Project Excellence). The results of the PLS model with 26 indicators do support that 'organisation effectiveness' has a direct effect and significant relationship (path coefficient 0.473) with 'project quality'(R square value 0.771).

Both the questionnaire survey and PLS modelling demonstrated a strong link and correlation between 'organisation effectiveness' or 'organisation quality', and the 'softer' success criteria such as 'top management support', 'project leadership' and 'stakeholder management' (see Table 2). These people related criteria were also embedded in the organisation culture of both the T5 and HS1 projects. The results from the PLS model and case studies confirms that the dimensions of project quality supported by operational excellence tools, periodic self-assessment and continuous training are the drivers of project excellence, and hence support the third proposition.

The three propositions were further analysed by comparing relevant findings from all three sources in order to calculate 'triangulation congruency measures' (Meglino and Ravlin, 1998). Proposition 2 was further subdivided as there was inconsistency in findings from three sources related to the link between the 'softer issues' and 'sustainability of outcomes'. The results of this analysis are summarised in Table 3.

## 6. Apex model

The APEX (Assessing Project Excellence) model is the outcome of the PLS model and case studies (see Fig. 3). The PLS model (Fig. 2) has three exogenous constructs (viz. Quality Management Systems, Quality Audits and Organisation Effectiveness) for 'Project Quality'. The case studies (both T5 and HS1) clearly demonstrated the existence of 'Performance Management' as an important additional construct to complement 'Project Quality'. 'Performance Management' is, therefore added as an additional construct to complete the APEX model. The exogenous constructs for 'Project Excellence' (viz. 'Operational Excellence Concepts' and 'Self-Assessment') remain the same for both the PLS model and the APEX model.

The addition of another exogenous construct (viz. Performance Management) in the APEX model is in line with the conclusions on additional latent variables by Temme et al. (2008). The gap identified in the construct 'Audit and Measures' by the PLS analysis has provided a substantive input to case studies for further investigation by an additional construct.

The APEX Model has already been either tested or actually applied successfully by BP Plc, Heathrow Limited and Crossrail Limited. The users have considered this model as a starting point to establish a project specific checklist of self-assessment and also towards more comprehensive maturity models. The constructs and checklist of the APEX model are also expected to significantly enrich the eight themes proposed in the Infra Maturity Tool (IMT) in the EU research project NETLIPSE (Hertogh et al., 2008).

There is little argument that the management of all major projects needs further improvement and therefore the recommendations arising from the findings and conclusions of this study should add value to the knowledge and business of project quality management. A summary of key recommendations comprising the best practices of managing quality in projects is presented and these are also reflected in the checklist in the APEX model (Basu, 2012). The recommendations are

