Journal of Enterprise Information Management

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Received 30 March 2012
Revised 11 June 2012
25 June 2012
Accepted 25 June 2012

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Abstract

Purpose – Coordination in supply chains and networks calls for information sharing among the members of the supply chain. Accordingly, information visibility – the availability of relevant information for making supply chain related decisions is an important concept in the context of supply chain management. The purpose of this paper is to identify the different dimensions of information visibility and propose a framework based on these information visibility dimensions. The proposed framework can be used to evaluate supply chain information systems (SCIS) and their contribution towards information visibility in supply chains.

Design/methodology/approach – Using the proposed framework, we compare two different SCIS (SAP APO and SupplyOn) to assess the extent to which these systems meet the information visibility needs within supply chains and networks. In order to carry out the comparison, data regarding the two systems in collected using multiple methods such as from system documentations, training sessions, interviews with experts and systems engineers.

Findings – The findings indicate that both systems perform well in terms of supporting information visibility, however they serve different purposes within supply chains and networks. Based on the findings, the authors discuss the role of different types of SCIS depending on the characteristics of adopting firms and their supply chains, and how the use of these different systems can complement each other. The research and practical implications of this study are discussed in the overall context of supply chain management.

Originality/value – The framework can be used by organizations to assess the extent to which relevant information is accessible within their supply chains and to select from various SCIS solutions that are available. This research advances understanding on ways of achieving information visibility.

Keywords Supply chain management, Information systems, Information visibility, Supply chain management information systems, Information sharing, SAP advanced planning and optimization, SupplyOn

Paper type Research paper

1. Introduction

Organizations view their supply chains and networks as critical determinants of efficiency and effectiveness in the face of rapidly changing and competitive business environments, short product lifecycles and rapid market fluctuations (Lee, 2002; Goswami *et al.*, 2011; Herndez-Espallardo *et al.*, 2010). Successful companies have identified collaboration (Olorunniwo and Li, 2010) along the supply chain as means for achieving heightened efficiency and better business performance (Lee, 2002). This has

This research is supported by CLVBA@TUM – a project sponsored by SAP AG, and the European SAP University Alliances program.

Journal of Enterprise Information Management
Vol. 26 No. 3, 2013
pp. 276-294

1741-0398
DOI 10.1108/17410391311325234

resulted in a progressive transformation of supply chains toward inter-organizational supplier value networks (Goswami *et al.*, 2011).

Information sharing is considered a prerequisite for cooperation in supply chains and networks (Olorunniwo and Li, 2010). Accordingly, there has been a significant research emphasis on the role of information sharing and information integration as means of achieving better supply-chain performance (Samaddar *et al.*, 2006; Rai *et al.*, 2006). Information sharing among members of a supplier network allows them to achieve the visibility that is needed to act upon changing business conditions, and the degree of visibility impacts performance gains within the supply chain (Lee, 2002). To realize benefits within the supply network, members should have access to timely, relevant and accurate information (Rai *et al.*, 2006). Despite this recognition, supply networks across industries suffer from poor and inexact information, delayed sharing of information and lack of information (Patnayakuni *et al.*, 2006; Straub *et al.*, 2004). In this context, it is believed that information systems can play an important role in enabling visibility in supply chains and networks, and accordingly firms adopt various information technology innovations to integrate and improve supply-chain processes and networks (Christiaanse, 2005).

Supply-chain management information systems (SCIS) enable integration along supply chains (Buxmann *et al.*, 2004). These systems are used within a company or in inter-firm networks to execute integrated supply-chain-related business processes (Helo and Szekely, 2005). Benefits of SCIS include enhancement of productivity and lower operating costs (for instance, through reduction of inventory, improved service levels, etc.), access to timely information, increased flexibility and improved production planning and enhanced resource control and asset management (Buxmann *et al.*, 2004; Seidmann and Sundararajan, 1997). The highest benefits from these SCIS can be realized through using them in a shared collaborative environment (Mc Laren *et al.*, 2002). These systems contribute to value creation through information sharing and act as enabler for collaboration (Klein and Rai, 2009; Lee, 2002; Richard and Devinney, 2005; Patnayakuni *et al.*, 2006).

A growing body of research has recognized the role of information systems in enabling sharing of information within supply chains and networks. For instance, researchers have focussed on analyzing the nature of IT used in exchange relationships, and how information sharing can help in achieving supply-chain process integration for performance gains (Rai *et al.*, 2006; Subramani, 2004); how capabilities of IS applications deployed in inter-firm relationships can help in performance gains (Saraf *et al.*, 2007); and how the use of standardized IT applications can help firms in overcoming knowledge exchange barriers in inter-firm relationships and subsequently attain better performance (Malhotra *et al.*, 2007).

