ABSTRACT

Although a number of methodologies exist for Business Process Re-design (BPR), Supply Chain Re-design (SCR) and e-business process design, there is a lack of an integrated BPR methodological framework to support e-business implementation for Supply Chain Integration (SCI). This paper proposes a detailed framework that integrates a number of different methodological strands derived from the reviewed literature. This literature review, revealed that elements of different methods and techniques found in different methodological strands can potentially be integrated into a framework for conducting BPR to support e-business technologies implementation for SCI. Accordingly, a number of relevant methodologies were identified, decomposed and compared at their stage and technique/method level aiming to identify a combination for development of the integrated framework. The proposed BPR methodology can be applied in any company or sector; methods and techniques incorporated are not specific to any sector. An application of the proposed BPR methodology was conducted in an Airline Maintenance Repair and Overhaul (MRO) supply chain, showing that it can clearly guide a BPR project to support e-business technologies implementation for SCI.

INTRODUCTION

SCI is at the core of gaining competitive advantage through Supply Chain Management (SCM) improvement (Prajogo and Ohlager, 2012). When integration is achieved, the supply chain operates as a single entity driven directly by customer demand. Despite the potential benefits, SCI has not been fully adopted. Even though enterprises are aware of the strategic importance of SCI, its nature and extent have been rather selective (Baghchi and Skjoett-Larsen, 2005). In search for solutions that can facilitate the construction of SCI, companies have turned their attention to e-business technologies. Organizations across different sectors have recognized the potential of e-business to share timely and reliable information, which enables business process integration and coordination of activities (Cagliano et al., 2003). Nevertheless, evidence in the e-business and supply chain literature shows limited adoption (Chen and Holsapple, 2012). New internet-based e-collaboration tools allow the integration of multiple organizations, making it feasible to construct SCI systems. However, it is necessary to undertake organizational and technological changes together with a co-alignment in structure, management processes, strategy, technology and individuals/roles for successful e-business adoption (Chen and Ching, 2002). At the core of organizational changes from an operational point of view are business processes. When e-business technologies are implemented, the business processes should be re-designed to support the new technology (Gunasekaran and Ngai, 2004). However, redesigning business processes to support the adoption of e-business technologies is difficult. Business processes are complex due to the many interrelationships of their activities. The increase of complexity in business processes
in supply chains results in the need for new methodologies to handle this complexity, particularly on how to integrate process information in enterprise networks (Roder and Tibken, 2006). Thus, based on the identified necessity to change business processes, the following research question is posed: “How to change business processes in support of e-business adoption for SCI?”.

**RESEARCH METHODOLOGY**

First, a number of relevant methodologies (Table 1) were identified within three relevant domains (1) business process re-design, (2) supply chain re-design and (3) e-business processes design.

<table>
<thead>
<tr>
<th>Business process re-design</th>
<th>Supply chain re-design</th>
<th>E-business process design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual framework for decision support system (Ashayeri et al., 1998)</td>
<td>Supply chain excellence approach (Bolstorff and Rosenbaum, 2007)</td>
<td></td>
</tr>
<tr>
<td>Business process redesign method (Adair and Murray, 1994)</td>
<td>Supply chain re-design framework (Changchien and Shen, 2002)</td>
<td></td>
</tr>
<tr>
<td>Business process redesign (Davenport and Short 1990)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business process change: a study of methodologies techniques and tools (Kettinger et al., 1997)</td>
<td></td>
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</table>

The review found that none of the methodologies provides a comprehensive solution to the research question, although it seems that a number of the methodologies reviewed could potentially be combined for that aim. Whilst considering different methodologies for a particular intervention, a number of methodologies tend to be more useful in relation to some phases than others; so, it becomes attractive to combine different methodologies for a better result. When linking different methodologies, it is necessary to decompose them into detachable elements. According to Mingers and Brocklesby (1997) it is possible to decompose methodologies at the stage level (what) or at the technique level (how). The relevant methodologies (Table 1) were decomposed at their stage level and grouped into generic stages. From this decomposition, an initial design for the proposed BPR methodology was constructed. Next, a second review conducted in the relevant domains resulted in the identification and adoption of appropriate methods and techniques for the proposed BPR methodology as shown in Figure 1.
In recent years the UK Airline MRO sector has been experiencing considerable growth. In order to remain competitive, MRO providers are aiming to improve their supply chain processes (Adams, 2009). Potential benefits from e-business applications are considered to be in the area of inter-organizational transactions, ability to track components status, speed of communication and reduction in inventory levels (McDonnell and Clegg, 2007). Within this context, contact was established with an Airline MRO provider in order to discuss a BPR project within their UK operations.