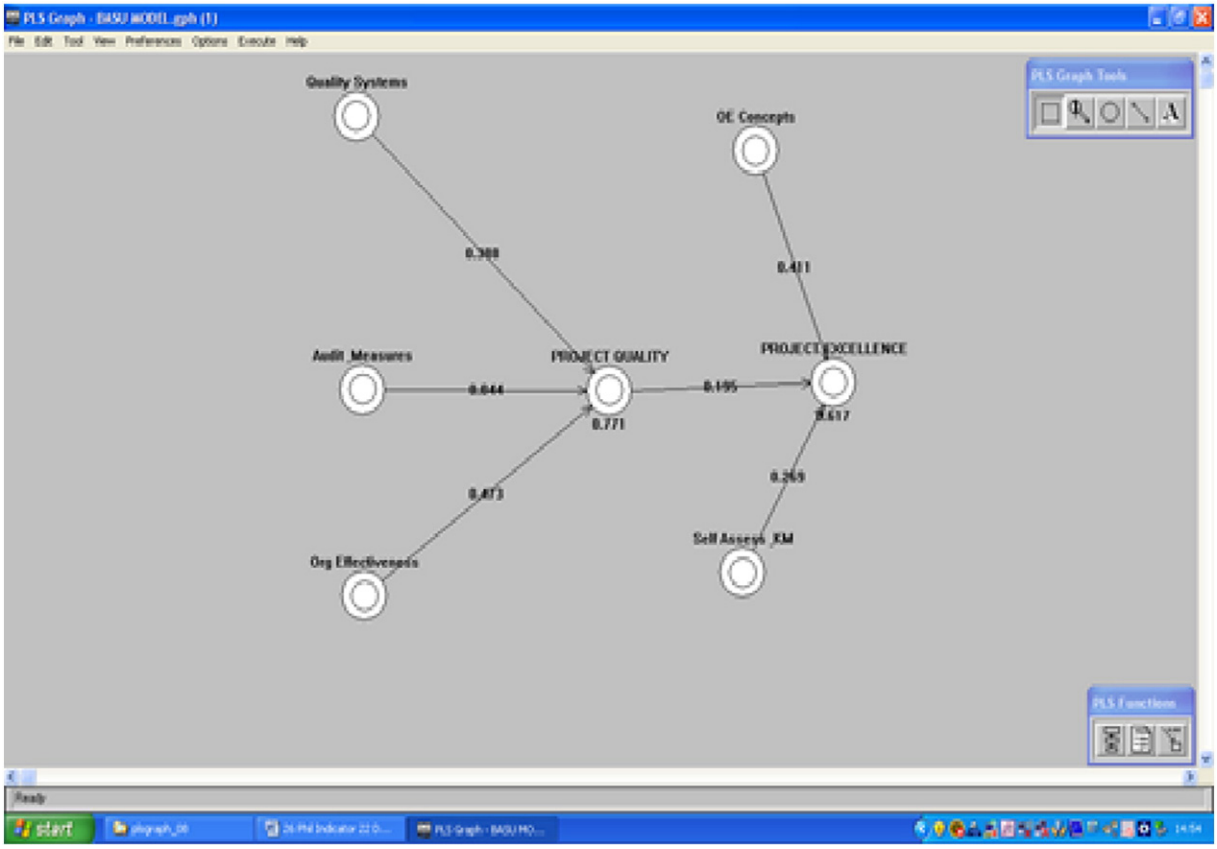


Fig. 2. The Partial Least Square (PLS) Model.

followed by an implementation plan of managing quality in major project.

## 7. Conclusions

These conclusions are summarised as the best practices of managing quality aimed at all types of major projects with particular focus on infra-structure projects.

### *7.1. Quality management systems and procedures*

Formal quality management systems and procedures for the project team should be in place before the implementation phase of the project. The quality management systems and procedures for suppliers/contractors should also be established supported by a structured training process. Quality management systems and procedures should follow the guidelines of the project methodology of PRINCE2 or PMBOK, and also the proven practices of company standards and delivered projects. The training programmes in both T5 and HS1 have helped to inculcate quality management systems, beyond just ticking boxes, to project team members.

### *7.2. Quality audit and compliance*

Formal quality audit procedures should be in place covering the three realms of design conformance, process conformance and supplier deliverables. It is vital that audit processes are explained and communicated to project teams and suppliers before the commencement of any audit. Audit teams should include members from the areas of quality, safety and the project team, in addition to contractors and users as appropriate. The audit process should be well supported by effectively designed documents, check lists, reports and continuous improvement.

### *7.3. Performance management*

A performance management system should be structured around the principles and four aspects of the Balanced Scorecard. The key performance indicators should reflect both enabling and delivered measures. It is vital that a performance management system spans across project groups and key suppliers. It should be aligned with gateway or milestone reviews (MSP, 2007) and also with audit, self-assessment and continuous improvement.