However, there is a lack of systematic investigation on the extent to which commonly used SCIS satisfy the information needs of the different supply-chain members. In particular, there is a scarcity of studies assessing the capabilities of large-scale information systems that are used at the network level (Reimers and Klein, 2006). SCIS are of different categories and fulfill different purposes within the context of supply-chain management and integration. They have been classified as transactional systems that are meant from exchanging and processing operational information, and analytical systems that allow strategic analysis of supply-chain-related information (Helo and Szekely, 2005; Shapiro, 2002). Moreover, certain SCIS are more expensive and call for a larger resource investments on behalf of the adopting firm, while open-platform internet-based solutions provide a less expensive alternative for supply-chain integration. Other factors such as complexity of implementation, maintenance cost or the overall firm strategy regarding flexibility *vis-à-vis* structure may influence the decision regarding whether firms integrate best-of-breed solutions from different providers or choose all systems from a single provider (Light *et al.*, 2001; Olsen and Sætre, 2007). Therefore, deciding on an information systems solution for supply chains or networks is a complex task for firms with many different systems competing with each other.

Accordingly, there is a need to assess the extent to which different SCIS support the information visibility needs of the network, and provide a mechanism for evaluating different SCIS. This paper addresses this need by defining an evaluation framework for assessing the extent to which information visibility is supported by an SCIS. We then use the proposed framework to compare two SCIS that are commonly used for supply-chain integration SAP Advanced Planning and Optimization (APO) and the SupplyOn systems.

2. Information as value enabler

An ability to sense where value lies within the supply network, and better coordination of activities in order to appropriate the value distinguishes high-performing networks and organizations. In complex and dynamic business environments, integration of information flow is viewed as the most critical factor in enabling coordination in supply-chain alliances (Hsu *et al.*, 2009). Furthermore, firms need to understand how to use information effectively to manage processes (Miller, 1996). Information sharing can help organizations in anticipating opportunities within the network (Bovet and Frentzel, 1999; Samaddar *et al.*, 2006), and thereby increase operational efficiency (Malhotra *et al.*, 2005; Straub *et al.*, 2004). For example, sharing information about the actual sales data at retail outlets allows manufacturers to better understand demand variations and thereby optimize their production capacities (Lee *et al.*, 1997). Buffers are common across any value network to deal with the uncertainties associated with demand and supply. An effective value network can allow firms to substitute information for these buffers and thereby increase agility in the network as well as reduce inventory costs, stock-out costs or costs of marking down products (Choi and Sethi, 2010; Goswami *et al.*, 2011; Magretta, 1998). In consequence, it can be stated, that information sharing is always beneficial (Gavirneni *et al.*, 1999).

Previous research in supply-chain management has highlighted the importance of information sharing. Simulations (e.g. Cachon and Fisher, 2000) and case studies (Ferdows *et al.*, 2004; Hammond, 1994) have confirmed information as an influencing factor for value creation in supply networks. Information sharing can help in achieving transparency for successful cooperation within the supply network (Sandberg, 2007), and is viewed as important for managing exchange relationships for value appropriation (Bovet and Frentzel, 1999; Lee *et al.*, 1997; Samaddar *et al.*, 2006; Rai *et al.*, 2006; Klein *et al.*, 2007). Access to information that is relevant, timely and accurate enable network members to react to various events in a timely manner and therefore such information is considered to be of a higher quality (Wang and Strong, 1996).

Visibility of information along the supply chain enables firms to synchronize their production, improve forecasts, coordinate inventory decisions and develop a common understanding of supply-chain performance (Lee and Whang, 2000; Simchi-Levi *et al.*, 2008). There can be different levels of visibility depending on the kind of information shared (Lamming *et al.*, 2001). The shared information can be classified as transactional, collaborative and strategic (Richard and Devinney, 2005; Patnayakuni *et al.*, 2006). While the exchange of transactional information allows the execution of daily businesses (Lee, 2002), the benefit of sharing strategic information is optimization of core processes within the supply chain (Klein and Rai, 2009). Visibility enables firms to analyze operational information and increase operational efficiency (Ivert and Jonsson, 2010). Examples are inventory reductions among supply-chain partners (Gavirneni, 2006), better utilization of capacities due to improved production and delivery schedules and optimized demand and forecast planning (Lee *et al.*, 1997, 2000). Information sharing can also contribute to strategic achievements whereby firms realize intangible assets (Straub *et al.*, 2004) such as strengthening bonds with customers and generating higher revenues (Anderson *et al.*, 1994).

3. Dimensions of information visibility

The extent to which information is available to different members of the network will determine the visibility within the network. While there is a general recognition that visibility is a desired characteristic of the network, there is less agreement regarding what constitutes information visibility. Accordingly, there is a need to define information visibility and identify its dimensions. The identified dimensions can form the basis for evaluating different SCIS in terms of their ability to support information visibility in the network.

