Information Technology and Performance Management for Build-To-Order Supply Chains

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Extended Abstract

Purpose of this paper	This paper is addressing the growth and importance of Build-To-Order (BTO) supply chains, which allow consumers and supply chain participants to select, configure, purchase and view order delivery status. The paper supports BTO as a source of critical competitive advantage to many organizations.
Design/methodology/approach	This paper uses an interpretivist case study research strategy that exploits multiple research methods.
Findings	This paper presents an overview of Supply Chain Management (including BTO-centric approaches) and Performance Management and then focuses on a case study in which an aerospace components company was attempting to become a BTO enterprise. Thenceforth, the authors analyse key business drivers of using Performance Management Systems (PeMS), and how supply chain-oriented organizations can best leverage IT and PeMS solutions in this regard.
Research limitations/implications (if applicable)	This paper is not seeking to produce generalisable conclusions due to the research strategy adopted. In expanding the research presented, a large scale survey could be used to see how generic the resulted reported are in a bigger context.
Practical implications (if applicable)	Initial expectations by the case study company were unrealistic in terms of outcomes and costs; Cost estimate and project review prior to commencing development and implementation should have been undertaken more rigorously; Better appreciation of the challenges faced in terms of existing IT/IS arrangements, resources and infrastructure; Recognition that unless a more open and collaborative approach (both internally and externally) is adopted, such an initiative will fail to deliver desired outcomes; Trial and error approach to development that was (implicitly) adopted is not a cost-effective way to proceed (i.e. foresight is better than hindsight).
What is original/value of paper	This paper offers a novel insight into BTO supply chains.

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Introduction

As noted by Lummus and Vokurka (1999) and Childerhouse and Towill (2000), much of the benefit attributed towards adopting Supply Chain Management (SCM) systems, center around the ability of information systems to speed up decision-making; increase visibility of value chain enablers; manage customer expectations better; reduce process cost; and increase the level of control available to management. The co-ordination of stakeholders in such a supply chain, is a vital and necessary step to implementing the sales-to-delivery cycle and to realising organisational and business benefits. Several definitions of SCM have been offered in the normative literature primarily focusing on a loose collection of these features. A common definition emerges of SCM as a network of trading partners that contract with manufacturers, logistics companies, and distribution organizations (Gattorna, 1998; Lummus and Vokurka, 1999; Trent and Monczka, 1998). This is more typically referred to as the "plan-source-make-deliver-return" cycle, as part of the industry-standard supply chain SCOR reference model (Huan *et al.,* 2004; Supply Chain Council, 2005). The holistic view of a supply chain encompasses the entire community of participants, in the business network by describing management processes, chain interrelationships, performance metrics, management practices and alignment to supply chain functionalities. No matter the type of chain, the purpose of supply chain management is to focus on meeting customer demand while minimizing inventory of both raw materials and finished goods (be it across multiple products, or geographical boundaries). Cooke (1999) highlights that logistics is the most neglected element of many supply chains and considers accurate order fulfillment a difficult task to achieve as noted by Perry and Sohal (2001).

Thus, it is becoming increasingly important to be able to integrate demand, or consumer-led, information with scheduling, production and logistics knowledge (Childerhouse and Towill, 2000; Goldman *et al.*, 1995). Over recent years and with the advent of improvements in Information Technology (IT) and Information Systems (IS), customers and consumers of manufactured goods are able to be involved in the so-called "design-to-order" process. That is, through the extension product-related information in the form of product and component catalogues via on-line internet-based product configurators, consumers can now effectively organize and specify product requirements, such as in the case of Dell Computer (Dell, 2000) and BMW (Economist Intelligence Unit, 2001). Such transparency, however, requires that the production organization must be amenable and flexible to providing supply chain information; and also be lean and agile enough, in order to satisfy such visible and potentially increased demands on it. These demand-led or "Build-To-Order" (BTO) supply chains, consist of five key components (Anderson, 2004). Product Data Management and Configuration allows the customer with the ability to not only view a catalogue of products that the enterprise manufactures, but also allow the fulfillment process to include information about how a chosen product or service can be customized via product configuration data (i.e. peripherals, add-ons, accessories, and associated third-party products that complement the "base" goods to be purchased). A Spontaneous build process which provides the capability to take any fulfillment request and process it as soon as possible using sufficient raw materials and stock to supply and / or make the artifact via an efficient resupply mechanism that will sustain the overall process (enabled via IT/IS). Strategic control of Inventory should be optimised in order to hold sufficient levels of stock to cover forecast demand, for standard as well as custom orders (Rivard-Royer *et al.*, 2002). Kanban resupply (Imai, 1986), should be an automatic, uninterrupted process, that occurs once a given inventory volume level (or equivalent rule) is

breached. Finally, in-house part fabrication is a core component of a BTO organization where facilities to manufacture, assemble or purchase core product are on-site, based upon a given customer request, using materials available from inventory (typically associated with enterprises that are primarily engaged in spontaneous and mass customization-focused BTO operations, Irani *et al.,* 1997). Ultimately, with many companies involved in co-ordinating and responding to supply chain events, visibility becomes critical to such an extended enterprise's success (Cooper *et al*., 1995; Ellram, 1991) and needs to be linked to a firm's supply chain metrics (Dutta, 2004). Hence, this paper seeks to discuss this situation in this context, via an analysis of a UK case study organisation's experience with implementing a performance management system within their Build to Order supply chain. The authors present a framework, which addresses how such an organisation can best leverage IT and performance management systems in order to enhance and optimise their fulfillment cycle processes. Hence, the proceeding sections detail the research methodology and case study detail of a BTO performance management initiative, where these factors will be used as a lens to develop greater understanding of the key issues involved in this area.

Research Methodology

The cornerstone of the research work is a case study that focuses on two UK Supply Chain 'partners' as they work towards the development and adoption of a BTO approach. The paper will describe the process and highlight that the companies failed in their efforts to implement a BTO approach. In this context, the study examines a number of important factors that underpin the key outcomes. These factors include organization/organizational behavior, communication and inter-organizational openness, existing vs required IT systems, resources, evaluation methodologies and resources, budget considerations and approach to project management.

