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Integrating quality control and performance management in developing complex bespoke systems

Article

INTEGRATING RISK AND PERFORMANCE MANAGEMENT IN QUALITY MANAGEMENT SYSTEMS FOR THE DEVELOPMENT OF COMPLEX BESPOKE SYSTEMS (CBSs)

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Abstract

Risk and performance management are at the core of complex bespoke systems (CBSs). CBSs are developed to customer–specified requirements in terms of structure, functionality and conformance. This paper examines how risk and performance management are integrated as essential systems in the successful development of projects across multi-organisational functions in complex bespoke system (CBS) organisations. The paper argues for the development of a quality management system that consists of two sub-processes: quality control and quality development. Using three case studies from engineering companies, we provide evidence and insights of the way change control, quality development and quality performance are developed in innovating business solutions.

Key words: complex bespoke system(s), quality conformance, quality performance, risk management and performance management.

1. Introduction

While there is a plethora of scientific- and practitioner-based research articles on risk and performance management, they are often viewed as separate disciplines and rarely considered together (Kumar et al., 2016; MacKerron et al., 2015; Vrassidas et al., 2004). In spite of this, risk and performance management are in many respects two different sides of the same coin. The quest to achieve higher performance is often associated with incurring or taking higher risk, and implementation strategies for reducing risk can adversely affect performance (Dey, 2012; Keil et al., 2013, Palermo, 2014 Tiwana and Keil, 2010). Despite lack of integration of the two in the extant literature, practitioner-based evidence demonstrates that the overlap between performance and risk management is very narrow (Keil, 2013; Palermo, 2014). Hence, lack of focus on integration of the two disciplines hinders effective exploitation of the benefits of such integration.

In theory, the management of risk and performance is related; however, in practice, their combination into a single system is frequently not considered a practical solution for reaching alignment (Palermo, 2014. As a result, many companies manage performance and risk independently, with separate systems and processes for each. Incorporating risk into performance management processes can foster a better understanding of overall organisational risk exposure and improve business results (Palermo, 2014). However, integration of these two management systems is becoming a norm in CBS companies due to the types of projects in which these companies engage (Keil et al., 2013). CBS companies in business to business (B2B) are increasingly offering CBSs that combine both physical products and intangible services into what is called 'an integrated solution'.

Complex bespoke systems (CBSs) are developed and, in most cases, implemented, with customer-specified requirements in terms of location, structure, functionality, conformance and performance. Examples of CBSs include high-speed trains, energy generation plants, aircraft engines and complex manufacturing automation systems. The growing need for CBSs in recent times can be attributed to advancements in technology and system integration, increasing competition and globalisation, acknowledgment of 'servitisation' as a pivotal part of service provision, and new environmental regulations (such as green and sustainable operations). The movement towards a more solution-centred business model has been advocated by conventional product-oriented manufacturers (Brax and Jonsson, 2009; Kindström and Kowalkowski, 2009), engineering-focussed companies (Zhang et al., 2011) and service-based companies (Davies et al., 2006).

Unlike mass commodity products, CBSs are sold before they are developed. Such contract-based, capital-intensive and high-tech systems are designed, developed and implemented with the customers' intimate input throughout the entire project lifecycle. Interaction between the customers and solution-providers takes place at all levels of project execution and in a complex, specific and ever-changing development and operations context (Zhang et al., 2016). It is also assumed that after installation of the CBS the lifelong services of maintenance, repair, possible use extension and system upgrading, and eventually decommissioning will be delivered, often by the initial solution provider(s). As such, when a CBS project progresses, new constraints and possibilities emerge, which have to be dealt with in order to reflect new and better understanding for both solution takers and providers in relation to future business performance.

The evolving and emerging nature of CBSs lends itself to a different approach for managing the processing, uncertainty and performance of complex projects. Due to the nature of CBSs, which provide one-off solutions, the quest to push for higher performance is critical; hence, CBS companies are constantly facing challenges, such as change control, quality development of the system, and uncertainty management, leading to higher risks. Thus, these companies have to develop approaches and strategies to consistently reduce risks during the process; however, mitigating risk could have adverse effects on the performance of the project (Wang et al., 2017). It is imperative, therefore, for CBS companies to establish sufficient balance between managing risks and achieving higher performance of CBS projects. From the literature, our understanding of how to manage uncertainty and performance in CBSs is limited (Liu, 2015). To bridge this gap, this paper seeks to address the way CBS companies integrate risk and performance management in quality management systems for the development of complex bespoke systems.

The paper explores the approaches and strategies that can be used to establish a well-balanced interrelationship between risk and performance management. This will assist in creating guidelines on the appropriate level of integration between risk and performance functions in the development of quality management systems for CBS companies. To achieve this, we investigated the development of a quality management system that consists of two sub-processes: quality control and quality development, and the strategies involving processes, tools and relationships that moderate the successful development of risk and performance management in three CBS companies.

The rest of the paper is structured as follows: the literature review explores risk and performance management in CBS projects, integrative models of risk and performance management and cognitive approaches for integrating risk and performance in CBS companies. This is followed by strategies for data collection and analysis. The findings and discussion sections display three case studies, showing evidence of how risk and performance are integrated in the quality management system in CBSs. Finally, implications and conclusions are delineated.

2. **Theoretical background**

In this section we examined the theories and relevant literature for this study. The first part presents an overview of risk and performance management analysis and critique of the approaches and strategies for integrating risk and performance in CBS projects. We then explain how firms can develop complex projects, and why we focussed on quality control and development, and cognitive approaches; specifically, the analytical and interpretive approaches. We then analysed the theoretical and empirical literatures to identify gaps and develop a framework for the study.

2.1 Risk and performance management in CBS projects

Managing risk is all about achieving objectives for performance (Woods et al., 2008). 'Risk management is the systematic process of identifying, analysing and responding to project risk. It includes maximising the probability and consequences of positive events and minimising the probability and consequences of adverse events to project objectives' (Dey, 2012:904). Recent studies (Hobday and Rush, 1999; Hobday, Rush and Tidd, 2000; Davies et al., 2006; Zhang et al., 2011) indicate that CBS innovation does not follow the conventional product lifecycle model. The decision-making process in a CBS is complex because of market novelty, risk, information processing and inter-firm decisions. It is difficult to use 'hard' operational research approaches to achieve complex development issues. The rate of product innovation compared with process innovation is consistently high (Davies, 1997), therefore risk is a critical condition that can hinder the success and performance of CBS projects (Liu, 2015; Rapaccini & Visintina, 2015). Although several studies indicate that there is a direct or indirect link of risk management to performance (Liu, 2015; Keil et al., 2013), there is a lack of extant literature that explains how this relationship is developed and implemented in CBS companies. The few studies attempting to explain this focus on control and performance, looking at high requirement volatility and change over the course of the system's development lifecycle (Liu, 2015; Keil et al., 2013; Tiwana and Keil, 2010). Therefore, there is a need for research into the approaches and strategies for innovation management in CBS companies for product, service and process development (Bunduchi, 2013; Presley et al., 2000; Smith et al., 1996).

2.2 Approaches/strategies for complex development projects and management of risk and performance

There are different approaches and strategies for the development of CBSs, which include organisational, technology and system integration, experience-based, quality control and development, and cognitive approaches (Brax and Jonsson, 2009; Liker et al., 1996; Eisenhardt and Tabrizi, 1995; Henderson and Clark. 1990; Gardiner, 1986). Although the different approaches and strategies explore ways in which CBSs can be developed, they focus on different aspects of CBS projects; hence, the applicability of some of these theories is limited when the aim is to integrate risk and performance management in CBSs.