The different dimensions of information visibility are identified based on literature. We draw from information systems (DeLone and McLean, 1992; Miller, 1996) and supply-chain literature (Closs *et al.*, 1997; Huang *et al.*, 2003) to develop the three dimensions of information visibility. Information visibility refers to having access to relevant information that can be used for various supply-chain-related decision making (Gulati and Kletter, 2005). Further, the information should be of a high quality (i.e. free of error), and it should be accessible in a timely manner (Straub *et al.*, 2004; Wang and Strong, 1996). Therefore, we choose variety of information, quality of information and connectivity as the three dimensions of information visibility in this study. The dimensions described below allow us to answer the following question in the context of the two information systems that are being assessed: what and how much information can be shared between supply-chain members using the SCIS? Is the shared information of a quality that allows makes them usable for the supply-chain members? Does the SCIS allow supply-chain members to seamlessly connect to other systems, either internal or external to the organization?

3.1 Variety of information

Variety refers to the different categories of supply and demand data that can be shared among firms. In practice, this includes inventory levels, sales data, demand forecast, order status, product planning, logistics, production schedules, etc. Sharing of inventory levels and sales data can help mitigating the bullwhip effect; sharing of performance metrics, such as product quality data, lead times, queuing delays, can help in identifying the bottlenecks within the chain and improve the overall performance (Lee and Whang, 2000). By sharing capacity information with the downstream partners, supply-chain partners can coordinate their production on demand and prepare against possible shortages (Lee and Whang, 2000).

Therefore, variety of information means that the system can provide all information that is needed to support decision making, to improve supply-chain performance and to get the required visibility (Closs *et al.*, 1997). In order to evaluate an SCIS, information variety can be considered to be made up of nine groups. These are master data, transactional data, demand information, inventory information, production information, transportation information, financial information, performance metrics and alerts.

Master data include structural information about the organization, its suppliers and customers and basic data, referring to the infrastructure and production processes, like raw material belonging to a machine and its production process (Benz and Höflinger, 2011). Transactional data include customer orders, expected delivery date, etc. (DeLone and McLean, 1992). Demand information provides forecast, information about promotional campaigns and therefore serves as a critical source of information about future business (Gavirneni, 2006; Ovalle and Marquez, 2003). Inventory information includes stock levels and decision models affecting order placements with supply-chain partners (Gavirneni *et al.*, 1999; Lee *et al.*, 2004; Ovalle and Marquez, 2003). Decision models are supported through expected service levels, inventory holding and backlog costs (DeLone and McLean, 1992).

Production information includes information about production lead-times, process steps and durations and help in the execution of production planning and steering activities (Benz and Höflinger, 2011). Moreover, resource and capacity information are used to optimize material flows, thereby increasing efficiency (Lee and Whang, 2000). Transportation information includes delivery schedules and an overview to track and trace products along the supply chain to increase visibility and improve distribution processes (Helo and Szekely, 2005; Montgomery *et al.*, 2002). Financial information contains information about the value of products, tax-related data and information regarding the processing of different types of invoices (Benz and Höflinger, 2011). Performance metrics are key performance indicators (KPI) that can support decisions for process improvements. KPI can assess inventory turn-rates, supplier performance, costs for special transports, etc. (Gunasekaran and Kobu, 2007). These metrics can be of internal or external use to monitor processes and alert firms in case of an exception (Montgomery *et al.*, 2002; Saeed *et al.*, 2011).

3.2 Quality of information

The quality of information refers to the degree to which the information meets the needs of the organization (Rai *et al.*, 2006). Quality of information ensures that information is of use for individuals, for the organization and the network (English, 2001), and is therefore an important factor affecting information visibility (Rai *et al.*, 2006). Furthermore, the information characteristics and their perception define the quality of information (Miller, 1996). Therefore, based on a review of previous research, information quality is further defined using six characteristics: accuracy, availability, compatibility, completeness, confidentiality and timeliness.

Accuracy ensures error free information (Closs *et al.*, 1997). The information shared should be complete, accurate and objective data and in the right context for firms to be able to use it effectively (English, 2001; Kaipia, 2009; Ryu *et al.*, 2009). Availability refers to information that is available and accessible in real time to align processes along the supply chain (Montgomery *et al.*, 2002; Premkumar, 2000). Compatibility means that information can be shared and interpreted by the different systems without requiring major transformations (DeLone and McLean, 1992; Premkumar, 2000). Efficient information sharing implies that information is available in a timely manner (Kehoe and Boughton, 2001), enabling firms to react before a disruption impacts their operations (Li *et al.*, 2006). Finally, confidentiality implies that only authorized parties have access to the relevant information (Premkumar, 2000).

3.3 Connectivity

Connectivity refers to how the information is transferred among the different parties. Accordingly, connectivity can be divided into internal and external connectivity. Internal connectivity refers to exchange of information across functions within the boundaries of the firm, whereas external connectivity refers to the possibility of exchanging information across enterprise boundaries with customers, suppliers, third party service providers and others (Closs *et al.*, 1997).

