Applications of Reference Models for Supply Chain Integration

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1. Introduction

As supply chains continue to replace individual companies as the management arena for value-adding from the beginning of the twenty first century, integrating operations across all facets of business flows within and beyond the boundaries of companies is one of the keys to success in business today. The achievement of effective supply chain operation depends on the seamless collaboration between distributors, manufacturers, and suppliers through the application of inter-organisational systems (IOS) (Daniel and White, 2005). While senior managers recognise that managing the supply chain cannot be left to chance, business owners are seeking ways to deal with the complexity of the task. Collaboration in the global supply chain via recent technologies—for example, Dell in the information technology industry, Walmart in the retail industry, and General Motors in the automotive industry—can be typically seen as such efforts (Chopra and Meindl, 2007; Simchi-Levi et al., 2008).

Similar to business process reengineering (BPR) at enterprise level (e.g. ERP adoption), execution of supply chain management project and related IOS requires preliminary process-driven analyses and improvements of organisational structure, business processes, and setting up of performance measurements in a supply chain context. Therefore, universally applicable reference models would be beneficial for supply chain practitioners in modelling and improving their supply chains. This leads to the development of reference models in the supply chain domain. For example, Williams (1994) discussed the building blocks of the Purdue enterprise reference architecture.

In this connection, the objectives of this special issue are to reflect the most recent advances on reference models in industrial and supply chain applications and to explore future directions. More specifically, multi-disciplinary research, incorporates various approaches and reference models, is the focus of this special issue. In particular, we seek original contributions on successful applications of various reference models in real industrial or supply chain cases. The next section reviews some of the reference models, followed by a summary of the selected papers published in this special issue.

2. Relevant Reference Models

The Supply Chain Operations Reference (SCOR) Model is probably the first and the most popular reference model in the supply chain management domain (Stewart, 1997). This was developed by the experts and practitioners of the Supply Chain Council (http://supply-chain.org/) and is a major framework for supply chain planning which features supply chain management practices and business process reengineering (Stephens, 2001; Lockamy III and McCormack, 2004). SCOR is referred to as a standard diagnostic tool for the configuration of supply chain management. The SCOR model builds on the concepts of process reengineering, performance measurement, and logistics management (Huang et al., 2004). It integrates these techniques into a configurable and cross-functional framework consisting elements of business processes, metrics, best practice, and suggested actions which can be used as a

common language for enterprises to describe the supply chains and the communication between them (Lambert et al., 2005). Despite being an integrative guide with many merits, it only provides a 'top-down' approach which requires the comparative analyses of pre- and post- performance indices as a basis of business process modification. Nevertheless, applications of SCOR are diversified in different areas (Li et al., 2011).

As mentioned in Section 1, enterprise modelling is another domain where reference models are useful in terms of modelling and analysing performance of enterprises (Wang et al., 2010). Another modelling approach that is popular in the literature for enterprise modelling is the IDEF (Integration DEFinition) family of models which has its root in the 1970s (Aguilar-Savén, 2004). It is divided into a number of different models, for example, IDEF0 (for function modelling), IDEF1 (for information modelling), IDEF2 (for dynamics modelling), IDEF3 (for business process modelling), and so on. Different variants serve different modelling purposes. For example, the IDEF0 "is designed to model the decisions, actions, and activities of a manufacturing organization or system in a structured graphical form" (Kim and Jang, 2002). To be precise, IDEF is a family of modelling languages that can be applied in a variety of scenarios, including modelling of manufacturing functions, integration of business processes, and so on (Plaia and Carrie, 1995). It is a descriptive tool which makes use of graphical and text description of functions, information and data, etc., so that a complex system can be broken down into details for analysis by using IDEF models.