Based on two models organisations can firstly adapt to unpredictable changes (Eisenhardt and Tabrizi, 1995). While the compression model adopts a well-known, rational process, relying on compressing the sequential steps of such a process, the experiential model focusses more on uncertain processes and relies on improvisation, real-time experience and flexibility (Eisenhardt and Tabrizi, 1995) for fast innovation of products and services rather than for development of a process integrating risk and performance as required for one-off complex product quality development. Secondly, the technology and system integration approach emphasises technology design for reducing the frequency of recurring problems(Henderson and Clark, 1990). Further, CBS companies are concerned with the development of knowledge and organisational capability at two levels: the primary and the hidden. At the primary level, component knowledge is explicitly developed to deal with core design concepts and the way they are implemented in a particular component. At the hidden level, the development of architectural knowledge is dynamically and implicitly embedded in a process of building these components into a coherent whole (Zhang et al., 2011; Brax and Jonsson, 2009). Thus, theoretically and ideally, the technology and system integration approaches are developed around system interfaces for the purpose of effective design of CBSs.

The experience-based approach uses a set-based system, in which a company develops problem-solving strategies from learned behaviours to effectively solve problems in its immediate environment. The 'set-based' system defines sets of solutions or designs at both the conceptual and parametric levels, and these are gradually narrowed through elimination of inferior alternatives until the final solution emerges. The CBS company, therefore, develops its capability, resources and skills by using experience-based strategies in order to match customer requirements and supplier solutions to solve problems within components and the links between them (Liker et al., 1996; Gardiner, 1986). The experience-based approach effectively focusses on the relationship aspect and since, in CBSs, solutions are one-off and unique to customers, the applicability of the experience-based approach is limited in the integration of risk and performance in CBSs.

Thus, the cognitive approach, which is a broad-based approach to CBSs, was deemed an appropriate theoretical underpinning for this study and, in the next section, we critically examined the analytical and interpretive approaches.

*2.**2.1** Cognitive approaches to complex development projects*

Cognitive approaches to complex product development are discussed differently in the extant literature. According to Peters (1998), in large civil engineering structures, cognitive approaches for developing complex systems can be classified into three main areas. Firstly, scientific thinking is based on scientific methods where the goal is to discover knowledge. Such thinking deals with concepts, hypotheses and theories, which are all abstractions. Scientific methods are linear and hierarchical, and aim to be independent of the thinker's personal and cultural value systems so that results can be repeated by anyone. Secondly, matrix (or artistic) thinking is a non-linear approach. It moves from track to track, from level to level through associated leaps in logic. Matrix thinking is subjective and always linked to the thinker's own value system. Thirdly, technological thinking is a combination of the above two approaches. Technologists deal with objects, not in abstractions. They are makers and not analysts; hence, they transform and translate information within and between projects. They 'creatively misunderstand' scientific results if that helps to get the job done (Peters, 1998: 48). Therefore, technological cognition is best suited for delivering complex man-made operations systems.

Lester et al. (2002) suggested that there are actually two extreme cognitive approaches to the process of product design and development. When the environment is predictable, stable and well-defined, analytical management is appropriate. The analytical manager seeks to define a clear objective and identify resources that meet that goal. The well-defined problem is then divided into a series of discrete components, each of which is assigned to a knowledgeable specialist. The solution is ultimately obtained by integrating all the components in some optimal combination. The entire development effort is viewed as a single project, which must be brought to closure as quickly and efficiently as possible.

When the environment becomes unpredictable, unstable and ill-defined, interpretive management is relatively superior to the analytical approach. In many cases, customers do not know what they really want or need, or they simply have no pre-existing needs. These needs instead emerge from a series of interactions or conversations. The features of the product emerge in the same way – through an ongoing 'give and take' process between the customer and the supplier. Nothing is fixed at the outset: neither the customers' needs, nor the product itself, nor even the process of delivering the solution.

Lester et al. (2002) tested this idea in a wide range of industries: fashion apparel, chip making, cellular phones, biotechnology and medical devices. They concluded that both analytical and interpretive approaches are valid and should be kept as company assets and core competences. Their idea is useful for CBS manufacturing in that a complex project comprises various development and implementation environments. Some approximate an analytical framework, while others lend themselves to interpretation. Approaches to innovation and change are not only related to the environment, but also to the outcome of mental structuring. Ekvall (2002) argued that strict control systems (e.g., Total Quality Management) help with efficiency, but suffocate creativity. This is because rigid routines or rules restrict free and open communications, support conventional values, strategies and policies and thus block creativity. A culture of risk taking (such as Management-by-Objectives) makes failure less dangerous and less threatening, thus promoting creative behaviours. Drawing on comparative studies in chemical and mechanical companies, Ekvall (2002) demonstrated that a condition of loose structure, high-risk inclination, debate and a playful atmosphere tend to stimulate creative activities at higher levels. However, this culture makes the accomplishment of projects less predictable, thus raising the question of balance between the two cultures. Creativity needs to be controlled so that complex projects can be delivered to budget and on time.

2.2.2 Quality control and development strategies for complex development projects and management of risk and performance

The above discussion on cognitive approaches underlines the differences between mass production and CBS operations. CBS decision-making often has to combine operational optimisation issues with development issues (Klein and Meckling, 1958). Complex projects are arguably in the situation of 'make-to-concept' as opposed to 'make-to-print' (Zhang et al., 2011). Most CBS projects are designed to deliver co-created value (in exchange and in use) – a symbiotic relationship (Gebauer et al., 2005; Kindström and Kowalkowski, 2009). These unique features and the dynamic process of developing and implementing a CBS call for a fundamental understanding of the strategies and in-depth knowledge that are developed and applied in providing these highly sought-after systems (Oliva and Kallenberg, 2003). This has implications for risk and performance management in terms of institutional development, corporate strategic planning, organisational arrangement. and inter-firm relationships

Quality management practices for integrating risk and performance in CBSs fall into two mentalities: quality control and development. Quality control refers to management efforts in establishing standardised processes and/or product characteristics, against which any changes are measured, tolerated and corrected (Liu, 2015). Quality development takes place where the way of integrating technology and configuring systems is novel, or the application of solutions is too complex to allow measurable common quality standards to apply, as in mass-production processes. Quality development does not necessarily rely on structural models and strategies, but suppliers and customers need to develop processes, conceive relationship strategies and invent tools to tackle unpredicted changes and to agree conformance criteria with each other on how the system is operating and how the performance is measured (Ehlers, 2007; Bunduchi, 2013; Rapaccini & Visintin, 2015; Dey, 2012).

2.3 Towards a blended approach to risk and performance management in CBS

CBS companies work in an environment of complexity, uncertainty and ambiguity. System and knowledge codification processes are intertwined with business and project processes, and this has fundamental implications for CBS companies regarding their decision-making in relation to optimisation and development (Zhang et al., 2011). These two types of decisions often conflict and are based on known and less-known information. Hence, CBS projects exhibit a combination of analytical and interpretive approaches involving quality control and development in quality performance and risk management. The analytical and quality control function adopts a rational, pre-structural approach that leads to optimisation of decisions and actions, and this may be used as an example or as a basis for developing new quality performance in CBS projects. The interpretive quality development function features open-ended, interactive and improvised processes in the performance management of CBS projects. With quality development a wide range of business operations issues is constantly explored due to the ever-changing package of systems and services. Previous studies, however, have failed to generate clear links between these two seemingly different functions, and this study explores this linkage.