Connectivity allows intra- and inter-firm information systems to be linked to improve process coordination. Use of internet-based systems and standardized supply-chain processes offer potentials to improve connectivity (Bussiek, 1999). Connectivity can therefore support various concepts of collaboration and coordination among supply-chain members such as Vendor Managed Inventory (VMI) and Collaborative Planning Forecasting and Replenishment (Nambisan, 2000).

The above dimensions (variety of information, quality and connectivity) can be used as evaluation criteria to assess and compare different SCIS. Table I summarizes our evaluation framework based on these three dimensions of information visibility. We will use these evaluation criteria to assess and compare the SAP APO and SupplyOn systems.

4. SCISs

SCIS are software packages aimed toward performing a certain sets of tasks within the context of supply chain and networks. SCIS have evolved significantly over time in response to changing business models, rapid technological developments, a need to adapt to such changes and provide the functionality to support complicated and sophisticated business requirements (Barrett and Konsynski, 1982). Helo and Szekely (2005) provide a systematic overview of the evolution of SCIS, outlining different categories of such systems and the different purposes that they can serve. Therefore, for a firm considering the selection of a SCIS, very different types of systems compete with each other (Helo and Szekely, 2005). Therefore, there is a need to be able to assess these systems, their criteria for information sharing (Kristianto and Helo, 2010) and the extent to which they support information visibility as described in the previous section.

From a strategic management perspective, SCIS can be classified into intra-firm or inter-firm systems. While intra-firm systems operate within the boundaries of a firm, inter-firm systems allow process integration across firm boundaries. Accordingly, one of the desired characteristics of SCIS is internal compatibility with other information systems used within the organization and external compatibility with business partners (Buxmann *et al.*, 2004). From a data management perspective, SCIS have been classified into transactional and analytical systems (Helo and Szekely, 2005). Transactional systems are used for acquiring, processing and communicating raw data about the firm's supply-chain operations. In contrast, analytical systems focus on strategic analysis of transactional data to develop decision models, and on the optimization of future planning and scheduling activities.

SCIS can be further classified into planning systems and execution systems from a process perspective. The planning systems use advanced algorithms and models to determine the best way to fill an order, while execution systems primarily deal with the

Variety of information Data category	Description
Master data (Benz and Höflinger, 2011)	Organizational, infrastructure and material master data Supplier and customer master data
Transactional data (DeLone and McLean, 1992)	Historical data Customer orders
Demand information (Gavirneni, 2006; Ovalle and Marquez, 2003)	Demand forecast Promotional uplift
Inventory information (Gavirneni *et al.*, 1999; Lee *et al.*, 2004; Ovalle and Marquez, 2003)	Inventory level Location
Product information (Benz and Höflinger, 2011; Lee and Whang, 2000)	Bill-of-material Production planning and scheduling Quality requirements Resource and capacity information
Transportation information (Helo and Szekely, 2005; Montgomery *et al.*, 2002)	Delivery schedule Order status for tracking and tracing
Financial information (Benz and Höflinger, 2011)	Value of product Tax related data Invoice type
Performance metrics (Gunasekaran and Kobu, 2007)	Logistic key performance indicators (KPIs)
Alerts (Montgomery *et al.*, 2002; Saeed *et al.*, 2011)	Notifications and exception alerts
Information quality *Quality category*	*Description*
Accuracy (Closs *et al.*, 1997)	The extent to which information is error free
Availability (Montgomery *et al.*, 2002; Premkumar, 2000)	The extent to which information can be accessed when and where desired
Compatibility (DeLone and McLean, 1992; Premkumar, 2000)	The extent to which information is capable of being used with or connected to other systems or components without modification
Completeness (English, 2001; Kaipia, 2009; Ryu *et al.*, 2009)	The extent to which information is not missing and is of sufficient breadth and depth for the task at hand
Confidentiality (Premkumar, 2000)	The extent to which information is secured and available only to persons authorized to see and to use
Timeliness (Kehoe and Boughton, 2001)	The extent to which information is current relative to the situation
Connectivity *Connectivity category*	*Description*
Internal connectivity (Closs *et al.*, 1997)	Connectivity with internal information systems and with internal functionalities
External connectivity (Closs *et al.*, 1997)	Data exchange formats and integration with external systems and platforms

Table I.
Dimensions of information visibility

physical status of goods, the management of materials and financial information involving all parties. Supply-chain applications that are based on open-data models can support data sharing both inside and outside the firm. These extended enterprise models contain key suppliers, manufacturers and end-customers of a specific firm. Each of the different classes of SCIS identified above, have different ways of handling data and this can result in significant differences in terms of information visibility.

Using the classification schemes discussed above, SAP APO can be classified as an analytical system while SupplyOn can be classified as a transactional system. SAP is the leading supply-chain application vendor with the largest market share (Trebilcock and Rogers, 2009), while SupplyOn is a successfully managed third-party hub which currently serves over 2,700 suppliers primarily in the automotive and manufacturing industries (Howard *et al.*, 2006). SupplyOn has emerged as a leading multi-enterprise business process platform by processing raw data across organizational boundaries and can integrate business processes in the areas of sourcing, logistics, engineering, quality management and finance. SAP APO focusses on forecasting and planning for the future based on the transformation of transactional data with the aim of improving supply-chain-related decision making.