There are various other reference models related to SCM such as SCM maturity model (Lockamy III and McCormack 2004b), the collaborative planning, forecasting and replenishment (CPFR) model (Seifert 2004), and Agent-Based Systems Reference Model (ABSRM) (Modi et al. 2006). SCM maturity model assumes that progress towards goal achievement comes in five stages and the model assists managers to pinpoint areas of progress and stagnation. The model extends the value and capabilities of the SCOR model by looking at number of areas such as integration, strategy, cooperation, collaboration, organisation structure, measurement systems, best practices and customer focus. The CPFR model (Seifert 2004) emphasises on enhancing supply-chain integration by collaboration, supporting and assisting joint practices. Since the mid of 1990s, CPFR model has been implemented in many well-known organisations including Wal-Mart, GSK and Heineken. ABSRM has also been adapted by many organisations that develop and deploy systems based on agent technology (Modi et al. 2006). Agent-based systems are capable of handling various supply-chain activities efficiently and effectively (Mishra, Kumar, and Chan 2010); thus, ABSRM is highly relevant for organisations since it serves as a basis for situating the complete set of functions that anyone may want or need to have in an agent-based system (Modi et al. 2006).
A number of other reference models used in the organisations assist them in a number of ways including educating enterprises; create standards; improving communication; and clarifying the roles and responsibilities of actors involved in its implementation. SOA-RM is a reference model for service-oriented architecture (SOA). Cardoso, Voigt, and Winkler (2009) referring to the Organisation for the Advancement of Structured Information Standards (OASIS) consortium defined it as 'a paradigm for organising and utilising distributed capabilities that may be under the control of different ownership domains'. This reference model was quite helpful to understand the significant relationships amongst the entities of SOA, a view that was also supported in the work of Laskey (2008) and Bernhardt and Seese (2009). A number of reference models were also developed for the IT services such as TCP/IP reference model, Mass Storage System Reference Model, and Electronic Discovery Reference Model (EDRM). The TCP/IP reference model (Tanenbaum 1996) was

developed in mid 1990s to connect multiple networks together that remain intact as long as the source and destination machines were functioning. The EDRM model focused on providing a standardised process for managing electronic discovery as stated on Symantec corporations website. Thus, it is evident that reference model framework assists organisations in a number of ways. This special issue though is focused on the application of reference models in supply chain.

3. Scanning the issues

The call for papers has attracted overwhelming responses – we have received over 30 submissions, let alone late submissions that we could not accommodate. Submissions are truly international as they came from five continents. The guest editors had to be very selective and eventually accepted 10 high quality papers for this special issue.

As discussed in Section 1, SCOR is probably the most influential reference model in the SCM domain. It is not surprising that there are a significant number of submissions that are related to SCOR. In this special issue, the guest editors picked up two of them. First, Liu et al. (2013) study the impact of additive manufacturing (AM) in the aircraft spare parts industry, with an emphasis on reducing the cost of holding safety inventory. Companies along the aircraft spare parts supply chain face significant challenges in providing fast repair and maintenance services whilst minimising costs. A large commercial airplane is made up of several millions of parts. Most parts are infrequently needed but they have to be kept in stock in order to ensure fast service time. AM allows on-demand production to improve supply chain dynamics. The SCOR model is used to evaluate different supply-chain configurations based on AM technology deployment, which helps narrow down the scope for quantitative analysis. Pertinent supply-chain performance metrics are then selected. A case study is conducted based on data obtained in the literature. It clearly demonstrates the potential of AM technology to reduce the required safety inventory in an aircraft spare parts supply chain. A sensitivity analysis is performed. It was found that centralised AM is more suitable for parts with low average demand, relatively high demand fluctuation, and longer manufacturing lead time, whereas distributed AM is suitable for parts with high average demand or very stable demand.

SCOR is not only applicable to the manufacturing industry. The construction industry, and mostly its logistics, is often characterised as unstructured, fragmented and uncoordinated. Many authors argue that these problems stem from a lack of implemented SCM practices. As of today, there exists no structured framework for implementing SCM in construction that is adapted to construction characteristics, to be used for mapping and measuring construction supply-chain performance. Thunberg and Persson (2013) aim to develop such a logistics framework via a case study approach. The objective is relevant for the special issue to fill the gap of missing logistics frameworks for the construction industry. The contribution to the special issue is a report on a successful application of the SCOR model in the construction industry. Models developed for the manufacturing industry cannot be implemented straight off into the construction context without adaptions. Even if the SCOR model aims to be a generic framework suitable for most industries, the study also contributes on showing that to be an applicable model it has to be adapted to a specific industry context.

