Analytical hierarchy process and SCOR model to support supply chain re-design

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A supply chain consists of different processes and when conducting supply chain re-design is necessary to identify the relevant processes and select a target for re-design. Through a literature review a solution is presented here to identify first the relevant processes using the Supply Chain Operations Reference (SCOR) model, then to use Analytical Hierarchy Process (AHP) analysis for target process selection. AHP can aid in deciding which supply chain processes are better candidates to re-design in light of predefined criteria.

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1. Introduction

The necessity to coordinate several business partners, internal corporate departments, business processes and diverse customers across the supply chain gave rise to the field of Supply Chain Management (SCM) (Turban, King, Lee, Liang, & Turban, 2011). At the core of gaining competitive advantage through SCM is Supply Chain Integration (SCI); when integration is achieved, the supply chain operates as a single entity driven directly by customer demand (Farhoomand, 2005). However the supply chain literature shows the existence of a number of challenges associated to the integration of supply chains (Awad & Nassar, 2010; Bagchi & Skjoett-Larsen, 2005; Sweeney, 2011). In search for solutions which can facilitate the construction of SCI, companies have turned their attention to e-business technologies (Aramo, Aminoff, & Punakavi, 2002; Cagliano, Caniato, & Spina, 2003; Chen & Holsapple, 2012; Wiengarten, Humphreys, McKittrick, & Fynes, 2013). Nevertheless evidence in the e-business and supply chain literature shows only a limited adoption of e-business for SCI (Aramo et al., 2002; Bagchi & Skjoett-Larsen, 2005; Chen & Holsapple, 2012; Croom, 2005). This lack of adoption highlights the existence of challenges in the application of e-business to enable SCI. New internet based e-collaboration tools allow the integration of multiple organizations, making it feasible to construct SCI systems. However, tools alone are not sufficient; 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 & 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 & Ngai, 2004). However to redesign supply chain processes to support SCI implementation is difficult (Palma-Mendoza, Neailey, & Roy, 2014). The increase of complexity in business processes in supply chains results in the need for new methodologies to handle this complexity; in particular, on how to integrate process information in enterprise networks (Roder & Tibken, 2006). Accordingly building on a literature review conducted in three different domains – business process design, supply chain re-design, and e-business process design – a methodology is proposed to re-design business processes to support SCI (Fig. 1).

One of the critical steps in this methodology is the identification of relevant supply chain processes and selection of a target process for re-design (step 3). A supply chain re-design can achieve radical improvement but can also be risky if it is not focused on the appropriate process; thus, if supply chain process re-design is going to take place, it is better to focus on a target process (Ashayeri, Keiji, & Broker, 1998).

A solution is proposed here to use the Supply Chain Operations Reference (SCOR) model (SCC, 2012) for the identification of relevant supply chain processes and Analytical Hierarchy Process (AHP) (Saaty & Vargas, 2012), for the selection of a target for redesign. This paper starts with a review of the literature on the identification of relevant processes and selection of a target for redesign. Next is presented the proposal of using SCOR model to identify relevant processes and SCOR model performance attributes and metrics as evaluation criteria to conduct an AHP analysis for the selection of
a target for redesign. The model was tested through application in an airline MRO supply chain, showing this proposal can guide the identification of relevant supply chain processes and the selection of a target for re-design. Finally, this paper concludes with some final reflections and implications in the use of SCOR model and AHP for supply chain redesign.

2. Supply chain re-design

A number of methodologies have been proposed in the literature to support supply chain re-design (Bolstorff & Rosenbaum, 2012; Changchien & Shen, 2002; Towl, 1996; Wang, Chan, & Pauleen, 2010).

Changchien and Shen (2002) identify seven general relevant supply chain processes as defined by the International Centre for Competitive Excellence (customer relationship, customer service, demand, order fulfilment, manufacturing flow, procurement and development and commercialization); with these processes Changchien and Shen (2002) propose to describe a supply chain. Finally Bolstorff and Rosenbaum (2012) propose to use the SCOR model to capture the AS-IS (current status) of a supply chain under study. The Supply Chain Council (SCC) developed the SCOR model in 1996 to understand, describe and evaluate supply chains [9]. The SCOR model provides a common supply chain framework, standard terminology, common metrics and best practices (Huan, Sheoran, & Wang, 2004). One of the applications of the SCOR model is to aid the understanding of a particular supply chain by means of mapping it in business process terms using SCOR model terminology (Wang et al., 2010). Thus, mapping with SCOR model will show the relevant SC processes present in the particular supply chain under study.