In order to investigate and describe the associated core issues the methodological approach developed needed to be one that could collect and accommodate *rich* contextual data surrounding the interaction of performance management within an organizational supply chain. The underlying objective of the research was one of exploration that will lead to the development of a framework for information technology and performance management systems for improving BTO products within a supply chain environment. A case study-based research strategy was chosen that used a qualitative research agenda to elicit data; together with other less formal methods such as minutes from meetings and informal discussions with employees. This in turn, later lead to the formation of an appropriate and relevant post-hoc evaluation model to assess the effect of the case study's approach taken in the context of identifying key factors that impinge upon IS integration efforts. The extrapolated data were then classified and coded, which lead to the authors crafting a talk-through story that ultimately lead to a number of lessons learnt. The research design is shown in Figure 1.

Insert Figure 1 here

Research approach

To acquire an understanding of the significance of human and organizational issues involved with supply chain interfaces, the development of a research methodology that involves and enfranchises organizations and their staff is needed. Considering the originality and contextual surroundings of this research, a case study research strategy was followed as advocated by interpretivist researchers such as Yin, (1994) and enacted previously by the authors (Irani and Love, 2001; Irani *et al.*, 2001; Sharif *et al.*, 2005). The case used for the research was not systematically sampled, and as a result, it is not possible to generalize the findings to a wider population. However, the findings are considered appropriate to provide others with a frame of reference when seeking to develop an understanding around information technology and performance management systems for improving build to order products within a supply chain environment.

Data collection and analysis

The data collection procedure has followed the major prescriptions of the normative literature for doing fieldwork research (e.g. Fiedler, 1978; Yin, 1994). As such, this involved a combination of primary source data, in the form of semi-structured interviews, observations and discussions with key individuals including the CEO's of the two companies involved in the case study.; and secondary source data in the form of internal and budget reports, business strategy documents newsletters and other publications that form part of the case study organization's history, along with relevant archived documentation that were later transcribed. An interview protocol based upon reflective feedback and informal long interview technique (as described by Yin, 1994) was utilised in this respect. The case data was subsequently analysed in an interpretive sense, i.e. via exploratory and descriptive means using the lens of the four key BTO Supply chain KPIs defined earlier. A framework for understanding performance management within BTO supply chains was then formulated from this information, as a result of which the authors extrapolated lessons which could be learnt from the case.

A research lens on Build-to-Order Supply Chains: a Performance Management imperative

A key aspect of BTO supply chains is the ability to respond to requests for manufactured products on demand (thereby negating the ability to forecast in advance – Anderson, 2004). Any SCM system must therefore be able to account for such changes in response and re-supply rates – both from downstream suppliers, as well as customers in the supply chain, via IT/IS. Techniques such as the Balanced Scorecard allow the assessment of external as well as internal effects on an organisation, based upon Customer, Internal, Growth and Financial perspectives (Kaplan and Norton, 1992). This is achieved through the linkage of critical success factors (CSFs) with key performance indicators (KPIs), in order to provide an "as-is" as well as a forward-looking strategic view of organisational lead and lag indicators. Information Technology can help to deliver such information and management control, through accessing enterprise data via ERP, legacy and database systems. This can be achieved via connectivity between existing enterprise systems such as ERP, project management tools, financial applications and other legacy packages. Methods by which data and information integration can be implemented, varies from invasive integration and manipulation with source data systems through to non-invasive, publish / subscribe approaches via Enterprise Application Integration (EAI) (Themistocleous *et al.*, 2004; Irani et al., 2005;

Sharif *et al.,* 2005). Noting these issues, the contemporary approach to deploying performance management is to deploy balanced scorecard-related information via a web-based application platform, providing the ability to drill-down into specific contexts (Sharif, 2002). As such, the following factors, combined with the preceding notions of flexible and resource-centric production operations, will be used as a lens on the case study data to view how BTO supply chains can be monitored from a performance management perspective:

- Type of demand (customized product based upon standard components);
- Volume of demand creation (one to many, many to one, cyclic, ad-hoc and / or a-periodic requests for product);
- PDM and inventory search (ability to be able to handle search and query requests about product range and configuration);

Fulfillment and supply process (level and location of inventory, as well as forecast schedule adherence).

Case Study Description

Company M is a leading UK manufacturer and innovator in the high technology manufacturing industry, supplying technology platforms for global aerospace and automotive customers with annual revenues of about £200 million pa and a workforce of approximately 40,000 employees. The business involves supplying a range of electro-mechanical, electronic and hardware / software components for a diverse number of companies. Such components are routinely used in aerospace and automotive application, such as actuation and control system monitoring, data logging and environment sensing. Company S is a principal parts supplier to Company M and has been for approximately 10 years also based in the UK. It has annual revenues of approximately £520 million and has approximately 80,000 employees. The nature of the business is such that Company M experiences a variety of low and high volume orders that include standard and non-standard parts. A number of its customers request regular orders using standard parts (for actuation control systems) whilst other customers tend to require specific configurations of non-standard parts (for data logging and sensing). The latter typically involves a lengthy amount of time in defining specific configuration / design requirements, sourcing components and building to order. Such elasticity in volumetric and product configuration demand, coupled with existing business supply chain processes and systems within in Company M, meant that Company M lacked insight into its relationships with it customers and more critically its suppliers, and a method by which to understand factors inhibiting programme performance. Thus, in order to sustain their market position and bring products to their customers quicker, with better quality service also, required a holistic approach to evaluating their operational supply chain business. Noting the variety of customer orders typically received and the resulting impact upon supplier re-supply orders enacted, Company M quickly realized that it needed to improve its overall supply and value chain efficiencies. In doing so, management agreed that a more agile and lean operation needed to be implemented, in order to remove these inefficiencies. As such, a Build-to-Order approach was seen as the most effective way to achieve this, for those products and configurations that source a commonality of parts. Company S pushed for better responsiveness with Company M in order for both companies to gain efficiencies from the overall supply chain and value the information exchange within the supply chain.