**Stage 1 and 2 Top management commitment, vision and business understanding:** A project plan was created and an agreement was reached on the conduction of a BPR effort centred on the aircraft component repair services to generate, evaluate, and propose alternatives for SCI through the use of e-business solutions. Using annual reports, industry reports, information from the company and a number of unstructured interviews with a number of company executives, a business logic map centred on the component repair services was created using the business ontology (Osterwalder and Pigneur, 2004) as shown in Figure 2.
Component repair services can be obtained by customers either as a single component service or as part of an Integrated Component Solutions (ICS) service. Target customers are worldwide airlines equipped with Airbus and Boeing aircraft. Different channels act to reach, promote and obtain airline customers. Continuous customer support is provided by a dedicated customer team. A number of supply chain activities are currently supported by an Enterprise Resource Planning (ERP) system to share and store component related information; however, data exchange with external supply chain partners is mainly done through fax and email.

Stage 3 Identification of relevant supply chain processes and selection of target for re-design: Relevant supply chain processes were identified using the Supply Chain Operations Reference (SCOR) model (Supply Chain Council, 2008), resulting on the map shown in Figure 3.

According to this map, when a customer demands a serviceable component (components which are ready to be used by an airline customer), his requirement is satisfied through components stocked in the company storage locations. Airline Customer returns components to be repaired/maintained (unserviceable components); this task is performed within the repair facilities of the company and with the aid of external repair vendors. After the identification of relevant supply chain processes, Saaty and Vargas (2006) Analytical Hierarchy Process (AHP) technique was used for the selection of a re-design target. The selection criteria used consisted on a two level criteria (SCOR performance attributes and metrics), as shown in Figure 4.
Information obtained from company executives was entered into the software Super Decisions 1.6.0 to be processed, resulting in a priority number for the repair of unserviceable components of 75.16%. Thus this process was selected as target for re-design.

**Stage 4 Definition of objectives for improvement:** From AHP analysis it was possible to identify by priority rank as shown in Figure 5, the most important metrics associated with the target for re-design.

Performance was measured and compared with industry benchmarks to identify gaps, leading to definition of objectives for improvement using SCOR model metrics, as shown in Table 2 (details not shown due to confidentiality agreement signed with the company).

**Table 2 Metrics for objective definition**

<table>
<thead>
<tr>
<th>Performance Attribute</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Management</td>
<td>Return of investment on components</td>
</tr>
<tr>
<td></td>
<td>Component Inventory turnover</td>
</tr>
</tbody>
</table>
Stage 5 Understanding the process AS IS: A business process map was constructed (Figure 6) through investigative methods as defined by Towill (1996). This business process shows the various organizational areas and supply chain partners involved in the component repair process. This business process map served as the basis to model the information transactions. Then a casual loop diagram was constructed as shown in Figure 7, to understand the variables affecting the component inventories/backlogs. With the use of these two models a hybrid computer SD/DES model was constructed. It was decided to use a hybrid SD/DES simulation model in order to construct a better representation of the real system. Parts of the real system such as information transactions could be better modelled using DES, whilst component inventories could be better modelled using SD.

**Fig. 6. Business process map**

**Fig. 7. Casual loop diagram**
The simulation model was constructed using Goldsim software. This model was then verified and validated (Law and Kelton, 2000) obtaining an 88% level of accuracy, close enough in terms of replicating the real system behaviour. From the computer model it was found that the poorest performances were the backlog of components waiting repair and the time necessary to receive repaired components from external repair vendors.

**Stage 6 Design of process AS TO BE:** A number of alternatives for improvement based on the use of e-business were generated using SCOR model best practices and e-business schematics (Weill and Vitale, 2001). One of the generated alternatives was to link the Airline MRO provider ERP system with external repair vendors via their web portals. Another alternative was to automate the generation of repair orders immediately after receipt of an unserviceable component by the logistics area. These alternatives were evaluated using the computer simulation model by incorporating and quantifying the new relationships. Table 3 summarizes the results.