In respect to the selection of a key process target for redesign, the Cardiff supply chain modelling and reengineering methodology (Towl, 1996) does not mention how to select a key process for redesign. Bolstorff and Rosenbaum (2012) propose the use of a worksheet to conduct an assessment of the impact and effort necessary to re-design the different relevant processes identified. The result from this assessment will be an impact/effort matrix showing the different processes according to their potential impact if redesigned and the effort necessary in time and money. The main drawbacks with this approach are the difficulties associated with producing a good estimate of cost and time necessary to redesign a particular process before conducting a complete analysis of the relevant processes. Changchien and Shen (2002) propose a Core Process Analysis Matrix (CPAM). CPAM needs a set of criteria to be defined in order to select a target process for re-design. Changchien and Shen (2002) suggest using four views; strategic, function, logistics-transportation and information management views. A number of authors propose to use AHP to identify and select target processes (Hahn & Lee, 1994; Korpela, Lehmsvaara, & Tuominen, 2001). In summary, it is clear that for the selection of a target for redesign, it is necessary to define a set of criteria, and then perform a comparison among the processes identified against the criteria. From the methods reviewed, multi-criteria decision analysis appears the most adequate in particular when it can be combined with SCOR model to establish a standard criteria for comparison (Huan et al., 2004; Rabelo, Eskandari, Shaalan, & Helal, 2007).

3. Identification of relevant supply chain processes

The Supply Chain Council (SCC) developed the SCOR model in 1996, to understand, describe and evaluate supply chains. It provides a common framework, standard terminology, common metrics, and best practices (Huan et al., 2004). The SCOR model follows a hierarchical structure with different levels of decomposition. The basic hierarchical composition of the SCOR model is as follows:

- SCOR model Level I Process types: Level I defines scope and content using five process types: Plan, Source, Make, Delivery and Return.
- SCOR model Level II Process categories: This level defines configuration level, where a supply chain can be defined using core process categories.
- SCOR model Level III Process activities: This level decompose processes in process elements, describing inputs and outputs, process performance metrics and recommended best practices.

The SCOR model aids the understanding of a particular supply chain by means of mapping it in business process terms. Accordingly, SCOR model levels I (process types) and II (process categories) can be used to identify and map the supply chain processes present. The mapping process starts at level I by identifying the process

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**Fig. 1.** Business process re-design methodology to support supply chain integration. Source: Palma-Mendoza et al. (2014).
4. Selection of key supply chain process for re-design

Some processes in a supply chain are more critical than others (Palma-Mendoza et al., 2014). Thus, in order to differentiate the degree of importance among several supply chain processes it is proposed to use multi-criteria decision analysis such as AHP as a decision support tool for process selection (Palma-Mendoza et al., 2014). AHP assumes that decision problems can be structured by translating goals into measurable criteria, which, in turn, can be related to alternative decisions. As result, AHP provides a priority number at each level of the hierarchy; then priorities of the alternatives are weighted against those of the criteria so that the eventual importance of the alternatives related to the goal are quantified (Saaty & Vargas, 2012).

AHP decomposes a complex problem into a multi-level hierarchical structure of objectives, decision criteria, and alternatives (Huan et al., 2004). The AHP structure proposed for the selection of a key supply chain process for re-design consists of a two level criteria composed by SCOR model performance attributes and level 1 metrics (Fig. 2) as first reported in Palma-Mendoza et al. (2014).

At the top of Fig. 2 is the overall objective, in this case the selection of a target for re-design. The next two levels are the criteria, here consisting of SCOR model performance attributes and level 1 metrics. Below are the decision alternatives, here represented by relevant supply chain processes previously identified through SCOR model mapping.

In the SCOR model, performance attributes serve to define generic supply chain characteristics and to describe supply chain strategy. According to SCOR model ver.11 performance attributes are

- Reliability
- Responsiveness
- Agility
- Supply Chain Cost
- Asset management

SCOR model metrics are organized around the performance attributes and possess different hierarchical levels, similarly to SCOR processes. Fig. 3 shows how level 1 metrics relate to performance attributes. SCOR model level 1 metrics are considered to be Key Performance Indicators (KPI) intended to measure and express the overall performance of a particular performance attribute. The other metrics levels are considered diagnostic measurements associated with particular process activities (SCOR model Level III). Considering that the identification of relevant processes will use only SCOR model Level I and II processes, the AHP structure proposed for the selection of a target process uses only performance attributes and level 1 metrics (Fig. 2).