Supply chain interaction between companies M and S, involved both inbound and outbound logistics, as well as reverse logistics. It is important to note that the case company, although aware of the SCOR framework, did not choose to adopt this industry standard, choosing instead to encompass its internal supply chain processes as a "bundle" of its own key processes. Therefore, the concept of introducing a high level set of performance metrics to capture key production and logistics factors was mandated by the CEO and board in order to become more effective in managing the inherent supply chain management interdependencies. It was understood that in order to deliver such metrics would require a more sophisticated reporting and delivery infrastructure than current ad-hoc spreadsheet and database query reporting (which normally took a long time to prepare), as the CEO of Company M noted:

> *"We need to minimize risk and maximize the benefit of performance information, relating to our supply chain, so there needs to be an identification of fit with our related organizational processes, strategy and general company-wide initiatives. Achieving this aim will help to consolidate our internal reporting and accountability requirements. Furthermore, using technology to deliver this information should provide insight into more than finance-focused information. Reporting should be rich in content (highly detailed and navigable) and also be able to provide insight into the organization."*

Specifically, the Procurement Director at a principal parts supplier to Company M, Company S, noted that:

> *"…we consider (Company M), to be our number 2 customer and believe our recent successful growth has been due to our close relationship."*

However, upon further investigation the management of Company M could not say the same for Company S. It was therefore important to understand the depth of information and processes already available, within both Company M and Company S and provide an SCM monitoring system that would encompass BTO aspects also. In doing so, it was found that Company M had many source IT systems, applications and data sources which fed into the quarterly accounting reports, and in themselves were not consistent across the organization. Coupled with this, was the fact that it had undergone a series of mergers and acquisitions in the recent past and was carrying out a rolling audit of their IS infrastructure. This view of the IS infrastructure was akin to a sea of "information spaghetti", from which the data required to drive the performance management system, would have to be gleaned. Thus, as shown in Figure 2, an Internet technology-based architecture was designed, which had as its basis, reliance upon core CRM, SCM and ERP data. This data would encompass sales orders, re-supply and logistics delivery information, which would be relayed via a central portal application (linking enterprise, customers and suppliers), in order to achieve a lean BTO platform.

Insert Figure 2 here

The performance management systems BTO status would be a constituent part of this architecture, but only be available via an extranet connection between Company M and Company S (as would component re-supply and inbound logistics information). Sales order information, in the guise of standard and non-standard Product Data Management (PDM) configurators would be accessible by all, via an Internet connection to the same portal (but hosted and serviced by a third party internet service provider). As such, the Procurement Director of Company S management was noted as stating:

> *"There must be visible change through the implementation of the performance management system, not simply additional reporting information. This should enable the display of performance information and inter-related business measures. To achieve this, the content must be personalisable, customisable and value-adding by allowing the user to drill-down into the relevant data. The information provided should be owned by process stakeholders."*

Thus, after a series of lengthy workshops and meetings to re-affirm sponsorship to the metric definitions and methods for delivering them, a hybrid solution was agreed. A performance 'czar' and administrator, was nominated who would collate relevant metrics on a periodic basis, into a spreadsheet, which would be uploaded into the ERP performance management system. It was agreed that a set of metrics corresponding to both suppliers and producers, were to be produced. These are shown in Figure 3.

Insert Figure 3 here

These metrics show several facets of the relationship between Company M and Company S, in terms of the traditional balanced scorecard facets of Financial, Customer, Internal and People strategic objectives. Subsequently these facets are underpinned by business drivers as identified by senior management in Company M. Although the breadth of the metrics defined is fairly wide, it was felt that the given scope of the scorecard should not only represent the strategic aspects of the firm (such as synergy savings, production strategy implementation, sales forecast risk assessment, business process improvement milestones, training investment index); but also specific operational, BTO aspects (operating profit to sales, liquidity, quality index, external customer satisfaction, number / value of orders processed, product configurability, on-time delivery, inventory variance, partnership value index, supplier spend / savings, cross-product coverage).

As a result, through agreeing the metrics and understanding the method for delivery of the performance information, divisional management quickly understood that their core objectives for running the business would have to focus on realising efficiencies in their BTO chain. This was in stark contrast to the highly finance and learning-focused data that the board was used to reviewing (these two areas were generally core competencies of the organization anyway). As such, Company M proceeded to implement the performance management systems, which involved an evaluation of existing vendor solutions (being largely packaged ERP applications). In doing so, the evaluation criteria used by members of the IT team was that of matching any potential technological solution to that of the existing "application stack". However, the authors did note that in order to successfully implement the chosen performance management

system solution (which was PeopleSoft-based), Company M employed external vendor and IT consultants to speed up the implementation process. In parallel with this, there was also a need to provide access to this performance management system data via the existing internal portal site, and make this data accessible to Company S. Company M already had an existing internet website, which it then also proceeded to develop to allow registered customers and suppliers to view and access on-line catalogues, configurations and fulfillment functionality. In doing so, Company M utilized in –house technical skills and expertise to realize these aims, which had previously successfully deployed and maintained its CRM and SCM systems. However the integration effort involved, far outstripped the implementation effort required for that of the performance management systems solution. This was due to the fact that a number of system interfaces had to be written between the SCM package (Manugistics), CRM (Siebel Sales), and core ERP (SAP R/3) – in addition to a feed to the performance management system itself (PeopleSoft), which would be collecting KPI data from all of these subsystems. The BTO process itself was confined to addressing how standard and non-standard orders from customers would be routed through via CRM and into SCM and ERP subsystems. The planned-for routing of information into the Computer Integrated Manufacturing (CIM) inventory control and logistics supply functions of Company M was not realized fully due to cost overruns and a lack of throughput volume orders to justify the capital outlay of such a system.

Case Study Analysis

Company M was more concerned on focusing on defining its supply chain than on improving and linking KPIs, CSFs to that of its BTO operations. This was a major contributor to the slow progress of the project. Due to a lack of agreement on the board level metrics scorecard, till late in the project, the delivery of the performance information was therefore also compromised. Because of a certain level of silo mentality within Company M and a familiarity with spreadsheet and paper-based reporting formats, this new approach to delivery was viewed and received with increasing caution by members of the board. It was later found that there were many reasons for this reaction, not least of which was based upon the culture of the organization and its hesitancy against tactical and strategic change (Sharif *et al.,* 2005). Moreover, a reason given by some directors, pointed to the sheer complexity of identifying data that could usefully represent the metrics, and difficulty in allocating adequate resources to extract it from upstream and downstream demand and supply systems.