Attention to environmental issues has been increasing in recent years. Therefore, applications of reference models by taking environmental concerns are worth mentioning in this special issue. Tseng et al. (2013) fill this analytical gap and suggest a rigorous quantitative approach for benchmarking eco-efficiency. However, there are qualitative and quantitative approaches

to the eco-efficient criteria. Hence, this study undertakes fuzzy set theory within reference model (Known as TODIM), a method that allows users to assess both qualitative and quantitative data together. This study provides guidance to practitioners and an example of a largest smart phone manufacturer across the globe to demonstrate the proposed technique is more with appropriate result to benchmark the eco-efficiency in green supply chain (GSC) practices under uncertainty. This study integrates the operational process across all facets of green SCM within and beyond the boundaries of a focal electronic firm. This study helps to benchmarking the eco-efficiency in their supplier selection with their supply chain. This study also achieves to the effectiveness of GSC operation depends on the collaboration amongst distributors, manufacturers and suppliers through the application of inter-organisational process analysis. The result presented that the ISO 14001 has directly impacted on environmental policy and planning decisions. As such, the management utilises ISO 14001 to benchmark the eco-efficiency in their supplier selection as well as to effectively mould the flow of production processes and supplier selection in GSC practices.

In another study, Gallear et al. (2013) recognise the major impact that environmental uncertainties on the performance of the supply chain and managerial decisions. Hence, the ability to align supply chain product delivery systems with the demands of the external environment is an important source of competiveness. Their paper addresses the need for managers to be better equipped with diagnostic reference tools that explicitly link environmental uncertainty to supply chain performance. Accordingly, Gallear et al. (2013) contribute to the theme of this special issue by demonstrating a novel application of data envelopment analysis (DEA) to facilitate the development of a diagnostic reference tool to analyse the supply chain performance of product value streams (business units) operating within a supply chain network. Using real industrial data across the linkages of product value streams, the diagnostic reference methodology can be used by managers to guide their efforts to improve their value streams' performance through role-model identification and target setting. It enables them to establish how well their product value stream is aligned with the uncertainties of the external environment in comparison with the best aligned value stream(s), to pinpoint weaknesses and to set appropriate improvement goals.

Furthermore, Genovese et al. (2013) explore the challenges associated with implementing supplier environmental performance measurement models (based on scorecard techniques and other reference models) in context of a global supply chain. This topic is of particular relevance as most of the academic literatures are mainly concerned with tools and techniques for decision aiding, overlooking issues that arise when such tools are implemented in a real-world scenario. After a thorough literature review on the topic, a research methodology based on the case study approach is adopted to investigate the real-life perspective of the issues encountered whilst implementing performance measurement models in industrial practice. An in-depth study of one of the biggest fast moving consumer goods companies in UK is discussed and analysed. Findings of this research provide insights for developing robust, efficient and usable environmental performance measurement frameworks in supply chains and avoid common traps related to framework design.

Service operation is another popular topic in the last decade. Reference model is equally applicable to service oriented operations. In this issue, two relevant studies are selected. Maull, Smart, and Liang (2013) begin with the recognition that most research in supply chains is in manufacturing yet most organisations combine product and service in a hybrid composition. The challenge is that research is needed in two areas; firstly, the service aspects of supply chains but also how do products and services combine in integrated value

propositions and what are the implications for product service supply chains (PSSCs). This paper addresses this challenge through the development of a process model of PSSCs. This is achieved through an in-depth single case study of a large Telco that provides products (phones, devices etc) alongside services in a series of integrated value propositions. Maull et al. (2013)'s findings are that the model provides a heuristic device for managing and coordinating PSSCs, particularly where there are multiple service concepts. For example, it allows managers to consider the interplay between product and service concept and to model the impact of changing the product on the service. Without the integrated model, changes might be implemented that have unintended consequence elsewhere in the system. Finally, we consider the implications for future work including the potential for further empirical work into types of integrated PSSC which combine the four product and four service types into 16 possible value proposition combinations.

Health care is another important service industry. Guven-Uslu et al. (2013) suggest that purposefully designed decoupling point as a reference model has a potential to address particular managerial problems. It is built on the concepts of process analysis, performance measurement and flow of services in managing a specialist health centre. It therefore suggests that there could be benefits in adapting reference models to particular organisational settings with help of partners from the organisation so that possible solutions could be discussed and analysed from different angles. This problem is relevant to the special issue because it explains an unusual adaptation of reference model in an environment where highly skilled professionals contributed to the process of designing the model making it more relevant and applicable in practice.