Based on the SCOR model version 11, level 1 metrics are:

- Perfect order fulfillment
- Order fulfillment cycle
- Upside supply chain flexibility
- Upside supply chain adaptability
- Supply chain management cost
Detailed description of performance attributes and level 1 metrics is found in SCOR model version 11 (SCC, 2012). At the bottom of the AHP structure (Fig. 2) are the relevant supply chain processes, which will be identified through SCOR model mapping. These relevant processes will be compared using the two level criteria (SCOR model performance attributes and level 1 metrics). In respect to how relevant supply chain processes will relate to the two level criteria, SCOR model assigns for each process category (SCOR model level II) different level 1 metrics (SCC, 2012). Once the structure is constructed, the AHP analysis for the identification of a target for re-design will follow the next steps (Satty & Vargas, 2012):

1. Pair-wise comparison: Pair wise comparison aims at determining the relative importance of the elements in each level of the hierarchy starting from the second level (performance attributes) and ending at the lowest level (supply chain processes). The decision maker expresses his/her preferences for each pair of elements.
2. Weight calculation: Mathematical normalization methods are used to calculate the priority vector from a comparison matrix constructed from the pair-wise comparisons. This priority vector shows the total relative weights among the criteria compared.
3. Consistency check: A consistency ratio is calculated to check for consistency in making the pair-wise comparisons.
4. Hierarchical synthesis: The calculated priority vectors at different levels are integrated to allow overall evaluation of the alternatives (supply chain processes).
5. Determine priority for all alternatives: The alternative (supply chain process) with the highest overall priority weight is chosen.

In the end the AHP analysis will provide a priority numerical order for the supply chain processes under consideration. From this priority numerical order it should be easy to decide on which supply chain process to focus the re-design effort.

One of the criticisms to the AHP is the process of selecting the set of criteria and the way the AHP is structured (Ishizaka & Labib, 2009). However, an advantage of combining the SCOR model with the AHP is that the SCOR model provides a standard and accepted structure of supply chain metrics as a criterion for the selection of a target for redesign. Moreover using SCOR metrics will potentially facilitate the evaluation process considering that managers involved will be familiar with this set of metrics. Furthermore, managers involved will be able to utilize their experiences in the selection of the target for redesign.

Another criticism is the rank reversal phenomenon: if a copy (Belton and Gear, 1983) or a near copy (Dyer, 1990) of an alternative is added or removed, (Troutt, 1988) a rank reversal may appear. This phenomenon has been explained in that the alternatives depend on what alternatives are considered; thus, adding or deleting alternatives can lead to a change in rank (Harker & Vargas, 1990). However, if we are in a closed system (that is, no alternative will be added or removed) then the rank reversal phenomenon will not appear (Ishizaka & Labib, 2009). Huan et al. (2004) states clearly that the combination of AHP and SCOR model metrics will not cause rank reversal since the set of criteria does not change; thus, there are no multiple choices to cause rank reversal.

Finally, another criticism of the AHP is that the uncertainty associated with subjective judgemental errors may affect the rank order of decision alternatives (Rafeo et al., 2007). Thus, the measure of consistency can be used to improve the consistency of judgements (Saaty & Vargas, 2012). If the consistency ration is less than 10%, then the pairwise comparison matrix can be considered as having an acceptable consistency; otherwise the judgements need to be checked.

5. Conclusions

Despite the need to re-design supply chain processes to support supply chain integration there is a lack of an adequate methodological framework to guide its implementation (Palma-Mendoza et al., 2014). In particular, it is not clear from the available methodologies how to identify relevant supply chain processes and select a target for re-design. From a literature review a solution has been developed to tackle this problem. First it is recommended to use SCOR model to map a supply chain under study, this will reveal the relevant supply chain processes present. The SCOR model, has been widely accepted by supply chain practitioners and researchers and has been proven to be valid (Zhou et al., 2011). Next, here it is recommended to use the AHP analysis combined with the SCOR model to conduct the selection of a target for re-design. The AHP hierarchical structure follows the natural tendency of the human mind to sort elements of a system into different levels and group similar elements at each level (Huan et al., 2004). This structured approach facilitates decision making. The SCOR model is a hierarchical model that consists of different process and metric levels; thus, it seems natural to combine the AHP with the SCOR model (Li, Su, & Chen, 2012).
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References


Jaime Palma joined Warwick Manufacturing Group (WMG) at the University of Warwick 6 years ago as a research engineer on the Engineering Doctorate programme. His doctoral research consisted in the creation, development and application of a Business Process Redesign Methodology to support e-business implementation for Supply Chain Integration. He was awarded the Doctor of Engineering degree in 2011 and since July 2012 is an Associate professor at Instituto Tecnologico Autonome de Mexico (ITAM).