The key underlying theme of these factors is the lack of understanding of the importance attached to delivering performance management concepts, that actually reflected the BTO processes. Company M simply did not realise that the most important part of the whole process, involved reaching an agreement on the metrics early, in order to have adequate time to design an appropriate metric delivery mechanism. Furthermore, the benefits of leveraging state of the art technologies were not fully realised, even though Company M was initiating multiple leading-edge innovations in other parts of the organization. As a result, the benefits that could have been achieved by adopting and following the fundamental aspects of balanced scorecard and performance management theory, were sadly not achieved in full. It was soon apparent that there was a lack of a general understanding about the value-adding aspects of corporate performance management approaches to monitoring BTO statuses. Company M clearly viewed the definition of the business strategy and value chain as high priority to be addressed. Conversely, Company S took a different view on the same issue.

Company S highlighted that it perceived that there was a *lack* of strategy and direction, an opposing view to Company M. More importantly, Company S believed overall, that any such initiative would be highly labour-intensive and would require time to and expertise to manage and integrate build-to-order supply chain data.

Noting these factors relating to the unsuccessful implementation of a build-to-order supply chain within Company M, the authors now outline those factors that impinge on delivering such a concept, via the generation of a framework model. As a result, the following paragraphs highlight those aspects of IT, organizational, supply chain and performance management factors which are affected by context specific effects (i.e. concept justifiers). Figure 4 shows how each of these concepts are connected graphically.

Insert Figure 4 here

Firstly, and in terms of the core IT/IS to be implemented, there needs to be some level of Information Systems Evaluation (ISE) of the component applications required, in order to put the required systems and technology into context. In carrying out a rigorous ISE of the core ERP, SCM, and CRM, as well as Internet and application integration technologies to be used (such as EAI) downstream risks can be avoided. These can be classified as risks relating to over-budget, delayed or expanded scope projects, which can ultimately lead to non-delivery and project failure. Matching the right technology to the organization alongside required skills and competencies to lead such efforts is fundamental to achieving success. Furthermore, and as a result of this, the impact of EAI technologies must also be taken into account in order to accommodate the multitude of supply-chain related information across supply chain tasks and processes. Without a clear ERP/EAI strategy, there is an inherent risk in trying to automate poorly understood or re-engineered business process flows (as highlighted by Sharif *et al.*, 2005 and Themistocleous *et al.,* 2004). What is required for successful build-to-order supply chain integration is the ability to convert order entry information into a range of Computer Integrated Manufacturing (CIM) data: such as CAD models, CNC instructions, supplier re-supply pull signals, and / or shipping instructions for the finished product. In terms of the organization (or organizations) that are to be involved in such an extended enterprise endeavor, a number of additional firm-wide issues should also be considered. Principally, there needs to be commitment and ownership of a strategic as well as operational vision from leaders in the organization (from senior management, IT and production management divisions).

This is crucial in determining and mandating the agreement of balanced scorecard metrics within (and in the case of Company M), across organizations. Additionally, there needs to be in place, the relevant and necessary risk and governance controls. These are in order to ensure accountability and responsibility for any issues arising from supply chain errors or exception between chain participants (suppliers and / or customers) and the associated processes for resolution. Of key and critical importance are then those factors that directly relate to build-to-order processes themselves, which are to be monitored and relayed via performance management system KPIs. These inputs relate to inventory control; production and parts control; logistics (delivery of orders and receipt of returned goods); and supply chain exception handling (production inefficiencies, supplier run-outs, incomplete / inconsistent order matching). The generation of

performance management metrics must also relate to the build-to-order supply chain as the underlying enabling IT/IS and organizational issues too.

In order to do this, there first of needs to be visibility and clarity in relation to navigating the performance metrics: decision-makers being able to recognize inter-relationships between operational and strategic measures as required. Gunasekaran *et al.* (2001) have highlighted this in terms of specific metrics for plan, source, production, delivery and customer service also. Of additional importance is a requirement for all information displayed for an operational process, to be directly relatable to some level of management responsibility. For example, a KPI relating to schedule adherence should be owned and tracked by the Production Manager or Job Shop Steward. Secondly, any such metrics and associated critical success factors, must be able to aid decision-making at all levels of the organization and have associated programme or project level milestones related to them. This once again enables a clear audit trail of responsibility for corporate and individual actions relating to the enterprise. Additionally, in carrying out such an exercise any errors in report consolidation potentially attributable to "quick fixes" or rapid tactical decision-making, can also be made traceable too. The agreement on performance and quality definitions as a result of a group of KPIs means that management can be satisfied with generating a common set of business reports. Such reports can then also give a clear indication of how underlying source supply chain systems are supporting the business and can be used to pinpoint those areas of value growth, in terms of forecast metric information.

Given that the aforementioned factors are necessary and contingent parts of realizing a build-to-order process, these components can only be realized in response to some given set of stimuli that define the context of the supply chain in question. These justifiers, or more precisely, concept justifiers, relate particular cases of use or situations within which the given system must be able to respond and hence justify its implementation. Therefore, the authors believe that the four key KPIs presented earlier as part of a research lens can be extended and enriched with the following observations from the case data, in order to define the response of a build-to-order supply chain:

- Type of demand (standard or customized product) is reliant upon:
    - Product focus and customization / configuration;
    - Interactive fulfillment systems / customer-value chain integration.

- Volume of demand creation (one to many, many to one, cyclic, ad-hoc and / or a-periodic requests for product) can be achieved by;
    - Developing supplier / customer service level agreements.

- PDM and inventory search (ability to be able to handle search and query requests about product range and configuration) can be implemented through:
    - Tight inntegration between CRM, SCM and ERP systems (i.e. SOP fulfillment, logistics, CIM, BOM and inventory control)
    - Optimization and Control of the entire supply chain;

- Fulfillment and supply processes (level and location of inventory, as well as forecast schedule adherence) can be effective monitored and aligned with the BTO supply chain via highlighting resource complementarities between:

- Inbound, outbound and reverse logistics;
- Supply chain processes and defined performance metrics;
- Rigorous cost base control.