## 8. Organisational effectiveness

Organisation structure should include the steering team (project board), project teams and a support team with a dedicated Quality Manager and budget for quality. This budget for quality should be above 0.5% of the project spends as found in T5 and HS1 projects. It is critical that high priority is given for Client Relations and Stakeholder Management (such as HS1 organisation). The co-

Table 3
Analysis of triangulation congruency measures.

| Propositions | Descriptions | Findings from questionnaire survey | Findings from PLS modelling | Findings from case studies | Triangulation congruency measures |
|---|---|---|---|---|---|
| Proposition 1 | There exists a new dimension of quality in projects beyond the product and process quality and that is organisation quality. | All three dimensions (design, process and organisation) together ranked second in the question for dimension of quality. *Supported* | The path coefficient between 'Organisation Effectiveness' to its endogenous variable 'Project Quality' is 0.473 indicating a strong relationship. *Supported* | Organisation quality is embedded in the structures of both T5 and HS1 projects. *Supported* | HIGH All three sources show the same presence |
| Proposition 2 | - The organisation quality in projects spans across critical success factors and softer issues in project management | High scoring factors such as Project Leadership, Top management Support Communication and Stakeholder Management all people and organisation related 'softer' factors. *Supported* | In the PLS model with 26 indicators the construct 'Organisation Effectiveness' comprised the 'softer 'or organisation related success factors showing high values of loadings. *Supported* | 'Softer' success criteria such as top management support, project leadership, stakeholder management and communication and training were embedded in the organisation and quality culture.in both T5 and HS1 projects. *Supported* | HIGH All three sources show the same presence |
| | - and softer issues in project management leading to the sustainability of outcomes. | The multiple regression analyses did not support any strong correlation between the 'softer' factors and sustainable outcomes. *Not supported* | The link between 'softer' indicators and 'Project Excellence' (for sustainable outcomes) was indirect via 'Project Quality'. *Partly supported* | Although they contributed to the longer term success of projects there was lack of evidence to support a direct link between 'softer' criteria and sustainable outcome. *Partly supported* | MEDIUM Two sources show the same presence |
| Proposition 3 | The strategy of organisation quality in projects supported by periodic holistic assessments, operational excellence approaches and continuous training leads to project excellence | Project Managers were aware and interested in these tools and concepts but their application not yet penetrated the project management culture. *Supported.* | Project Excellence comprising Project Quality (containing organisation effectiveness) and two additional latent variables (viz. operational excellence concepts and self- assessment & knowledge management) leads to the sustainability of outcome. *Supported.* | There were evidences of excellent application of Six Sigma and EFQM in HS1 and Supply Chain Management in T5. Both T5 and HS1 showed workable processes of periodic self -assessment and training programmes with sustainable outcomes. *Supported* | HIGH All three sources show the same presence |

ordination of contractors and sub-contractors should be ensured by supplier partnership agreements (such as the T5 agreement).

HR should have a clearly defined role supported by job descriptions of Project Team members. The RACI (Responsible, Accountable, Consulted, and Informed) process is used for relevant tasks related to Work Breakdown Structure. It is important to recognise that softer critical success factors such as leadership, communication and user involvement are embedded in organisation culture (see Table 2).

### 8.1. Operational excellence concepts

Proactive application of Six Sigma concepts should be pursued as a cost effective programme. Even if there is no formal application of Six Sigma, there should be evidence of processes and initiatives in order to instil a TQM culture within Project Teams and suppliers. Secondly, there should be a clear recognition of the supply chain management principles, with dedicated resources if appropriate in procurement, forward planning and supplier partnership. Finally it is vital to demonstrate the proactive application of Lean Thinking in minimising non value-added activities and process cycle times.

### 8.2. Self-assessment and knowledge management

In line with quality audit, performance management and maturity or excellence models, there is evidence of the value of well-structured checklists to perform holistic health checks. The APEX (Assessing Project Excellence) Model should also be considered to complement these health checks. Also important is the appropriate application of maturity or excellence models such as EFQM (2003) or IPMA (2007). There should be evidence of regular self-assessment to identify and follow up areas of continuous improvement. Moreover, continuous education and training and communication tools need to occur in order to share and enhance the skills, process and systems knowledge of project team members and suppliers. For major infra-structure projects, there should be a separate group installed at least six months before the project closure focussing on longer lasting outcomes and legacy for cultural, economic and environmental objectives.