From the above theories, we developed a conceptual framework (see figure 1 below) showing that risk and performance management in CBSs could be developed either from the analytical approach, using a quality control strategy, or an interpretive approach, using a quality development strategy. In the literature, although the two approaches have different strategies, both use certain processes, tools and relationships to integrate risk and performance management in CBSs. This study, therefore, used the developed conceptual framework to examine the types of approaches, strategies and processes, relationships and tools and the way they are used in the three case companies to integrate risk and performance management in quality management.

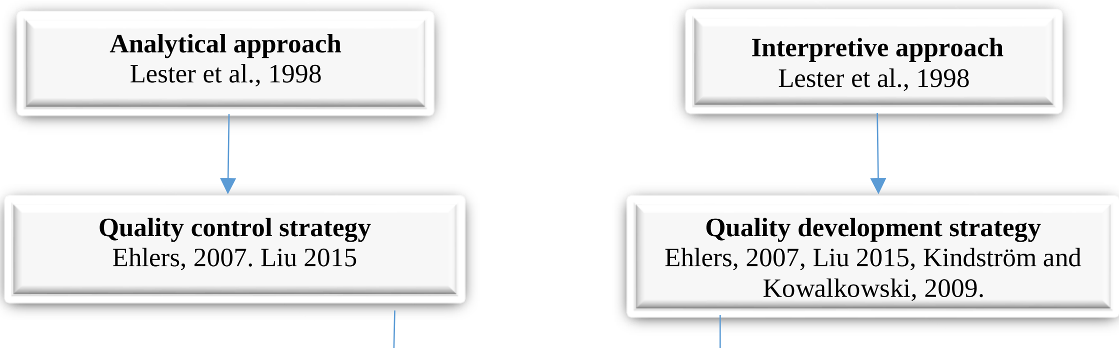

Figure 1 A blended approach and strategy to risk and performance management in CBS

3. Methods

To investigate how CBS companies integrate risk and performance in quality management and performance, we employed a case study approach using semi-structured interviews. Nine out of fifteen companies selected from the British Industry Index participated in a preliminary study. The companies varied in product, organisation and size of project handled, industry and customer. However, they shared one thing in common: they all contracted design-build to tailor their complex system offerings. On-site visits to each firm by the researchers outlined the research purpose and mutual interests, and explored how data were collected. The preliminary fieldwork conducted helped to identify the pattern of project changes, solution development and supply risk management. An agreement was then reached for researchers to intensify probing of the company's risk and performance management in quality systems and the specification management process; a process used by CBS companies for system codification and solution validation. Three companies, SAIC, PPL and ASC, were finally selected for the study, using a purposive sampling (Yin, 1994).

ASC is a global firm providing world-class power and propulsion systems for use on land, at sea and in the air. The firm has a balanced business portfolio with leading positions in civil and defence aerospace, marine and energy markets. It operates in 50 countries with 59,000 employees and a revenue of 14,955 million. This study focusses on ASC UK. It has a reputation for producing high-quality products and complex bespoke solutions, and for continuously seeking ways to extend this reputation as a complete service solutions provider for its customers.

With an annual turnover of around £3 billion, SAIC, a division of a MNC that was established over a hungdred years ago, designs and provides automation products and solutions for several industries. The company employs 6,000 people and has over 600 sales and support locations in more than 80 countries, and a number of training, engineering, service support and manufacturing centres around the UK. It has diversified businesses, mainly in drive systems, medium voltage products, packaged control devices, global technical and business services, and engineered systems and services (ESS).

PPL (Power Plant Ltd), based in the USA, operates in the energy and power market. Their products include energy-related technologies, HRSG (heat recovery steam generator) and varieties of expert and maintenance services, which all contribute to the development of complex energy solutions. It currently employs about 3500 staff around the world. Their main European divisions include ESC (Energy Solution Centre), and MBTC (Manufacturing Base and Technology Centre). They also run several overseas operating offices and companies in China, Vietnam, Taiwan, USA and India with a market share of 30% in the UK and 10% in the rest of the world.

3.1 Data collection

The in-depth exploratory case studies were based primarily on semi-structured interviews with project directors, system managers, project managers, proposal/sales managers, human resource managers, quality auditors, (chief-) engineers, and project coordinators. We also used documentary evidence in the forms of company reports, quality control, development and performance documents, and we observed project/programme meetings. A total of 50 interviews were conducted.

Two projects with typical values of £200,000 for SAIC, and £200 million for PPL and ASC were selected from each company for the case study analysis. This allowed an analysis to take place across projects and at multiple levels: centres, projects and activities. The design and execution of the multi-embedded case study also helped to address the multi-faceted problems encountered in the current servitisation and service innovation research. Droege et al. (2009) acknowledged the challenge in classifying and analysing innovations at the organisational level. They indicated that both typological and taxonomical approaches have their advantages and drawbacks. The pattern of repetition approach was used to predict the activities and processes that were used for system codification and solution validation in the case study companies. For example, change control as a mechanism was being used for case companies to identify, prioritise, mitigate, scale down and tail off risks within and across the project.

Following purposive sampling and initial interviews with the case company liaisons, we used a ‘snowball technique’ to negotiate contacts for subsequent interviews based on the concepts and categories that needed to be saturated. The snowball effect was achieved by establishing contact for the next interviewee through the previous interviewee (Strauss and Corbin, 1998).

3.2 Data analysis

Data collected were transcribed and analysed using the thematic analysis to identify, analyse and report the pattern of themes within the data collected, and to infer the integration of risk and performance in quality management from the analysis (Boyatzis, 1998). We read and re-read the data to familiarise ourselves and to generate an initial list of ideas (labels) about the data. We then generated the initial codes through a line-by-line coding based on the initial themes in the conceptual framework developed from the literature (Braun and Clarke, 2006). Some of the codes regarding specific tools, relationships and processes salient from the three companies (see figure 3) were in-vivo coded from the interview and secondary data (Strauss and Corbin, 1998). Following identification of initial codes, we matched them with all data extracts from the interview scripts explaining the themes coded. This was then collated together within each code through tagging and naming the selections of text within each data item. The line-by-line coding process, content and cross case analysis was then conducted, and sentences were coded onto the themes to explain them. To identify the relationships between the themes we mapped the themes based on the initial conceptual framework (see figure 1) and expanded these through the development of new tables (see figure 3) to identify the different themes into overarching themes and sub-themes to explain relationships between them (Braun and Clarke, 2006). The majority of the overarching themes were developed from the conceptual framework, whilst the sub-themes for tools, processes and relationships were in-vivo-codes from the data analysis. We then reviewed, verified and confirmed the themes by visiting the data many times (Miles and Huberman, 1994) to ensure that they worked in relation to the data set and all themes were coded. The themes were then refined, defined and organised into coherent and internally consistent figures and tables to explain the relationship between risk and performance management in CBS firms. From the data analysis, the original themes from the conceptual framework became prominent. The relationships between the various parts changed and specific aspects were clarified through the in-vivo coding and relationship development. This led to modification of the conceptual framework initiated from the literature review to a theoretical framework (see figure 2), and to identification of specific tools, processes and relationships from the three CBS (see figure 2) companies in the findings section.

4. Findings: A blended approach to risk and performance management in the three CBS companies

In this section, we presented the findings of the study. First, the three participating companies' analytical and interpretive approaches and strategies to integrate risk and performance management in quality management systems. Second, the tools, processes and relationships for the integration, using figure 2 to explore the similarities and differences across the three cases.