These factors define the success and / or failure of any such initiative in the context of what Company M was attempting to achieve. Hence, as a minimum, in the goal of satisfying standard and non-standard ordered products on a mass or volume scale, requires that the preceding points be addressed by the incumbent organization(s) taking part in such supply chain integrations via IT/IS. Hence, the authors now also examine some of the other key influencing factors within the case study and relate these to relevant elements of the synthesized framework, in terms of Organizational Culture and Business Relationships; IT / IS; Concept Justifiers; PeMS / Balanced Scorecard; and Organization attributes, as detailed below.

Organizational Culture and Business Relationships

As with many business integration/transformation systems the effective implementation of a BTO supply chain is dependant upon a number of fundamental success factors relating to organizational culture and business relationships (trust, openness, collaboration, effective communication, accountability, empowerment etc). If some of these characteristics are missing then there is a risk that desired outcomes will not be met. In the case study there was a number of underlying cultural/organizational issues which had a significant and adverse effect on the outcome. In practice Company M's organizational culture lacked an open and proactive approach to dealing with issues being mired in poor historical industrial relations and exhibiting symptoms of a 'blame culture'. In addition, there were signs of tension in the middle/senior management interface that hindered decision making processes. There were also relationship issues between Company M and Company S. In terms of trust, openness and collaboration in the spirit of an effective working partnership the flow seemed to be one way only i.e. from S to M. Company S was naturally keen to improve its relationship with M. As such it was prepared to share information and engage in a proactive manner. Conversely, Company M was far more guarded in its approach. It appeared to be reluctant to give too much information away about the operation of its business even to a close business 'partner' with whom it was 'collaborating' in a SCM systems development initiative. One reason for this could have been that Company M was sensitive about relative deficiencies in business processes, practices and systems resulting in some form of institutionalized paranoia which outweighed any need to be open and collaborative. Overall, therefore, there appear to be several overriding cultural and relationship level issues that would tend to negatively impact any business transformation process especially in the area of SCM where trust and openness are paramount.

Information Technology / Systems

As mentioned previously, the IT infrastructure within Company M was fragmented following acquisitions and likened to 'information spaghetti'. This was not helped by the fact the IT/IS function was partly outsourced and its focus was on keeping existing systems up and running via a Helpdesk, supporting hardware and networking issues. It did not have the capability to undertake strategic or tactical IT/IS design and implementation. Although external consultants were used on occasion this tended to be on relatively small ad-hoc projects rather than on overall systems integration issues.

Company S, on the other-hand, had a relatively sophisticated IT/IS organization which was reflected in its systems infrastructure. In these circumstances, a formal ISE carried out by experienced consultants would have provided vital baseline information as an essential prerequisite for the development of an efficient and cost-effective system. Again, it is important that the key (non-commercially sensitive) aspects of the ISE are shared amongst the relevant business partners in order to provide an informed perspective across the supply chain. An up-front ISE of this nature was not conducted within the case study. Despite this, there was an expectation within Company M that the development of the BTO approach would be instrumental in sorting out the prevailing IT mess. It had been recognised that there were too many systems driven by too many business requirements which were not harmonized and the view was that the BTO initiative would, in itself, deliver across the board improvements.

Concept Justifiers

At a conceptual level it appears that both Company M and Company S had considered the 'concept justifiers' business case for a PeMS led BTO approach and were attracted by the potential business benefits associated with the adoption of such a system i.e. there was a business case which resulted in high-level buy-in to the proposed approach. On reflection, it appears that Company S was the main driver of the inter-company initiative. They already had relatively mature systems and metrics and were keen to improve supply chain efficiency and its interface with M. The focus of M, on the other-hand, appears to have been dominated by internal improvements. The problems experienced in practice were due to the lack of awareness and skills necessary to translate from concept into practice, in terms of inventory control, production control and logistics. In Company M, for example, the executive team were not 'operational managers' and tended to take a very high level view of things. In many circumstances this would be okay as long as there was an effective interface between senior and middle managers. As highlighted earlier this was not the case in Company M where there was disconnect between various tiers of management resulting in a breakdown when moving from the concept stage through to the implementation phase.

PeMS/Balanced Scorecard

As stated previously, the performance metrics associated with BTO supply chains need to be clear, relevant, appropriate and visible in order to support the business decision-making processes. In the case study Company S already had a well developed PeMS (including the necessary performance metrics) and used a company-wide balanced scorecard as a means of driving a culture of continuous improvement. In terms of Company M, its Purchasing Department used a limited internal supply chain scorecard but there was no overall scorecard or agreed business-wide metrics. As stated earlier, a failure to reach timely agreement on key metrics was a key reason for the delay and failure of the BTO initiative. Again, the underlying management tensions were a significant influencing factor. For example, middle managers responsible for agreeing and sourcing the relevant data for each metric suddenly became "unavailable" at critical times or they delegated responsibility to junior members of staff who did not have the knowledge or authority to act on such an important issue. As such, senior management had a difficult time obtaining the necessary data and metrics even though most managers agreed that this would be a useful means of improving efficiency and productivity. Therefore, whilst it was recognised in principle that it was necessary to develop and agree key metrics and adopt a company-wide scorecard, cultural problems hindered the agreement and implementation of meaningful parameters.

Organization

The synthesized framework highlights the inputs of Risk Control/Governance and of Change/Project Management. Each of these represent an essential part of the effective development and implementation of integrated business systems. Again, the aim is to promote an open, proactive and collaborative approach based on an up-front understanding of the objectives, costs, resource requirements and accountabilities. These critical elements of the framework were found to be significantly lacking within the case study. For example, Company M did not conduct a 'project' scoping exercise which addressed practical necessities such as deliverables, costs, timescales, accountabilities etc. The lack of a detailed breakdown of costs is particularly surprising. The senior managers expected the transformation (including the 'fixing' of the fragmented IT system) to be met within existing IT operational budgets. Hence, there was no real investment made in order to deliver the desired business improvements. Therefore, the senior management perceptions of cost-overruns were relative to a 'standard' annual budget rather than to a specific BTO 'project' cost estimate. This appears to be a case of totally unrealistic management expectations resulting in a loss of appetite to continue as specific costs were incurred. In turn, this sort of issue highlights the importance of Risk Control measures. With respect to Governance and Project Management the case study included the formation of cross-company workshops, the nomination of a performance czar and the development of a step-by-step approach. Therefore, at face value, there seems to have been reasonable efforts made to establish Governance processes and adhere to a explicitly stated systematic approach. Again, however, it seems to be a case of the concept not being adequately translated into practice. The systematic approach was indeed articulated but not properly executed within Company M due to management tensions.