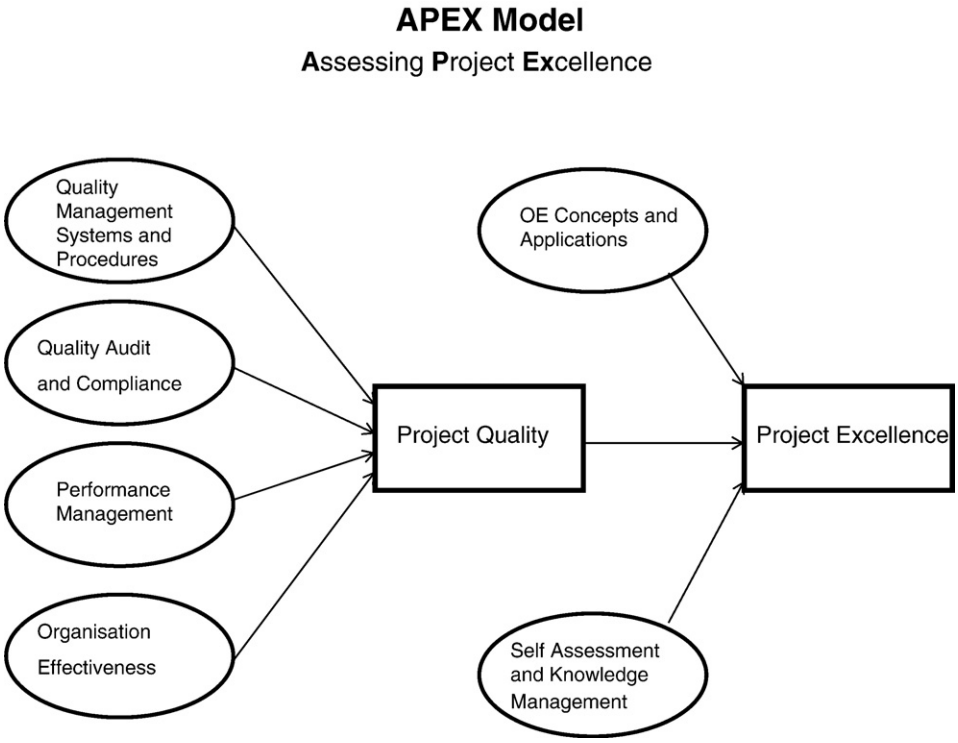


Fig. 3. APEX model.

The conclusions leading to the practical contributions to the business world of project management and quality management are summarised as a seven-step implementation plan in 'Managing Quality in Projects' (Basu, 2012).

## 9. Contribution to knowledge

The research has contributed to the definition of project quality as delivering customer requirements ensuring three dimensions of the quality of the product (design specifications), the quality of management processes ( conformance to specifications) and the quality of the organisation ( leadership, skills and communication). The longer term sustainability of project outcomes leading to project excellence is achievable by the three dimensions of quality supported by operational excellence concepts, self- assessments and continuous training.

From a methodological perspective one important contribution of this study is the effective use of the mixed methodology supported by a structured approach of methodological triangulation (Basu, 2010). Given its attempt to examine the causal relationship between the dimensions of quality and project excellence by Partial Least Squares (PLS) approach (Chin, 1998) the epistemological underpinning of the present research takes predominantly a *positivist* stance. However this research also demonstrated the effective use of semi-structured interviews (Sekaran, 2003) to develop a robust instrument of questionnaire survey (Openheim, 2000), a balanced blend of both exploratory and explanatory case study strategies (Yin, 2003) and also a four steps structured triangulation approach (Denzin, 1978) of synthesising results from three sources.

## 10. Way forward

It is hoped that the ideas, dimensions of quality, processes and practical implication of the APEX model presented in this paper should assist the Project Leaders and Quality Managers to manage quality beyond the generic guidelines available in PMI (2008b), PRINCE2 (2009) and ISO 10005 (2005). The field research and case studies are supporting data to validate the contents of this paper. However it a part of a continuous learning process aiming towards further improvement and it is recognised that 'the devil is in the detail'. It is important to note that the results of the field research reported in this paper have some limitations especially related the scope of quality, assumptions and responses from the on line survey.

