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Improving the global supply chain through service engineering: A services science, management, and engineering-based framework

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ABSTRACT

Great changes within the business environment in the last 2 decades have made supply chain management (SCM) an important topic for academics and practitioners. Globalization, larger reliance on layered suppliers for specialized capabilities and innovation, changing customer needs, reliance on supply networks to maintain a competitive advantage, and developments in technology have all contributed to a very different supply chain environment. Most current works view customers as being outside the supply chain design; however, we believe that customers are the missing link in the supply chain. Therefore, in this paper, we focus on the customer's role in the process. We present an original discussion of the emerging discipline of services science, management, and engineering (SSME) in SCM, identify and bridge the gaps between SSME and SCM, as well as discuss ways to align them. In addition, we consider the specific challenges as well as the opportunities for SSME in supply chain management.

1. Introduction

The global supply chain facilitates functions such as purchasing, operations, manufacturing, and logistics. It plays a key role in supplying goods and services to final customers (Narasimhan & Talluri, 2009). Traditionally, interest in global supply chains has focused on operational issues, such as manufacturing and efficiency (Kuei, Madu, Lin, & Chow, 2002; Lin, Chow, Madu, Kuei, & Yu, 2005). However, since its foundation in the manufacturing industry in the 19th century, supply chain management has undergone substantial changes. In today's highly competitive global economy, changes in customer requirements, the business environment, and supply networks, as well as shortened product cycles, have together changed the competitive environment of supply chains. There is now a greater need for rapid responses to meet customers' demands for more high quality products and services (Lin et al., 2005). Clearly, the keen competitive environment of the 21st century requires supply chain management (SCM) to be more proactive than in the past.

Because of the continuing transformation of industrialized economies from a manufacturing base to a service orientation, the global supply chain, which is characterized by multilayered supplier-customer relationships, presents a number of opportunities and challenges (Demirkan et al., 2008; Smith, Karwan, & Markland, 2007; Spohrer & Maglio, 2008). Numerous studies have shown that high levels of quality and service are essential if suppliers wish to meet supply chain challenges and enhance their competitive position in today's global environment (Abdullah & Tarib, 2012; Bendoly, Donohue, & Schultz, 2006; Chua & Linb, 2011; Doukidis, Pramatari, & Lekakos, 2008; Lin et al., 2005; Roussinov & Chau, 2008; Singhal, Singhal, & Starr, 2007). However, some scholars argue that the importance of services has been underemphasized (Metters & Marucheck, 2007). Therefore, companies in the supply chain must understand the needs of service stakeholders in order to identify problems and opportunities (Li, Wang, Yu, & Yang, 2007).

In recent years, an interdisciplinary field called services science, management, and engineering (SSME) has emerged to coordinate the design and implementation of services systems. The rationale behind SSME is that service is a complex system that requires organizing people and technologies to perform tasks that provide

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value for others. The objective is to combine fundamental scientific and engineering theories, models, and applications with facets of the management field (Dietrich, Paleologo, & Wynter, 2008; Li et al., 2007). Most importantly, SSME stresses the critical importance of customers, and emphasizes the balance between technology and the fulfillment of customers' needs. It provides a framework for organizations to rethink their service design philosophy and reexamine the enabling process in a scientific manner.

SSME is a new discipline, so academics and practitioners in the SSME community are still laying the groundwork for this challenging research area (IBM, 2009). Researchers argue that there is an urgent need to: (1) explore the use of SSME in the supply chain; (2) consider the service dimension of complex, global, and emerging supply chains, and increasingly service-orientated enterprises; and (3) facilitate and enhance service innovation (Johnston, 2005; Neely, 2007; Paton & McLaughlin, 2008; Roth & Menor, 2003; Voss, Roth, & Chase, 2008). Hence, researchers are keen to identify the frameworks and theoretical perspectives most appropriate for studying service-oriented management issues (Demirkan et al., 2008; Maglio & Spohrer, 2008; Spohrer & Maglio, 2008). However, relatively few studies have focused on ways to bridge the gap between SSME and SCM.

Given this background and our belief that customers are a fundamental part of the supply chain, we consider the following research questions in this study: (1) What can SSME contribute to the global supply chain, and what are the gaps between SSME and SCM? (2) What are new conceptual frameworks and theoretical perspectives appropriate for studying service-oriented technologies and management practices?

In the remainder of this paper, we provide a survey of SSME, and express our views about the field and its development. In particular, we discuss the relevance of SSME to SCM, and examine opportunities to emphasize the concept in supply chain management. We also identify opportunities to make SSME help SCM. Finally, we present an SSME-based supply chain framework that pinpoints how to use SSME to SCM. Our goal is to foster a better understanding of how best to encourage service innovation in an increasingly complex business environment.