Lessons Learnt

The development and efficient implementation of a PeMS led BTO supply chain depends in practice on providing effective interfaces between disparate IT/IS and performance management systems within the context of open and collaborative business partnerships. Within the case study there were existing problems and inadequacies in the fundamental building blocks of a BTO supply chain which spanned the IT organization, its infrastructure and resources; the implementation of performance data and metrics; and a rigorous control and governance of management processes and systems (e.g. change, project and risk management systems). However, these problems were not insurmountable and could have been adequately accounted for within a scoping exercise (e.g. ISE and Risk/Governance reviews) such that realistic management expectations could be translated into a timely and cost-effective deliverables. The fact that these issues did, indeed, prove to be major obstacles was due to significant and underlying cultural, organizational and relationship issues. From the case study, it would appear that there would have been significant in-company problems within Company M if the initiative had related to an entirely 'in-house' system e.g. due to a lack of co-operation and trust. These intra-company issues were compounded by the inter-company dimension via the involvement of Company S. Interestingly, despite a failure to adopt and implement a BTO approach the initiative has not been abandoned by either Company. Both Company M and Company S were frustrated that after all the talk and (albeit limited) action that there was little to show for the effort.

However, from a Company M perspective, a post-hoc review of the approach and pilot exercise has brought home to them a number of key learning points e.g.:

- Initial expectations were unrealistic in terms of outcomes and costs;
- Cost estimate and project review prior to commencing development and implementation should have been undertaken more rigorously;
- Better appreciation of the challenges faced in terms of existing IT/IS arrangements, resources and infrastructure;
- Recognition that unless a more open and collaborative approach (both internally and externally) is adopted, such an initiative will fail to deliver desired outcomes;
- Trial and error approach to development that was (implicitly) adopted is not a cost-effective way to proceed (i.e. foresight is better than hindsight).

A starting point in recognizing these learning points was to commission external consultants to carry out a thorough and open systems audit and to facilitate the agreement of scorecard metrics to monitor their BTO/SC capability.
Based on this, discussions have resumed with Company S in a more open and collaborative climate, with a view to addressing the following points:

- Development of a holistic supply chain management technology solution that spans product development, to component procurement from amongst common target contract manufacturers;
- Extension of reported metrics in order to capture order workflow details;
- Further investment in setting up private linkages with other common suppliers and customers.

Conclusions

This paper has discussed key aims, benefits, characteristics, considerations and constraints of Supply Chain Management (in general), Build-To-Order supply in particular and examined the associated use of Performance Management Systems (e.g. Balanced Scorecard) and IT/IS applications. In discussing these aspects within the context of operations management, a series of conceptual models have been proposed, which were used to set the scene in support of their interfacing with one another. In reaching this position, a case study was used to address some of the practical issues relating to the design and implementation of BTO applications supported by PeMS and IT/IS. This case study is based on empirical primary data and results in the presentation of a grounded framework for Performance Management in BTO supply chains. Within the case study, it can be extrapolated that the organization fully recognized the need to improve supply chain efficiency from a *service*, *speed*, *quality* and, ultimately, *market* share perspective. It regarded the development and introduction of an integrated BTO system as the vehicle to deliver the necessary improvements thus, emphasizing it as a change agent. Nonetheless, a fully developed PeMS driven BTO supply chain was not introduced in practice for a variety of reasons. Overall, the case study has highlighted the need for the evaluation of PeMS implementation solutions regardless of their typology; wholly vendor based, best of breed or combination of vendor solution and in-house development, but also an internal audit of processes and existing IS that would aid the implementation of such a concept.

Furthermore, the intra- and inter-company political/social/commercial tensions (e.g. relating to anxieties about measuring and highlighting relative business performance) needs to be recognised, acknowledged in an open/honest manner and addressed in order that such tensions do not outweigh the concept justifiers which drive systems improvements. Education, ownership, responsibility, sponsorship, openness and collaboration between and amongst the supply chain participants will aid in overcoming these barriers.

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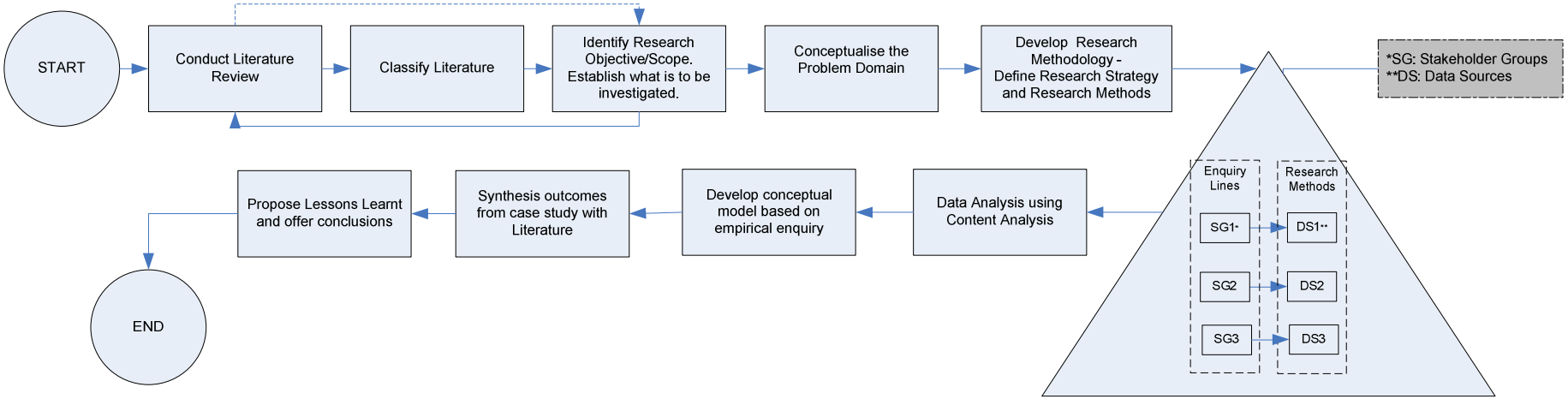