The scope of this paper is primarily focussed on major and contemporary infra-structure projects in the UK. It is expected that the general conclusions of this research could be extended judiciously to other major projects in the UK. However it is questionable whether these same conclusions should equally apply in the context of another culture. For example, the organisation quality strategy of the London 2012 Project may not be comparable to that its predecessor, the Beijing 2008 Olympic Project. Accordingly replication studies across different countries, sectors and types of projects are encouraged.

Another area of constraint is the assumption of keeping the factors related to cost, time, risk and safety as independent of project quality and excellence. As such, no specifically designed constructs related to these factors are included in the instruments of this research. There are some academic publications examining the links between cost and quality (Abdelsalam and Gad, 2009),

between safety and quality (Ling et al., 2011), between risk and quality (Zou et al., 2007) and time and quality (Luu et al., 2008). The scope of research can be expanded by including constructs related to cost, time and risk to incorporate a conceptual research model on project quality and project excellence. A quantitative model of cost benefit analysis could also constitute an area of further research.

The construct for 'Quality Audit, Compliance and Measures' in the existing PLS Model was partly supported by PLS-Graph simulations. The case studies of HS1 and T5 demonstrated the strong presence of both Audit and Compliance and Performance Management within this construct. Further research can be carried out by incorporating two latent variables (e.g. 'Audit and Compliance' and 'Performance Management') supported by additional reflective indicators to replace this construct in the PLS model. Although the rationale for an additional construct is in agreement with Temme et al. (2008), further research is recommended in the PLS model with an additional construct to bolster this finding.

An important area to explore will be the validation of findings and conclusions across other types of major projects in the UK, especially major ICT projects. The research can also be extended to encompass different cultural environments in Europe, North and South Americas, Africa, Australia, Middle East and Asia. Even though the fundamentals of the project quality and excellence model may prevail, there are bound to be many specific requirements related to the type of projects as well as local priority and culture.

## Appendix 1. On line questionnaire (NB: Only Level 1 shown)

URL: http://www.hostedsurvey.com/takesurvey.asp?c=cqi-01

*Section 1: Introduction*

Q1.1. Would you describe the size of your project/programme as
1.2. Would you classify your project/programme primarily as
1.3. Would you describe your project/ programme in
1.4. What is the budget for quality management allocated to each project (as percentage of total project spend)

*Section 2: Definition of quality*

2.1. In the context of your project/programme you would define project quality as:
(Show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 most important.)
2.2. In the context of your project/programme your primary focus on the dimensions of quality is:
(Show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important.)
(NB: Design quality relates to product and specifications, Process quality relates to service and conformance and Organisation quality relates to people and longer term outcomes).

*Section 3: Quality in project management*

3.1. In the project organisation project quality is the responsibility of:
3.2. Pinpoint how you monitor project quality and performance
(Show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important.)
3.3. You set the quality standards and guidelines in your project/programme by
(Please choose only ONE option and show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important.)

*Section 4: Project success criteria and factors*

4.1. For the last most significant project/programme in which you have been involved please rate important criteria of success:
(Show in a scale 1–4, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important).
4.2. For the last most significant project/programme in which you have been involved please rate important factors of success:
(Show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important).

*Section 5: Project excellence and maturity*

5.1. Have you used in the significant projects in which you have been involved to assess project effectiveness or excellence:
(Show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important.)

*Section 6: Operational excellence in projects*

6.1. For the significant projects/programmes in which you have been involved you have applied operational excellence (OE) initiatives such as:
(Show in a scale 1–5, where 1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = most important.)

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**Dr Ron Basu** is currently a Visiting Fellow at Henley Business School and a Visiting Professor at SKEMA Business School. Previously he was a Management Consultant at A T Kearney and held executive roles in Unilever and GlaxoSmithKline. He is the author of ten books published through Butterworth Heinemann, Elsevier, John Wiley & Sons, Gower and Reuters. He also published in journals *like International Journal of Business Systems and Research, International Journal of Production Research, International Journal of Six Sigma and Competitive Advantage, Measuring Business Excellence, Industrial Engineer* and others. He has a PhD in project quality from Reading University. He is also the recipient of the APM 2009 award for the best research project.