4.1 Approaches and strategies used in the three CBS companies

According to ASC, SAIC and PPL participants, CBS project lifecycles vary. Most may look similar but the respective processes involved differ in terms of stages, content, activities and relationships (see figure 2). The data analysis revealed that the three participating companies use a combination of analytical and interpretive management approaches in the integration of risk and performance in quality management systems. For example, due to SAIC's limited outside access to the core development team, it appoints project managers to act as focal points of contact, but these project managers continued to play an interpretive role in communications between system developers and customers. PPL instituted a formal operation/business process with well-defined stages, characteristic of an analytical approach, but one that still encouraged cross-functional and cross-organisational dialogue throughout the solution and project processes. In relation to the two GT projects in ASC, the analytical approach is exemplified in quality controls covering the supply chain, business, and design and manufacturing activities in the process; however, due to the uncertainty of GT projects for quality issues with suppliers, dedicated teams in the manufacturing department are assigned to suppliers to give continuous support and advice and develop quality solutions during the process which is interpretive.

Using the analytical approach, the participating companies develop quality control strategies. The strategies help them to develop optimal solutions with clearly defined risks and performance components. Based on research into customer needs, clear objectives are agreed, goals are set; and resource availability and constraints for the projects are identified. The risks are divided into a series of discrete components and each assigned to a knowledgeable specialist. In contrast, with the interpretive approach, the firms develop core solutions using quality development strategies through interactions between project stakeholders to define and refine solutions throughout the project lifecycle; hence, there are no clearly-stated risks and performance objectives at the beginning or the end. This involves uncertainty and ambiguity, with constant improvisation of risks and performance indicators.

The two approaches and strategies discussed are implemented through tools, processes and relationships, and in the next section, we explored how the CBS participating companies use these to integrate risk and performance in quality management.

4.2 Tools, relationships and processes used in the three companies

The data analysis espoused a rich source of tools, processes and relationships developed and applied in quality control and development in the three companies illustrated in figure 2. We found similarities and differences across the three cases in relation to integrating risk and performance management.

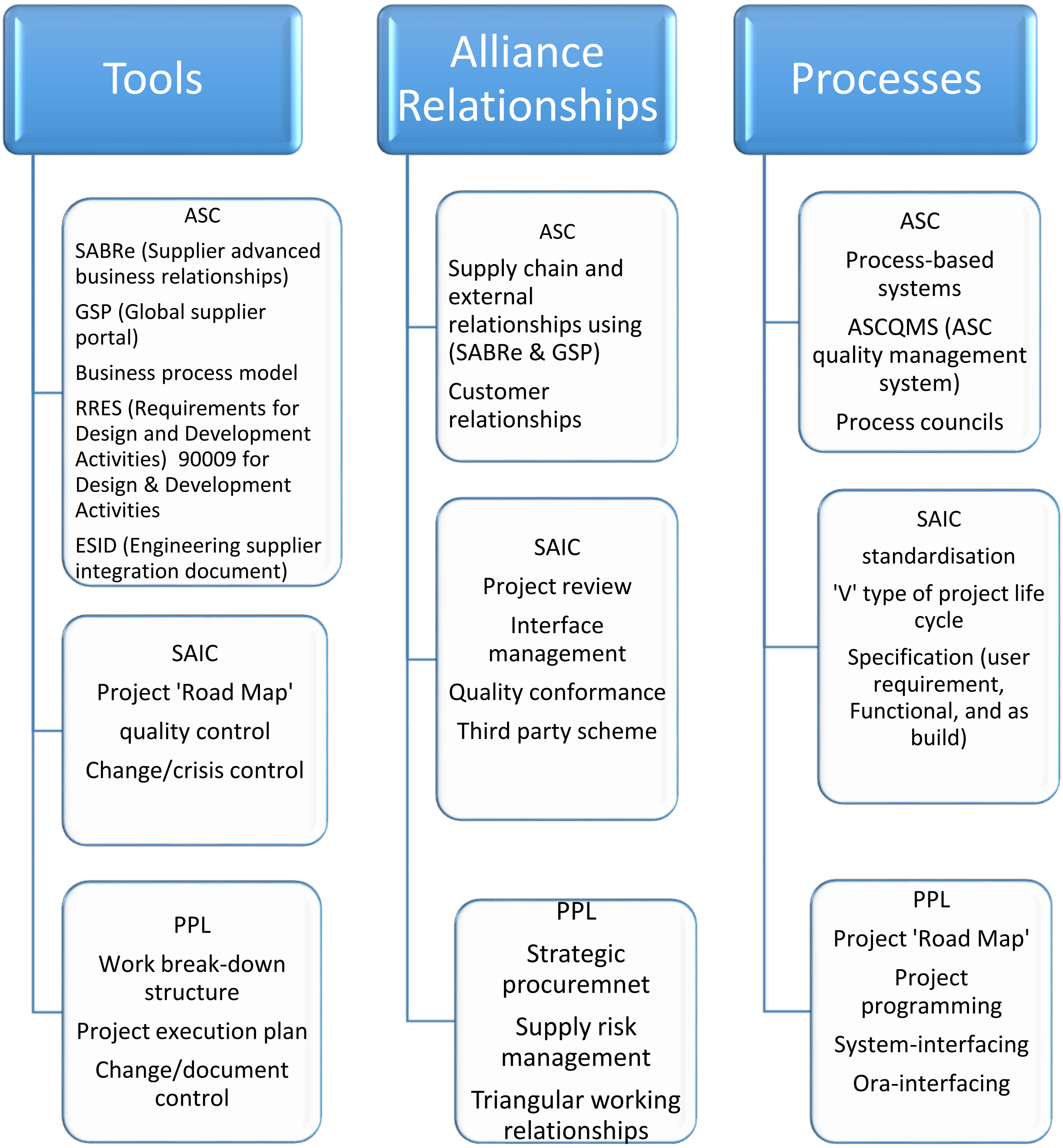

Figure 2 Tools, processes and relationships from three CBS companies

4.2.1 ASC

Integration of risk and quality management is embedded in ASC's tools, processes and alliance relationships. ASC employs the following specific tools: GSP, SABRe RRES, Business model and ESID, and adopts a world-class quality system known as the ASCQMS (ASC Quality

Management System), which comprises a robust set of processes across its operations in the GT projects to integrate both risk and performance management.

> We have, for instance, a very strong risk management process in ASC. I would say rational risk and rational opportunities which I am encouraged to do. What rational risk means is that we would not work on things that are not likely to be useful for the business even in the long-term future *(University Liaison Officer).*

During the GT projects, two types of relationships are developed: supply chain and external relationships, and customer relationships. ASC develops a partnership relationship with suppliers to achieve and exceed quality requirements in the GT CBS projects, which are one-off. Supply chain and external relationships are developed using the SABRe tool. This is the supplier-facing element of ASCQMS, which assists the firm to formally communicate requirements and expectations of the global supply chain, which are made available under the GSP. It is a set of quality standards processes detailing the framework and requirements that are agreed upon by the suppliers and ASC to facilitate the purchasing function for the projects. This delineates the general, product and production requirements, and the production product approval process (PPAP). Key functions to develop and achieve the performance of quality with suppliers involve supplier approval and maintenance, supplier quality development and ME-P (manufacturing engineering purchasing). The quality management system (ISO9001) defines the organisation's approach to ensure that GT products and services satisfy the customer's quality requirements and comply with the applicable standards and regulations of the product and services.

> We strive to be excellent in all that we do; for example, our quality management processes. We try and improve the quality process continuously through any of the latest techniques every year to meet customer quality expectations. (Head of Business Management).

ISO9004 details guidelines for performance improvement during the quality management process. Quality control covers the supply chain, business, and design and manufacturing activities in the process.