Figure 1. Research Design

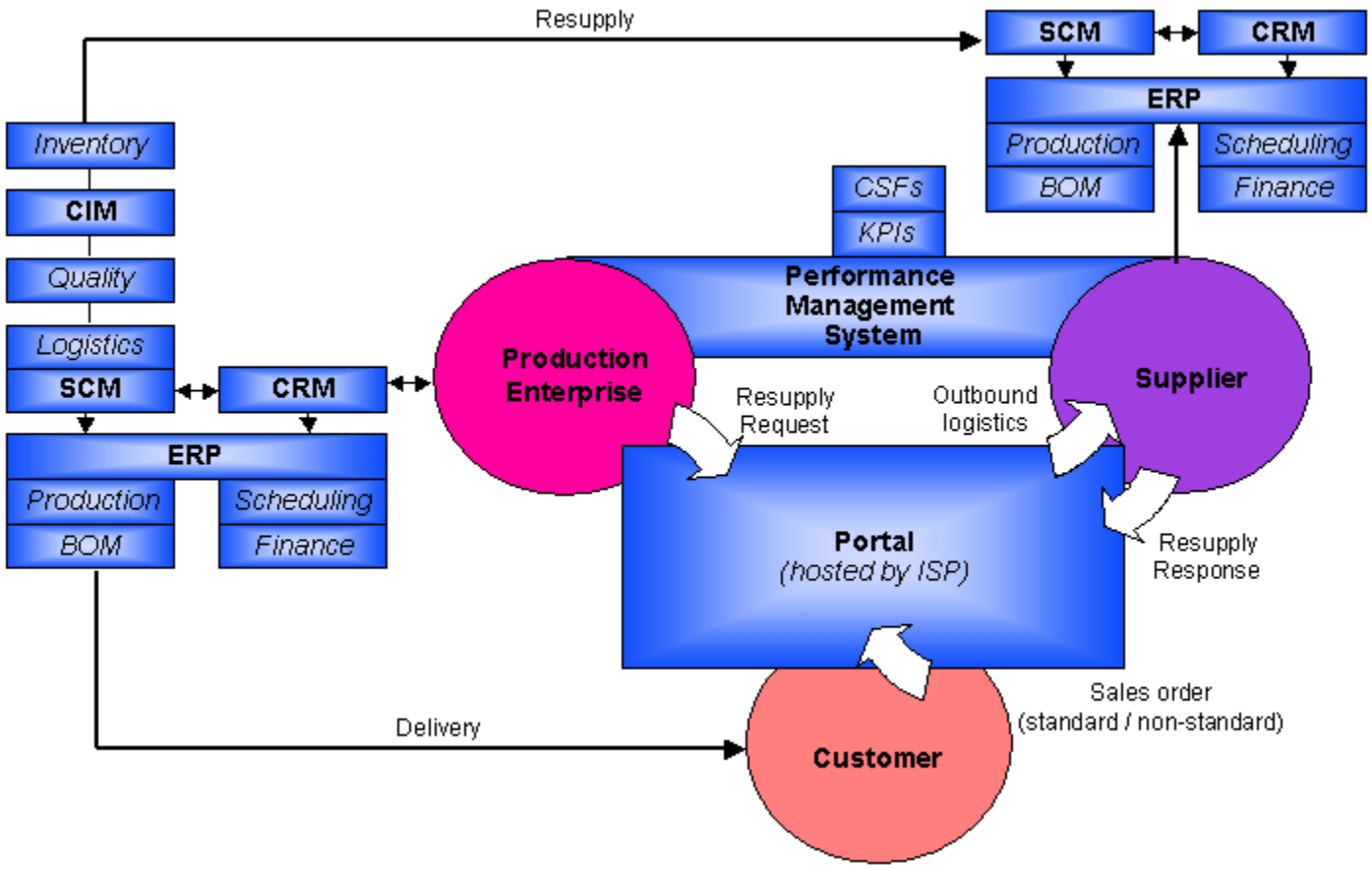

Figure 2. Envisioned Performance Management System portal architecture

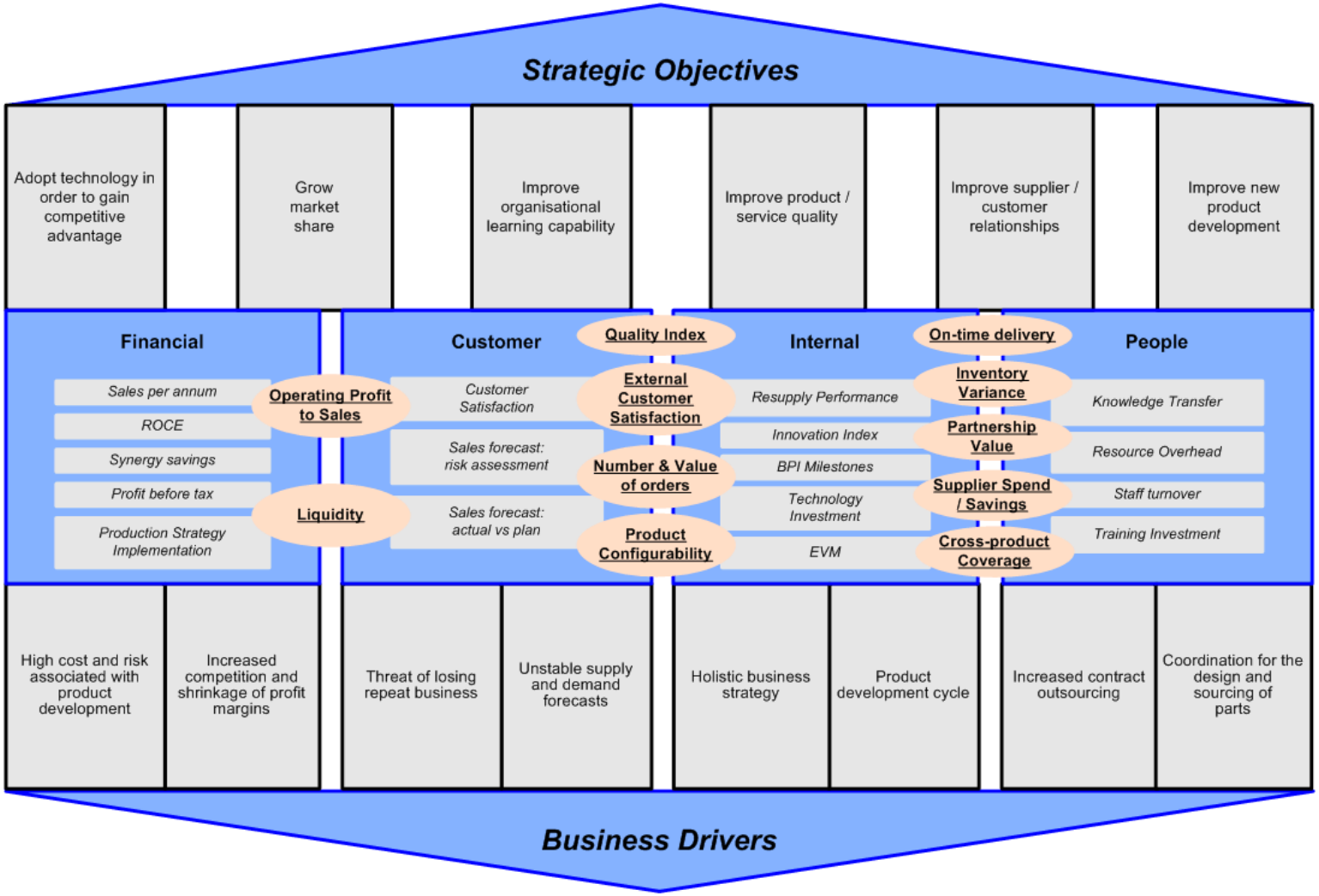