4.1 SAP APO

Planning is the critical first step in the process of achieving operational efficiencies within supply chains and networks. The SAP APO is primarily a planning tool supported by data from the SAP enterprise resource planning suite (SAP R/3), and the business warehouse suite (SAP BW). Firms cannot use SAP APO on its own, but have to use it in conjunction with the R/3 and the BW systems. The architecture of SAP APO (later on also referred as APO) is shown in Figure 1 (Ivanova, 2009). The APO can be used as an analytical system that can simulate different scenarios using current and historical data from the other systems. Each business unit within the organization can be linked to the APO, and further, using enterprise application integration (EAI) platforms other customers and suppliers can also be integrated into the APO systems for the purpose of supply-chain collaboration, such as through collaborative planning, forecasting and replenishment (CFPR) (Fliedner, 2003).

The supply-chain processes covered by APO include demand planning, production planning and detailed scheduling, supply-network planning and transportation planning. Demand planning includes forecasting figures for short-, mid- and long-term planning. The production planning and scheduling module allows the optimization of resource capacity utilization as well as the creation of detailed production schedules. Supply-network planning optimizes the supplier order processing in conjunction with planned production schedules based on customer orders and available resources. Transportation planning is used to manage and optimize the distribution network in order to meet customer requirements. Since the planning and scheduling done by APO is based on actual transactional data from the ERP systems, there is visibility into inventory levels, delivery schedules, etc. Accordingly, simulations can be carried out over the entire supply chain, or parts of it.

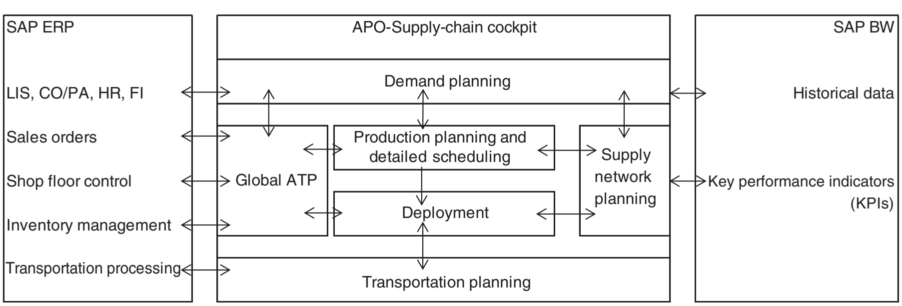

Figure 1.
Schematic overview of the SAP APO system

4.2 SupplyOn

SupplyOn provides an on-demand platform, which allows business partners to access and share real time information such as detailed information about production batches. Setting up the data structure that will be exchanged is the responsibility of SupplyOn's users. For communication between business partner's standardized formats (xml, Edifact, WebEDI, etc.) and transport protocols (ftp, http, etc.) are used. Therefore, SupplyOn is not limited to any specific architecture and can be connected to many information systems. However, the platform is not able to perform further actions with the data like scheduling or capacity planning. Therefore it is classified as transactional system, acting as an intermediary in a global environment.

SupplyOn can be divided into four main categories, which focus on different supply-chain processes (see Figure 2; SupplyOn-AG, 2011). These are sourcing, quality, logistics and finance. For each of these four categories, further distinction is made between development and production phases. Sourcing deals with purchasing and related aspects such as identification of potential suppliers, request for quotation and price negotiation. Quality deals with product quality planning, supplier rating and other aspects of quality management. Transfer of transactional data, like call-offs, delivery instructions, etc. as well as the possibility to have transparency of stock levels, implementation of VMI and Kanban are supported within logistics. Finance deals with invoices, settlement advice and remittance advice, although actual payments are not handled by the SupplyOn system. SupplyOn relies on platform independency, usage of standardized communication formats and the possibility for multiple connections between various business partners, for supporting "m:n-relationship."