Suppliers are approved and maintained through the AVL (approved vendor list) using the STEP (supplier total evaluation process). The STEP involves a number of assessments to measure the capability, quality and performance of suppliers of materials required for GT projects according to the ASME (American Society of Mechanical Engineers) code requirements. For supply development, problems with supplier delivery performance are integrated into the supply chain through analysis of the root cause in the supply chain process by black- or green-belted accredited members. Based on the analysis, risks and performance improvement actions are identified and improvements made during the process, which is iterative.

> In terms of the formal part of process improvement, what we have is a series of process councils. So to reach the major processes in the firm, there is a process council, which has responsibility for owning and improving that particular process (Director of Operations and Technology).

However, due to the uncertainty of CBS projects, for quality issues with suppliers a series of activities are concurrently carried out through testing, process observations, and reviews. To ensure capability and performance of suppliers, dedicated manufacturing teams are assigned to suppliers to give continuous support and advice, and to develop quality solutions during the process.

The business process model tool provides a set of processes that facilitate the development of customer relationships and solutions. The customer relationship is developed initially through a customer's request for information or proposal for the GT project. The request begins with the specification process through a system's response to the customer request and the research team's assessment of the customer's needs. The requirement for design and development involves interactions with the customer's specifications and the market. This forms the basis for the development of design solutions throughout the lifecycle of the project.

> We depend on customers. Without them, we would not have a business. Creating customer solutions is effectively a large cycle management for projects and services. So it goes from when you have an idea of what you are trying to do all the way up to when you need to dispose of it… So it has been successful for us, making sure that we know how to develop engines for instance, which are very complex items (Vice-President Corporate Venturing).

RRES 90009 serves as the quality assurance system during the design phase of the GT project for demonstrating how risk and performance management are integrated. It specifies the set of requirements for the management of the ASC Design and, thus, serves as an interface between the supplier's Design & Development and the ASC Design & Development business. This tool demonstrates the level of equivalence between the supplier's design assurance system (documented processes and procedures) and ASC's design and development requirements during the GT projects. Where the design assurance systems are not equivalent, the ESID, which is an interpretive development tool that demonstrates equivalence between the supplier's design, assists to develop and define mitigating actions during the process of the GT project to manage the risks to achieve performance. Due to the lack of certainty in the design variables of the projects, the specification requirements continuously changed throughout the process, and were communicated to the different design teams. During the design process, the uncertainty of customer requirements flows into other sub-systems' requirements; hence, the system solution leads to changes that generate risks in the process. The variables in a GT project, for example, changed about every 4-8 weeks for between a 12-24 month period, after which it stabilised. The continuous quality improvement system incorporates measurements, analysis and improvement controls to ensure risks and performance management integration to achieve customer satisfaction.

SAIC

SAIC uses an official 'road-map' to generate collective cognition of the kind of new issues and risks that may occur and the way suppliers and customers interact. The road-map indicates that CBS projects start with open specifications (i.e., URS – User Requirement Specifications and FDS – Functional Design Specifications), and end with closed specifications (US&S – Updata Specifications and Standards). Between these are the hardware and software development, system testing, installation and other staged activities. The road-map thus serves as a fulcrum that brings together, internally, ESS solution processes; and externally, the customer's own project processes, in order to engender inter-firm multidisciplinary manufacturing/engineering.

Both suppliers and customers experienced unexpected changes in the projects observed. To amplify the positive side of changes and to reduce or devolve their negative side, ESS has developed at least three management tools for change/crisis control. These are critical point analysis (e.g., design freeze), specification flow (e.g., feedback and feed-forward loops) and decision-making hierarchy. Conventional project management tools such as CPA (Critical Path Analysis) and WBS (Work Breakdown Structure) are frequently used. However, as specifications develop or when unexpected changes occur, the originally designated project path and operations activities alter and, therefore, the WBS and CPA change accordingly.

The project core team and other stakeholders meet regularly to review the project or when unexpected issues emerge. A project review report is developed, which covers areas such as information on commercial issues, assembly, parts outstanding, drawing, coding, purchasing, project scheduling, resourcing, quality status, risks and impacts. During the integration process, risk review and quality conformance are closely related to the use of a third party programme, which integrates a variety of inputs from suppliers of sub-systems, such as safety system parts and communication packages. The programme is temporary and contract-based, thus free from problems regarding mutual and in-depth understanding. As one ESS manager reflected:

> If you are using a third party, you have again got to be careful in specifying what you need and make sure that they understand their scope and where their scope limitations are to make sure that they don't do things that you don't want them to do and stop them charging you before it happens. (Project Manager C)

To help find new markets and reduce unanticipated risks, the ESS supplements its internal skills with relevant expertise, experience, skills and knowledge through the third party programme.

Another example is replacing an interface design (as part of HDS) that subsequently causes a change to FDS, the upstream design, and SDS, a parallel design to HDS. The re-writing of a safety manual (as part of SDS) leads to the design freeze being invalidated, which can have a severe impact on project timescales because the project critical path has to change. In both cases, the overall risk assessment is rated high, and the ESS negotiates with customers on related impacts, such as who should bear the extra cost. In most situations, the quality of the solutions is negotiated and agreed between ESS, customers and other suppliers due to the many non-standard integrated architectures and interfaces; thus, the quality (performance, structure and spare parts) needs to be defined and accepted in regard to the bespoke situation.

The B-C project, for example, illustrates an analytical approach. The customer's need for 'complete automation' and 'Asset Management Solutions' for manufacturing personal care products was thoroughly clarified and discussed in detail at the kick-off meeting. Strict goals were set before key elements of design and key project activities were determined. This consisted of packaged hardware together with embedded software, engineering and project services, and documentation. These design elements and project problems were then assigned to experts (e.g., in PLC coding, loading and configuring servers, configuring simulation, panel safety checks and interconnections, procurement, manufacturing, and panel installation) and a solution was ultimately obtained by integrating all these components into some optimal combination. However, many applications need specific and interpretive approaches. In a project delivered to a pharmaceutical company, SAIC team members were asked to follow the client's detailed instructions for developing the systems (i.e., the 'V' type of project life cycle). Adopting process and product standards with which SAIC is unfamiliar is viewed as a crisis. As quality conformance becomes central to the completion of projects, project managers work on specification processes in identifying and negotiating a 'win-win' solution to overcome potential quality problems.

> The customer doesn't want risk. He may influence your decision on the choice of platform to reduce his risk. We might be trying to sell him a certain type of system. But he doesn't want it because he has another system, which is different. The risk to him is that he knows less about your proposed system than the system he already has. And you can't necessarily support internally that piece of equipment. (Engineering Team Leader, SAIC)

The user requirement specification (URS) emerges from customer's enquiries, invitations to bid and ESS proposals. Most customers served by SAIC are not technology experts in the area of industrial automation. They need to interact with SAIC in order to know what they can be offered so they can develop their requirements. The next relationship-building process is the Functional Design Specification (FDS). ESS led the development of the FDS, which is their interpretation of how the URS can be realised to the satisfaction of the client. The FDS specifies ESS methodologies, technologies and resources. If the customer or other project stakeholders have queries and suggestions, they will have the chance to intervene before the client formally approves it. So the development of the FDS involves technology specialists and application specialists both inside and outside the organisation. FDS provides foundations for project implementation plans and system interfacing solutions. Other working relationships are built in the process of system-testing specification, hardware design, software design, updating and many other co-working activities.