Reference models can be applied in other operations management areas, such as enterprise system. Current trends in supply chain networks are moving towards a greater connectivity and collaboration amongst trading partners'. It is relevant that supply chain nodes support their operations based on standard and references structures leading to a better integration across the network. Moreover, it is expected that a better capturing and evaluating of the performance measures will help to enhance the competitive advantage. Nevertheless, organisations lack on using integrated perspectives of reference model and architectures which extend beyond their own operations. This lack of visibility implies that the integration, synchronisation and the optimisation of the operations processes across the supply chain becomes a great challenge. In addition, due this lack of integration, the collaboration does not always lead to success. Hernández et al. (2013) present new reference model for the organisation of the operations processes involved in managing the collaborative planning activity based on reference modelling languages and the standard framework of Zachman. In addition, and using the multi-agent system technology, this architecture has been applied to one automotive supply chain configuration in where improvements in the service level for each node has been observed considering the proposed collaborative approach.

In traditional supply chains, small and medium enterprises (SMEs) have a very limited possibility to differentiate and add value to their product if they act alone. The unique capacities and capabilities of SMEs are no longer sufficient for them to compete with large companies and lower cost countries. Keeping these business constraints in mind, the SMEs, specifically European SMEs, need to collaborate in order to adopt new business models and to establish dynamic and non-hierarchical networks, assuring a differentiated supply, faster time to market and competitive prices. Such collaboration networks allow SMEs to join and control the knowledge, capabilities, resources and critical mass required to offer unique solutions to complex requirements. To allow SMEs to overcome these limitations and to

support them in the creation and effective management of non-hierarchical networks, Carneiro et al. (2013) describe the design, implementation and validation of an innovative and integrated framework composed of a methodology, reference business processes and a support web-based platform. This paper is aligned with the main scope of the special issue because it presents a Collaboration Processes Reference Model and its application in two case networks from the fashion industry. This Reference Model is part of the conceptual developments which support companies in the definition of virtual organisations and aims to support SMEs by providing a conceptual framework and reference business processes for the main operational activities in collaboration projects related to the design and manufacturing of complex and customised products. This kind of Collaborative model allows supporting organisational change in SMEs for the creation of seamless flow between suppliers, distributors and manufacturers. The re-engineering of business processes is the first step to make SMEs aware of the potential of creating trustful relationships which need to be based on an information and communications technology platform, where competences, capabilities, resources could be shared to create economies of scale. In this way, SMEs can answer to challenges which they cannot afford in case they act alone.

Inventory management is a traditional operations management topic. Huang et al. (2013) make use of an inventory management reference model to show how to manage the customer orders with incompatible product families in a group company. Order management is an important link in SCM. The group company consists one headquarter and several subsidiaries which are considered as parallel batch processors. Given that many customer orders are driven by on-time delivery, the performance measure of interest is the total weighted tardiness. Based on the similarities of the batch scheduling problem and the order management problem considered in our paper, the referenced batch scheduling model is used. This batch scheduling model is widely used to minimise the total weighted tardiness on identical parallel batch processors with incompatible job families. This paper has made several contributions to the theme of the special issue with respect to integrated order management and referenced batch scheduling model application. Besides, a number of interesting general observations and managerial implications are derived from the specific case application and simulations.

Concluding remark

The number of submissions to this special issue is a good reflection on that application of reference models in SCM is a popular and timely topic. Importance of the reference models has been demonstrated by the quality of the submitted works. It is not surprising that SCOR is one of the key reference models in supply chain applications. In addition, the guest editors also observed that three coherent themes, namely, enterprise systems, environmental management and service operations, can be beneficial from the applications of reference models. This is a solid evidence to help conclude that applicability of reference models is diversified in many areas. The guest editors hope that you can enjoy reading the selected papers in this special issue. We also hope that you can obtain insights from them and that they can contribute in your future research or industrial applications.

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Their submissions are all with good quality but due to limited publication space, the guest editors have to select the very best out of the best for publication. We have inevitably disappointed some contributing authors and we wish them every success in publishing their papers in other outlets. Last but not least, the guest editors are grateful to Dr Stephen Childe, the Editor of Production Planning and Control, for accepting to publish this special issue. We would also like to thank the editorial and publishing team who provided all necessary supports to us. Without their assistance, this special issue would not have been able to be published.

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Note

1. http://supply-chain.org

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