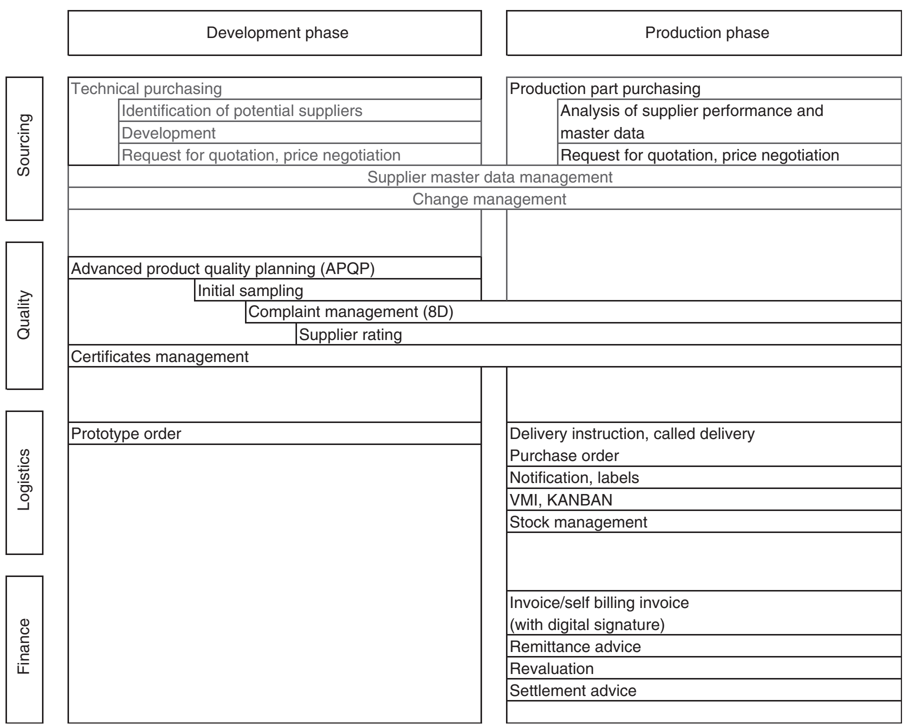

Figure 2.
Overview of the SupplyOn system

5. Research method

The information visibility dimensions and the various criteria listed in Table I are used to evaluate the two SCIS – SAP APO and SupplyOn. In order to assess the extent to which these systems satisfy our evaluation criteria, two independent researchers collected data from a variety of sources. In the first round of data collection, we systematically went through and reviewed the various system documents (functional documents, training documents, user manuals, etc.). This was then followed up with the researchers participating in two user trainings (two one-day training, one for each system). Demo versions of the SAP APO system hosted in the university competence center (of the researchers' home university) was independently reviewed by the researchers in order to get a better understanding of the different information and processes support by SAP APO. For SupplyOn, we were able to obtain a two-week access to a demo instantiation of the system that is used by SupplyOn for providing client trainings. Having access to both systems over a prolonged period of time helped us in assessing them in an objective and detailed manner, and provided us with valuable insights into the systems. This helped us in getting a better understanding of both systems, the different supply-chain processes and functions they supported and the kind of information that could be shared using the system. Following this, we carried out four interviews with support engineers from both SAP and SupplyOn to clarify any further doubts regarding the systems, and to validate our findings and assessments regarding the functionality afforded by these systems. These were semi-structured interviews with each interview lasting over one hour. The interview data were reviewed to analyze the extent to which these systems supported information sharing and assign the scores (reported in Tables II-IV).

5.1 Assessing information visibility in SAP APO and SupplyOn

Table II indicates the extent to which SAP APO and SupplyOn meet the criteria for variety of information. The last two columns in the table indicate whether or not the particular information type can be shared using the system.

Since SAP APO uses transactional data from the SAP R/3 ERP system, it has access to all relevant information regarding products, customer orders and their current status in the inter-company supply chain, production plans, inventory-related information. In contrast, SupplyOn only supports the sharing of basic data about inventory planning, and delivery schedules (such as truck pick-up times), used primarily for communication and reporting. It does not support the sharing of forecasting and scheduling information, and further does not support any kind of transformation on the shared information. SupplyOn further supports the sharing of financial information, which is not provided by the SAP APO system.

Our analysis indicates that SAP APO provides more breadth in terms of the variety of information that it supports (Table II). Accordingly, it can be stated that SAP APO can be used as a steering tool within the supply chain or network, while SupplyOn is more suited for sharing basic information among network members.

For assessing the different criteria of information quality, we used a three-level scale where "high" indicates that information quality is assured, "medium" indicates that information quality is partly met and "low" means that there is no assurance of information quality. Table III shows the comparison between SAP APO and SupplyOn.

In SAP APO, data accuracy is determined by the extent to which data is accurate in the base systems (R/3 or BW). Therefore incomplete or missing data, particularly for data that is generated through manual entry in the base systems will affect the

Variety of information Data category	Description	SAP APO	SupplyOn
Master data (Benz and Höflinger, 2011)	Organizational, infrastructure and material master data	Yes	No
	Supplier and customer master data	Yes	Yes
Transactional data (DeLone and McLean, 1992)	Historical data	Yes	No
	Customer orders	Yes	Yes
Demand information (Gavirneni, 2006; Ovalle and Marquez, 2003)	Demand forecast	Yes	No
	Promotional uplift	Yes	No
Inventory information (Gavirneni *et al.*, 1999; Lee *et al.*, 2004; Ovalle and Marquez, 2003)	Inventory level	Yes	Yes
	Location	Yes	No
Product information (Benz and Höflinger, 2011; Lee and Whang, 2000)	Bill-of-material	Yes	No
	Production planning and scheduling	Yes	No
	Quality requirements	No	Yes
	Resource and capacity information	Yes	No
Transportation information (Helo and Szekely, 2005; Montgomery *et al.*, 2002)	Delivery schedule	Yes	Yes
	Order status for tracking and tracing	Yes	No
Financial information (Benz and Höflinger, 2011)	Price, tax-related data, invoicing	No	Yes
Performance metrics (Gunasekaran and Kobu, 2007)	Logistic KPIs	Yes	No
	Supplier assessment	No	Yes
Alerts (Montgomery *et al.*, 2002; Saeed *et al.*, 2011)	Notifications and exception alerts	Yes	Yes