PPL

PPL strategically uses management tools to facilitate system codification and solution validation. The CBS processes in PPL are designed and redesigned at multiple levels and guided by the PEP (Project Execution Plan). The PEP is a master document that guides project planning, implementation and control. It defines and redefines complex projects as they progress. It describes many specific project strategies, which include organisation, finances, procurement policies, internal and external interfaces, risk management, planning and programming. It is more bespoke and covers the actual project expertise and experience required. Since the key priorities of solutions differ at different stages the PEP is updated frequently and reissued to the project core team to keep them up to date.

At PPL there are three main changes: external, internal and system specifications and/or sub-system changes. Change control means that all changes requested or identified are examined, approved and validated for the project or, alternatively, sent to the 'Orange Book' as good ideas for future solutions or to inform other projects. PPL has also developed the practice of 'Orange Book' for CBS projects as opposed to the conventional 'Blue Book' (the baselines, which initially articulate the systems and the projects). This practice aims to record what individuals have learnt on proposals, contracts or projects. Thus, they are encouraged to document their experiences and suggestions on how to improve internal and external solution processes and current estimating procedures, and make their business competitive and sustainable in the Project Orange Book. These and other 'best practices' enable CBS to be developed and implemented effectively and efficiently.

Like SAIC, PPL developed a ‘solution road-map’, which indicates how the roles of risk and performance management merge in complex projects. PPL employees identified about 100 key operation activities in the ‘total energy solution’: marketing, capture strategy, bid/no bid decision-making, key vendor selection, tender, review of the contract, project launching, process design, design freezing, project financing, shipping, commissions and operations support. From these, they extracted key process drivers that depict the relationship between different areas of business and management focus.

The analysis shows that the number and order of activities constantly change from project to project, and overlap, merge and iterate in a way that fits bespoke project stakeholders. The gap between the road map and actual activities means that project members need to improvise around the bespoke solution. For example, the main concern for capture and execution (C&E) staff is whether the order is both competitive and realistic. For the strategic procurement and technology team, the main concerns are the discrete decisions necessary for balancing flexibility and productivity, and the long- and short-term core capabilities. All these create tensions (i.e., a triangular relationship) between proposal owners, project teams and resource management.

Another complicated integration process observed in the projects is project programming, which took place at (observably) five levels. This multi-level project programming facilitates organisational interfacing, which is intertwined with system interfacing. In India, Mainland China, Taiwan and the UK, each of these multi-level projects represented cost-profit centres and had its own interests, motivations, priorities and business cultures. In co-ordinating planning activities, the ESC has to identify risks related to multi-level project slippage; however, some targets or responsibilities are intrinsically intertwined and difficult to break up into micro processes and discrete activities. The ESC fulfils the cross-firm planning and coordination mainly through middle-level programming, using WBS and CPA tools dynamically and iteratively; thus, close working relationships are crucial. For example, in the SD project to develop boiler systems within which many components and materials and, particularly, spare parts, were supplied by the Chinese client, agreements had to be constantly achieved on how to bridge differences between Chinese and British industrial standards.

Another example of quality conformance is the role of the system integrator, which varies in PPL. With the TC project, whether it involved a small variation to the process, the materials used, or a vital precursor that engendered new activities and unforeseeable impacts on other processes, the owner and representative accepted responsibility for coordinating activities for system and organisational interfacing. With the SD project, the client exercised limited authority on system integration, so PPL coordinated the majority of these related activities. This required constant identification, clarification and coordination of system interface (technology viewpoint) and related organisational interface activities between PPL (mainly via ESC) and the other two consortia members (i.e., a turbine maker and a generator maker). The quality of interfacing activities and results, however, depends on the appropriate incorporation of their respective capabilities, assets and objectives. These 'match-making' activities are time-consuming but often result in generation and codification of new project knowledge and proactive problem solving. PPL interprets this as, 'changes are … innovations that are not assumed in the initial plan'.

> Most difficulties we have had within project execution is not at the high level steps, but it's with the very detailed 'nitty-gritty' interfaces that come later [that have to be accommodated]. I think it's useful to have the general overview [formal BOP and Level 1]. But I'm not sure how to enable you to stand back and say: 'well, where are we now on the process?' [since] most of the detailed problems occur at the detailed interfaces on these lower steps (ERP Manager, PPL).

Many trade-off decisions in procurement are made to address the balance between cost-effectiveness and supply risk. For example, due to the nature of supplies for SD and TC projects, PPL adopts different quality development strategies. For bulk materials and mass-produced commodities that are product-based, PPL strictly follows conventional quality control procedures and an arms-length strategy, and views quality as a series of precise and measurable variables. For the supply of significant engineered products, such as control valves, pumps and fabricated components, PPL adopts manufacturing-based quality support systems. PPL regularly monitors suppliers to ensure that ISO 9001/ISO 14000 are fully observed in production and inspection processes. For specialist items, such as fans and mills, the important aspect is the sharing of understanding and interpretation of quality expectations of end users, and the way these are met in the design and delivery of the system.

5. Discussion

This study identified two broad types of cognitive frameworks: the analytical and interpretive management approaches essential for integrating risk and performance in quality management systems for developing CBS solutions (Lester, et al., 2002). The findings show that the CBS companies use a combination of the two approaches, hence specific business or project activities do not necessarily fall perfectly into either one or the other. The cognitive frameworks underpin the strategies of quality control and quality development that are used in the case study companies. This 'holistic system' is summarised in figure 3 below and explained here.

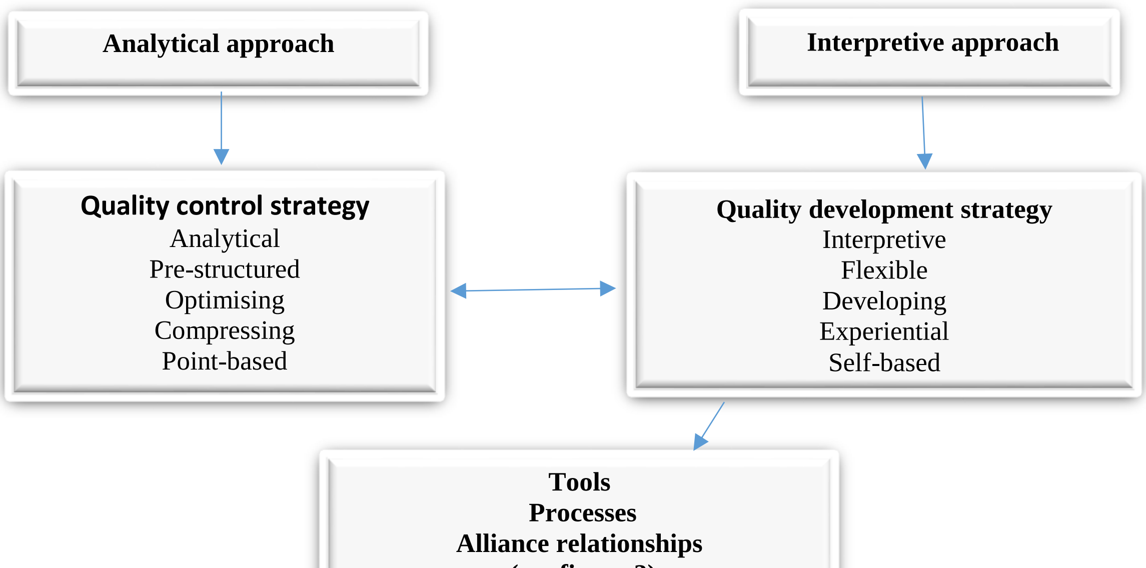

Figure 3 A blended approach to risk and performance management in three CBS companies

The findings show that under the analytical approach, risk can be translated into a clearly defined problem for which an optimal solution can be designed (Ekvall, 2002). The analytical manager defines a clear objective, usually based on research into customer needs, and then identifies the resources available to meet the goal, as well as constraints on those resources. The manager then divides the risk into a series of discrete components and assigns each one to a knowledgeable specialist (Simon et al., 1986). This is exemplified in the finding of the B-C project within SAIC and TC project at PPL. The analytical perspective tends to prevail in contract manufacturing when customers' requirements are highly specified. With large-scale projects, such as the TC project, for example, the client, represented by a technical consulting company, came up with very detailed contractual specifications in terms of the boiler's measurable performance, system structure, component supplies and spare parts. The flow of the system development process and its end point were thus clearly defined in PPL's project documents, such as the PEP (Project Execution Plan). Management tools, such as Project Road Mapping, Project Programming, CPA and WBS, were used mainly in an analytical manner.