Figure 3 . Example BTO Metrics for Company S

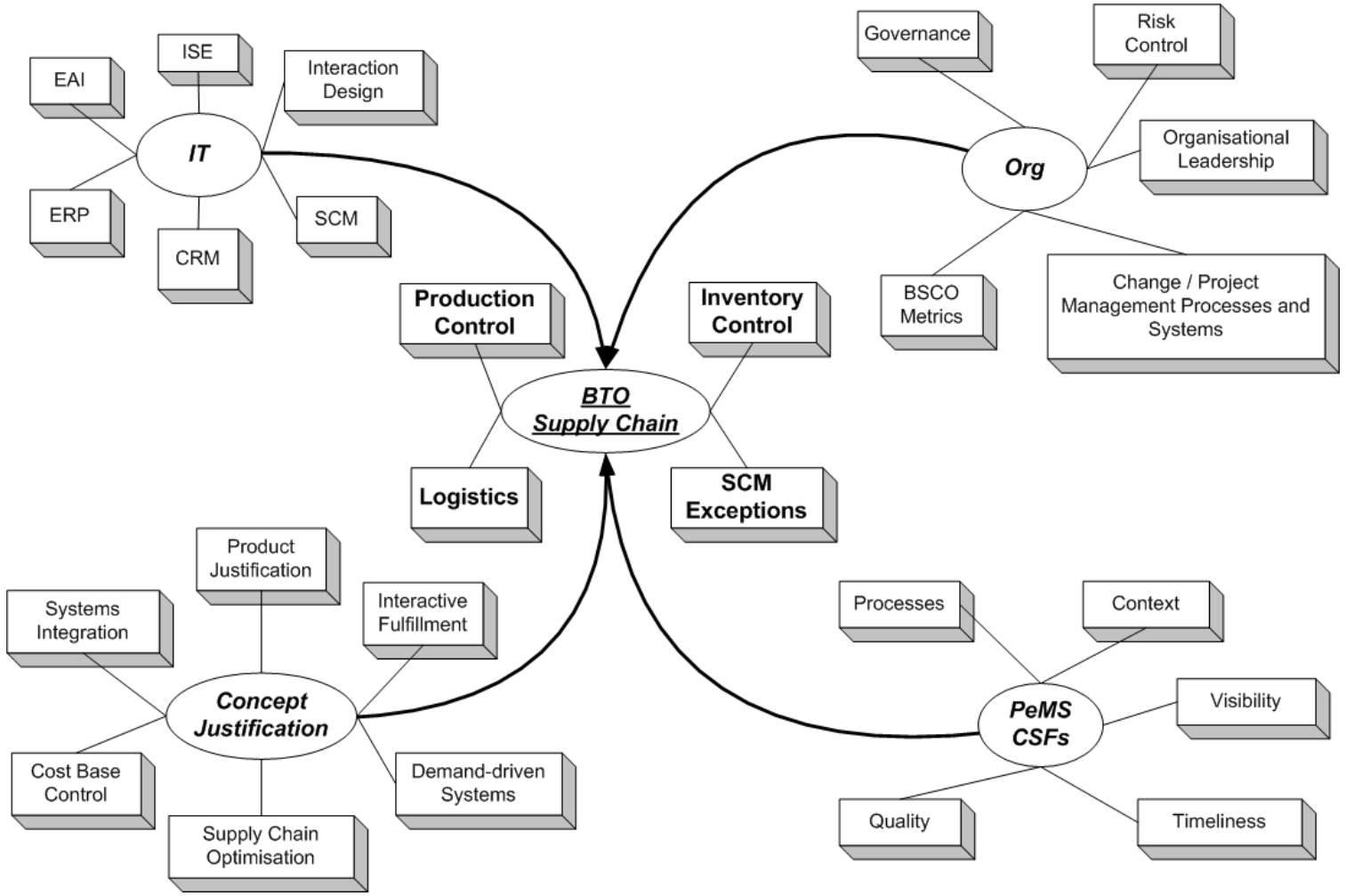

Figure 4. Research Synthesis: Framework for IT and PeMS in a Build to Order Supply Chain