<table>
<thead>
<tr>
<th>Performance Attribute</th>
<th>Metric</th>
<th>Best alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Management</td>
<td>Return on components</td>
<td>Alternative 2: Automation of notifications for repair</td>
</tr>
<tr>
<td></td>
<td>Inventory turnover</td>
<td>Alternative 2: Automation of notifications for repair</td>
</tr>
<tr>
<td>Supply chain cost</td>
<td>Unserviceable component inventory cost</td>
<td>Alternative 1: Integration with external repair vendors</td>
</tr>
<tr>
<td>Reliability</td>
<td>Delivery performance</td>
<td>Alternative 2: Automation of notifications for repair</td>
</tr>
</tbody>
</table>

Even with a reduction in component inventory cost, the improvement from alternative 1 seems to be localized, whereas alternative 2 produces benefits across other parts of the process. This suggests that a main bottleneck is caused by delays in processing the notifications for repair. When alternative 1 is combined with alternative 2 it gains the benefit of better improvement on inventory cost, as well as in most of the metrics monitored.

**Stage 7 Implementation:** From the previous analysis it was decided to proceed to the specification of the two alternatives in one single new process. First, from reviewing RosettaNet Partner Interface Processes (PIP) standards (RosettaNet, 2008), it was possible to understand the necessary electronic interactions between the Airline MRO provider and external repair vendors. Next, ERP reference models were reviewed (Knolmayer et al., 2009) to provide detail about transactions and platforms necessary to design the new process. It was found that, through an Inventory Collaboration Hub (ICH), it is possible to support integration between the airline MRO and its external repair vendors. ICH is a low-price collaboration platform accessible through a web-based user interface via the internet, even when users have different ERP systems. Through ICH, the Airline MRO provider can exchange component information with external repair vendors. To automate the creation of repair orders triggered by component receipts, it is necessary to modify ERP master data information for each component type per costumer and then to associate this information with the receipt transaction. If component receipt is successful, a notification is sent for
a repair order. The new process is shown in Figure 8 using the Architecture of Integrated Information Systems (ARIS, Scheer, 1999).

With this, the BPR project was concluded, leaving the detailed technical implementation to the Airline MRO provider and external repair vendors.

CONCLUSIONS

Through a literature review conducted in different domains, a methodology has been developed and proposed here to tackle the re-design of business processes to support e-business adoption for SCI. By adopting a number of relevant methods and techniques this methodology proved distinct from other BPR methodologies by providing specific solutions in supporting SCI based on e-business technologies (Table 4).

Table 4 Differences between the proposed BPR methodology and other methodologies

<table>
<thead>
<tr>
<th>Stages</th>
<th>Difference with other methodologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Top Management Commitment and Vision</td>
<td>Similar to other methodologies</td>
</tr>
<tr>
<td>2. Business Understanding</td>
<td>Integration of the business model ontology into a BPR methodology to map the logic of a business with emphasis on understanding the current roles of SC activities and e-business in the creation of value.</td>
</tr>
<tr>
<td>3. Identification of relevant SC processes and selection of target for re-design</td>
<td>Use of a particular AHP structure which uses as criteria for evaluation SCOR model performance attributes and metrics for the selection of a target for re-design.</td>
</tr>
<tr>
<td>4. Definition of Objectives for Improvement</td>
<td>Use of SCOR model to define relevant metrics for objective definition</td>
</tr>
</tbody>
</table>
5. Analysis of process AS IS

Use of a combined DES and SD computer simulation modelling approach for the analysis of supply chain processes.

6. Design of process AS TO BE

Use of SCOR model to identify best practices in the use of e-business and use of e-business schematics to represent alternatives for improvement.

7. Implementation

Integration and use of RosettaNet PIP standards, reference models and ARIS architecture in a BPR methodology for process specification.

The BPR methodology was tested and validated through a practical application. This application was meant to support the creation of a SCI between this MRO Company and its external repair vendors (23 main repair vendors). Experience from this application suggests that the proposed methodology can clearly guide a business process re-design to support e-business adoption for SCI.

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