However, not all the activity that takes place in complex solution and system development can be accommodated within such a strictly structured analytical framework (Lester et al., 2002).

Frequently, in complex project manufacturing, customers do not always know exactly what they want or need. Instead, needs emerge from a series of interactions, or conversations, during which customers and suppliers together discover something about the customer's situation and how the new solution might fit into it (Gebauer et al., 2005; Kindström and Kowalkowski, 2009; Zhang et al., 2011). Not everything in complex projects is fixed at the outset. Unexpected changes often render a supposedly 'perfect' project plan useless (Oliva and Kallenberg, 2003). All projects surveyed within ASC, SAIC and PPL recorded changes and rework of either small or major dimensions. Solution-based businesses evolve in such unforeseeable ways and with such unforeseeable consequences that the development effort is better understood as an open-ended process (Liker et al., 2002; Schroll and Mild, 2011) rather than as a project in which a specific problem is internally solved. Interpretive managers, unlike analytical managers, embrace ambiguity and improvisation as essential to CBS solutions. They look for new ways to promote conversations about the future. As uncertainty increases with CBS, the emphasis on interpretation also grows for companies and managers to reveal new possibilities as well as new constraints. When project changes become stable and predictable, structured analytical behaviours are achievable with fruitful outcomes, such as acceptable profit and measurable customer satisfaction.

The experiences from ASC, SAIC and PPL project practices indicate that it is extremely helpful to incorporate a view that combines both approaches in the process of risk management and project performance. 'Incorporating' both analytical and interpretive frameworks into a complex solution development process increases the need for 'program management' to coordinate and harmonise the processes of project delivery and solution development.

Both approaches are valid, but each serves different purposes and calls for different organisational strategies and managerial skills (Lester, et al., 2002). The findings show that the quality control and development strategies are implemented using tools, relationships and processes. The findings indicate that several tools (see figure 3) are developed to facilitate the identification of criticalities and the mitigation of risks to justify individual processes in CBS solutions (Ehlers, 2007; Bunduchi, 2013; Rapaccini & Visintin, 2015 Dey, 2012). The functioning and development of these tools, however, depends very much on the dynamic development of the client requirements, the nature of the emerging changes and how quality and risk issues are dealt with (see Figure 3). This requires the function of specification management to facilitate and intervene to increase the chances of 'positive-sum' gains.

Specification management as a framework (SMF) deals with two interrelated aspects: system development and client requirement specification, and both are open to changes. The SMF (see Figure 4) is used by participating companies to codify on-going development of systems (software, hardware, groupware, etc.) and validate integrated solutions to clients (i.e., the application environment and its supply network). This is because with complex projects, many components and materials are non-standardised and the ways of integrating systems are far from fail-safe. Very often a project lifecycle incorporates sub-processes developed from different departments and different organisations (see Figure 4). Conflicts of norms, beliefs, objectives and gaps in co-operation impede the smooth development of solutions. To enable effective on-going interactions, the three CBS companies adopt and develop processes dependent on the type and scale of solution required. These processes (see Figures 3 and 4) provide opportunities and motivations that link the different departments' operations. Such multi-linkages, i.e., project combination of tools, processes and relationships, function to ensure risks and quality performance are well-analysed and interpreted in accordance with the customer's quality requirements and the standards of the CBS. SMF enables project iterations and interactions since many specifications (e.g., interface design) are often generated on site. CBS stakeholders are included in regular discussions and negotiations to ensure they understand the solution-based system and associated risks. The SMF therefore serves as a quality conformance device for project people to monitor activities, reach agreement and validate the next stage of CBS development. Such quality conformance activities nurture cross-function and cross-project culture (Salimian et al., 2017), which encourages productive working relationships, both internally and externally, and the transfer of tacit knowledge (Goffin and Koners, 2011).

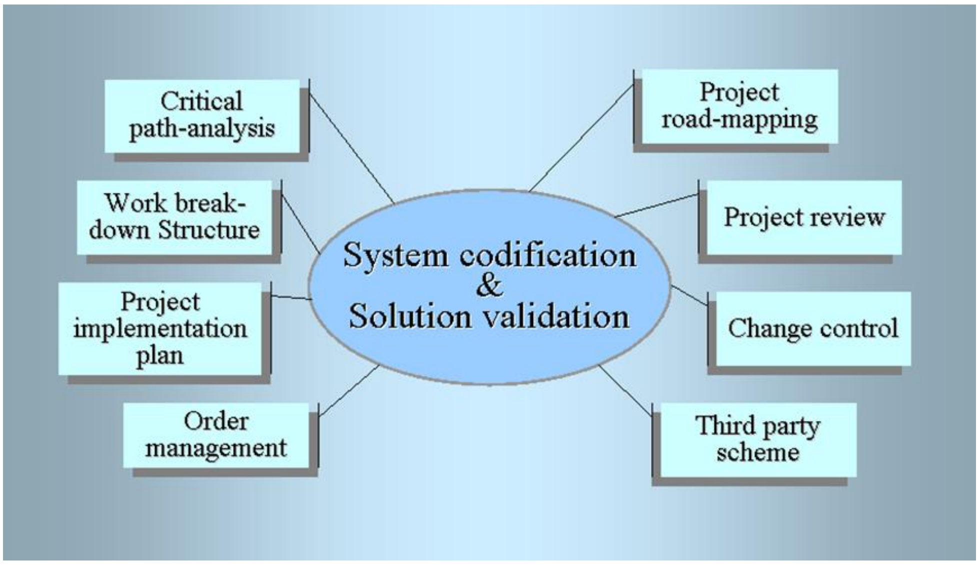

Figure 4 Specifications management framework

CBS projects and their supply networks are inherently risky due to the high degree of uncertainty, variance and trust (Chen et al., 2016). The findings indicate that SMF plays a key role in integrating systems and services, and mitigating solution-embedded risks, whether anticipated or hidden, quantified, semi-quantified or unquantified. SMF also serves as a key mediating device for project management to identify and take actions on unplanned changes that are perceived to be critical in the quality development and performance of solutions. The findings also show that the way practices of managing project changes and development of system specifications become 'institutionalised' or 'best practices' depends very much on companies' industrial and historical legacies, and how, from such foundations, project-related actors, with their capabilities and intentions, reinforce the patterns (i.e., relationships, tools and processes) through concrete actions (den Hertog et al., 2010; Zhang et al., 2011).