Table II.
Analysis of variety of information

Information quality Quality category	SAP APO	SupplyOn
Accuracy (Closs *et al.*, 1997)	Medium	Medium
Availability (Montgomery *et al.*, 2002; Premkumar, 2000)	High	High
Compatibility (DeLone and McLean, 1992; Premkumar, 2000)	High	High
Completeness (English, 2001; Kaipia, 2009; Ryu *et al.*, 2009)	High	Medium
Confidentiality (Premkumar, 2000)	Medium	High
Timeliness (Kehoe and Boughton, 2001)	High	Medium

Table III.
Analysis of information quality

accuracy of SAP APO. Similarly, in SupplyOn, the accuracy is determined by the quality of the input files or errors in manually entered information (since not all firms use automatic data transfer). Therefore, both systems are rated as medium in terms of data accuracy.

Availability is high for both systems, since they are accessible anytime and from anywhere using internet enabled access. Both SupplyOn and SAP APO are capable of

Connectivity category	Characteristic	SAP APO	SupplyOn
Internal connectivity (Closs *et al.*, 1997)	Connectivity with internal information systems	SAP R/3, BW, EM, ICH	Integrated web-based SCM solution
	Connectivity with internal functionalities	PUR, MM, PP, Log, SD, HR, CO	Integration of internal system
External connectivity (Closs *et al.*, 1997)	Data exchange formats	Direct-entry, WWW, EDI, XML, FTP, RFID, Barcode, Spreadsheets	Direct-Entry, WWW, EDI, XML, FTP, Web-EDI, Barcode

Table IV.
Analysis of connectivity

receiving and transferring data over standardized interfaces and protocols, which results in high levels of compatibility. In terms of completeness, the APO system has access to more complete information for planning and coordinating complete supply-chain processes (intra-firm processes, as well as inter-firm processes). In contrast, SupplyOn is not suitable for coordinating and integrating intra-firm processes, but is primarily targeted toward exchange of transactional information across firm boundaries.

Both systems ensure confidentiality using access control through authorization. However, SupplyOn implements a stricter access control by means of digital signature verification, particularly for the exchange of financial information. Timeliness refers to the extent to which the information is current. SAP APO is directly connected to SAP R/3 system, which collects data from machine subsystems, logistic subsystems and other systems within the firm that support real-time updating of information. SupplyOn primarily carries out data transfers across firms based on automated hourly, daily, weekly transfer or manual transfers.

Table IV shows the analysis of SAP APO and SupplyOn in terms of connectivity. SAP APO is usually integrated with SAP R/3 and BW systems, and can also be connected with the SAP event management systems and the SAP inventory collaboration hub. Therefore, in terms of functionality, SAP APO can connect with procurement, manufacturing and logistics system. SupplyOn can be run as an integrated web-based SCM solution, and can be connected with various functional systems (such as existing ERP systems, inventory systems, etc.).

In term of external connectivity, both SupplyOn and SAP APO support open interfaces and standards. SAP APO can be integrated with various kinds of data acquisition technologies, such as direct entry, Spreadsheets, EDI, XML, FTP, RFID and it can be linked to other non-SAP systems. On the other hand, SupplyOn supports EDI and WebEDI for exchanging information. WebEDI is EDI messages as web forms which the suppliers receive via the internet in a straightforward manner. internet data exchange is based on the XML format.

5.2 Implications of SAP APO and SupplyOn on information visibility

SAP APO and SupplyOn have fundamentally different approaches toward information sharing. While SupplyOn is primarily meant to be used as an integration tool across firm boundaries, SAP APO is used for advanced supply-chain operations such as planning, forecasting and optimization through close integration with other SAP systems. Despite these differences, both systems provide significant support for information visibility. SAP APO and SupplyOn are very similar in the extent to which they satisfy the requirements for information quality and connectivity. For variety of information, SAP APO has access to and therefore supports the sharing of a wider spectrum of information that are relevant from a supply-chain management perspective.

While SAP APO provides advanced features and capabilities for planning and optimization within and across firm boundaries, these features require the availability of data from other internal SAP systems. Therefore, using SAP APO to integrate with a supply-chain partner that does not also have SAP systems prevents firms from realizing the full potential of SAP APO (Monge *et al.*, 1998). In such circumstances, SupplyOn may be more suitable for achieving information visibility within the network, as the web-based structure of SupplyOn allows platform independence for firms sharing supply-chain information.