Several factors of the specification management framework influence the initial trajectory of organisational learning and knowledge codification. Among these factors are the customer's quality expectations of performance, the solution space (e.g., quality function deployment) and validation strategies (i.e., quality control and quality development). From the findings, the quality management of complex projects may be centralised in a powerful quality assurance department, or it may be in the hands of design and engineering staff, or in the hands of project coordinating managers. The findings show that, in CBS, quality conformance plays the role of system integrator (Henderson and Clark, 1990; Iansiti, 1998; Miller and Sawyers, 1968; Gardiner, 1986), where the owner and the representative take responsibility for coordinating activities for system and organisational interfacing. From the findings, a broad set of coordinating mechanisms was created between project stakeholders, among core teams, and within infrastructures in the case companies. These mechanisms included planning and control systems, contractual and commercial debates and negotiations, project reviews, and specification processes. The mechanisms were utilised to shape the project organisation, project behaviours and project outcomes. The foundation and consolidation of solution-based centres (i.e., Engineered Systems and Services in SAIC, Energy Solution Centre in PPL, ASC Business process model) engender system codification and solution validation. The centres act to enable these recurrent mechanisms to function and to ensure effective exchange of transaction, experience, knowledge, goods and services.

The findings demonstrate that a single project has a definite start and finishing point, but that CBS or solution-driven business has a vision of the 'end stage' only and, relatively speaking, no clearly-defined path to reach it. Projects as small as in SAIC (i.e., a project of less than

£10,000) and as big as in ASC and PPL (project of more than £200 million), are very often interdependent in terms of service expertise and engineering resource sharing, procurement and outsourcing choice structures. The temporary nature at this stage of solution development indicates that it is unlikely to see the whole picture during the project lifecycle or business proposal development, or to take advantage of its full potential. It is the integration of risk and performance in program management that provides a platform, together with all these quality management approaches, for transforming business resources and project processes into realisable and sustainable solution-led capabilities.

6. Conclusions and implications

The purpose of this study was to examine how risk and performance management are integrated in quality systems for successful development of CBS projects. Although extant literature demonstrates that there is an overlap between performance and risk management (Keil, 2013; Palermo, 2014, there is limited empirical evidence showing the relationship between the two in CBS companies (Liu, 2015; Keil et al., 2013; Kumar et al., 2016; Mackerron et al., 2015).

Our paper therefore bridges this gap in the academic literature by exploring how the relationship between risk and performance management is developed and implemented in quality management systems in CBS companies. Using data from three CBS companies, we provide evidence and insights of how they have integrated change (and risk) control, quality development and quality performance in innovating business solutions. Clearly, from the literature, there is a lack of framework from both academic and practitioner-based literature to facilitate our understanding of the integration of risk and performance management in quality management systems, specifically in CBS companies. This paper brings together literature from both practitioner and academic sources to develop a conceptual framework focusing on the approaches, strategies and tools, relationships and processes for understanding how risk and performance management are integrated in CBS companies.

Based on the conceptual framework, this study has developed a comprehensive empirical framework that effectively integrates risks and performance management in CBS. The novelty of the findings in our study is the analytical framework, which suggests specific approaches and strategies for integrating risks and performance in CBS. Our findings suggest that to integrate risk and performance, CBS companies should employ a blend of analytical and interpretive cognitive approaches, using quality control and development strategies. Although the two cognitive approaches were identified in extant literature (Lester et al., 2002), they have not been associated with the integration of risk and performance in CBS. The analytical approach and quality control strategy identified assist the CBS companies to clearly define the goal and the type of risks for a particular solution development. Risk can also be divided into a series of discrete components, and a knowledgeable specialist assigned to each. This enables the CBS companies to research into customer needs and identify critical resources to meet the defined goals. We also identified that the analytical approach is often used as a basis upon which to develop the interpretive approach, which underlines quality development strategy. Due to the uncertainty in delivering CBS solutions, which are initially developed with ambiguity, and the evolving system and ever-changing interfaces, analytical approaches are used as guides to develop interpretive approaches.

The paper also contributes through identification of specific rich evidence of the way CBS companies employed an armament of tools, alliance relationships and processes for dealing with quality development characterised by changes and risks that unavoidably emerge during the project lifecycle and performance. The findings illustrate how project-specific tools, alliance relationships and specification processes interact seamlessly, or sometimes seemingly conflicting, contributing to the effective management of risks and performance. The alignment of company-specific quality management tools and methods supports a well-defined specification process that serves as a key intermediate process or device for suppliers, clients and other project stakeholders to identify and to take actions on unplanned changes. The in-depth case studies provided several examples of how project actors interacted to identify and bridge quality gaps in the practice of quality conformance. Quality development deals with the on-going development of the clients' requirements and the identification of risks involved in the project. It clarifies customer needs, not as a one-off event, but as a lifelong cycle endeavour throughout the process. One important finding is that, due to emerging issues and risks in the process of generating solutions, quality conformance between project actors needs to be under constant discussion and negotiation. Hence, the alliance relationship serves as a component to co-ordinate all these aspects of development. When customers need to reflect on the development of solutions to clarify and evaluate their previous requirements, their deep engagement in the process of developing quality and conformance certainly increases customer satisfaction, project success rate and the chances of developing new businesses. Specification development serves as a primary arena in generating new ideas, finding constraints and opportunities, validating new designs, new ways of integrating technologies and/or configuring systems, co-ordinating schedules and, most importantly, achieving project milestones.

Our findings have implications for both practitioners and researchers. The paper suggests a well-developed framework of integration of risk and quality performance for quality management systems. In complex projects, as the case studies depict, it is unavoidable that managers have to deal with many types of risks due to changes and errors during the process of development. This is due to the difficulty of pre-specifying the risks and outcomes of complex interactions involved in the solution process. Customers' evolutionary requirements, unlimited open solution spaces and engineers' tendency to keep refining and changing designs all contribute to the conceptualisation and shape of complex solutions. Thus, researchers can use the framework developed and the findings for further research, while it can be used by practitioners for quality development in the strategic choice for solution-driven projects.

The proposed findings can be applied to similar CBS projects in different industries to explore the interrelationships and dynamics in the integration of risk and quality performance to improve its effectiveness in CBS projects. The findings also have implications for practitioners. Since the study bridges the gap between theory and practice, managers who want to integrate risk and quality performance effectively, could use this framework to develop analytical and interpretive development as a strategic choice for solution-driven projects. Further, managers could employ the framework and findings to develop effective strategies, processes and alliance relationships, to enhance communication and interactions, to mitigate risk and improve quality management in CBS.

Using a qualitative research method approach, the ensuing findings will assist project managers, general management practitioners and policy makers to understand how risks and performance are integrated, and the dynamics, strategies, approaches and tools that could be developed to enhance performance. The novel findings and framework serves as a springboard for developing context specific strategies. These findings are also very useful for highly-complex solution engineering and general management firms that lack such a framework.

6.1 Limitation and future research

This study has advanced a theory on the way risk and performance are developed in CBS firms. This is a novel finding that has created interesting avenues for future research. As we have explored the integration of risks and performance in CBS manufacturing firms, a more thorough examination of the impact of the findings in general management would be valuable. The framework developed from this study would be viable for further exploration of the interface of risk and performance management in general management. We suggest that general management literature would be informative and shed light on the different approaches, strategies and tools for risk and performance development. Such a study should examine how risk and performance are integrated as a single system in different contexts, and the processes adopted in general management to reduce risk. It should also explore the similarities and differences between the integration of risk and performance in CBS and the general management perspective. Further, it would be interesting for future researchers to generate more data to understand how quality conformance, which is common practice in CBS projects, accommodates these two quality sub-processes. Comparative case studies would also be useful for developing different types of quality and conformance systems. Further, a large-scale survey could be used to find determinants and moderators in quality control and development and to identify how these affect project outcomes.

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