6. Discussion

SCIS are critical for synchronizing information among members of supply chains and networks, and accordingly there is a need to better understand the similarities and differences between different SCIS in order to be able to carry out a systematic evaluation and selection of such applications (Mc Laren and Vuong, 2008). Our paper contributes toward this by developing an evaluation framework for assessing information visibility in different SCIS. The framework is based on the identification of three information visibility dimensions – variety of information, quality of information and connectivity.

We use this framework to compare two different SCIS and assess the extent to which they satisfy information visibility criteria. The two SCIS are analyzed and compared based on the relative presence or absence of functionalities, which allow them to fulfill the information visibility requirements within a supply chain or network. Our assessment indicates that both systems can serve the purpose of increasing information visibility among firms in supply chains or networks.

Firms, using the SAP APO system or other SAP systems (such as R/3, BW, etc.), have to invest in them simultaneously. SupplyOn on the other hand does not depend on any specific system and can be relatively easily integrated with any other system. Therefore, SupplyOn calls for less investment effort on the firm's behalf. SupplyOn is an attractive option for smaller firms who need to coordinate with larger manufacturers, or integrate with other firms within their networks. It supports both data exchanges and supply-chain process integrations using standardized interfaces. Accordingly, SupplyOn is also used as a supporting system for locally installed ERP and SCM systems within firms. For larger firms, the choice of the SCIS could be based on factors such as whether or not they have large-scale ERP systems, the characteristics of their supply chain/network and the IT infrastructure and capabilities of their trading partners. For example, a large firm may consider adopting SupplyOn when they want to exchange information with multiple suppliers, whereas, a one-to-one relationship with a major supplier or buyer could be managed by integrating using SAP APO. This research distinguishes between the characteristics of two different breeds of SCIS, and can act as a guide for practitioners to select the right system based on their supply-chain strategy and the needs of the supply network. The importance of such guidance is further underlined by the fact that multi-tiered and inter-connected supply chains require different information technology solutions compared to inter-organizational systems for point-to-point connection (Steinfield *et al.*, 2011). Moreover, the research allows firms with focus on supply-chain management to align processes by selecting appropriate systems supporting information visibility. From a theoretical perspective, our paper contributes toward existing literature in information visibility in supply chains and networks by reviewing the role of information sharing and identifying the three critical dimensions of information visibility to assess different SCIS. The dimensions of information visibility can be used to not only compare different SCIS, but also be used to further analyze the role of information visibility in various supply-chain-related decisions and outcomes.

7. Limitations and future research

Our research results are limited as we compare two different types of SCIS, used to serve different supply-chain functions. Additional research is needed to generalize our findings, such as by comparing similar systems (e.g. comparisons between multiple analytical systems that are similar to SAP APO, and comparisons between multiple web-based systems such as SupplyOn). However, by assessing two seemingly different systems, our research provides a more holistic view on information sharing in supply chains. Our findings and analysis indicate that both systems can complement each other by contributing to information visibility either on a supply-network level, or on a point-to-point relationship in the supply-chain level.

Our analysis relies on interviews with software engineers, documentation, training material and an analysis of the two systems by the researchers. Future research can be used to strengthen our findings by conducting case studies to investigate various implementations of SCIS in business settings, and analyze the extent to which they satisfy the information visibility requirements in the context of their use. Future research can also investigate the extent to which these information visibility dimensions actually result in better coordination and decision making in supply chains and can attribute to performance gains. For instance, case studies and surveys could be used to get a better understanding of supply-chain practices and the current state of information visibility within supply chains and networks. Further, simulations can be carried out to investigate the relationship between the different levels of the three information visibility dimensions and supply-chain performance.

Further, detailed case studies can be used to investigate the level and patterns of information sharing within supply chains and networks: which information is shared? How much information is shared? With whom is information shared? What factors determine the level of information shared? A more detailed analysis of information sharing patterns would help to understand supply-chain performance and differences between firms in a supply chain. In a consecutive step, it would be helpful to analyze how different SCIS address the information sharing needs and information sharing patterns of firms in the supply chain in certain industries, and for different products.

8. Conclusion

This research provides a framework developed from literature to compare SCIS and to analyze information sharing capabilities of SCIS. The framework is based on three major dimensions of information visibility, and therefore enables practitioners and researchers to identify the strengths and weaknesses of SCIS at a detailed level of analysis. From a practical standpoint, the findings from this research has significant relevance for supply chain and network practitioners by allowing them to analyze and choose a SCIS solution that is the most suitable for their firm based on the characteristics of their supply chain and network. Researchers can use this framework to analyze various supply chains and networks, and identify the relationship between the various information visibility dimensions and their implications on supply-chain performance.

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Further reading

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