2. Previous work

2.1. The service background

Service innovation is a critical driver for business growth, and has gained much attention in the last decade (Paton & McLaughlin, 2008; Paulson, 2006). The majority of workforce is engaged in service providing rather than in agricultural or manufacturing activities in modern world. Research also provides evidence that many of the major manufacturing companies generate a growing portion of their revenues from service activities. Bryson et al. (2004) argued that the demand for services as an input to the production of goods has been growing enormously in the past decades. Given that background, Chase and Apte (2007) pointed out that researchers and practitioners have been aware of the importance of services in the supply chain with the continuing growth of the service sector. Weng, Su, and Lai (2011) also argued that service is indispensible part of business success, while Lien, Wen, and Wu (2011) emphasized the critical role of service quality for process.

Service innovations have the potential to influence service productivity, service quality, and the rates of growth and return of service systems (Spohrer & Maglio, 2008). As a result, most large manufacturing companies have now recognized the importance of service and adopted service-oriented business strategies accordingly. For example, a shift from service orientation to the focus of product-orientation of their business strategies by leading global corporations, such as IBM, HP, and EDS, have been observed (Li et al., 2007). Moreover, top management of IBM transformed itself as an service business because of realizations that the company must achieve effective service innovations (Demirkan et al., 2008). Since 2004, the company has expended efforts on incorporating service concepts into its business model, and thereby redefined its business strategy. IBM's key service concepts are to improve quality, sustainability, learning from customers, and innovation (Li et al., 2007; Zhao, Tanniru, & Zhang, 2007).

2.2. SSME

SSME developed from the pioneering work of researchers at IBM and associated institutions (Allen, Mugge, & Wolff, 2006; Chesbrough, Vanhaverbeke, & West, 2006; Maglio & Spohrer, 2008). Specifically, SSME highlights the importance of service, and tries to harness the power of scientific and engineering theories, models and applications to support service design as an industrial product. This enhances service innovation and user satisfaction (Bitner & Brown, 2008), and motivates both practitioners and academics to nurture the adoption of SSME (IBM, 2009).

Spohrer and Maglio (2008) emphasized that service can create value and supported by many studies (Demirkan et al., 2008; Lusch, Vargo, & Wessels, 2008; Sampson & Froehle, 2006; Vargo & Lusch, 2004). To date, the majority of SSME studies have focused on system development.

Studies of services have been applied on marketing, management or service sector economics (Demirkan et al., 2008). For example, the call center operations (Chevalier & Van den Schrieck, 2008), the financial services industry (Menor & Roth, 2007; Nair & Anderson, 2008), and the health care industry (Cayirli, Veral, & Rosen, 2008; Van Dijk & van der Sluis, 2008). Li et al. (2007) observed that there are still few studies in SSME because SSME is a relatively new area. Many studies focus on an overview of the field and are not directly relevant to SSME. A business-technology perspective, which induces more synthesis, is greatly needed; despite this, earlier studies only discussed service from a business perspective (Li et al., 2007).

Our survey of previous works identified several trends in existing SSME studies. First, service innovation and technology issues should be both valued, in contrast to merely focusing on the technological aspect for the new discipline (Abe, 2005). Second, service-oriented architectures must be emphasized as this issue has been emphasized by many studies (Bitner & Brown, 2008; Chesbrough et al., 2006; Demirkan et al., 2008; Janner, Schroth, & Schmid, 2008; Lusch et al., 2008; Spohrer & Maglio, 2008; Vargo & Lusch, 2004; Zhao et al., 2007).

2.3. The need for an SSME framework

SSME requires interdisciplinary research to enhance its applications while the attention from multiple disciplines acting independently is positive (Abe, 2005; Allen et al., 2006; Chesbrough et al., 2006; Paton & McLaughlin, 2008; Paulson, 2006). There is also a great need to study SSME from a business operation perspective (Demirkan et al., 2008; Goo, Kishore, Rao, & Nam, 2009; Maglio & Spohrer, 2008; Smith et al., 2007).

SSME is in its exploratory phase. Voss et al. (2008) proposed a service framework for the field of operations management. They argued that framework developing is young in this field and to develop a clear concept and framework contribute to the development of SSME (Li et al., 2007). Nevertheless, the literature on the supply chain is quite sparse. Hence, there is a great need for a framework that: (1) includes the unique characteristics of SCM; and

(2) can identify the specific challenges and opportunities in the supply chain.

3. The framework

Before describing our framework, we consider the gaps between SCM and SSME. SCM possesses unique characteristics that differentiate it from other fields. First, the supply chain has been characterized as a link between different parties; therefore, it must have a strong service-oriented foundation to satisfy customers' needs. More specifically, goods and services pass through a series of linked channels before being delivered to the final customers. Each layer of the buyer–supplier relationship is a subdivision of the whole supply chain, and must satisfy the customers in that stage. This high level of interaction suggests that the units coordinate dynamically. In today's competitive global market, where customers' needs change rapidly, customers are less inclined to stay with one supplier because they normally have several opportunities to change their suppliers on an *ad-hoc* basis. Business relationships tend to be short-lived, especially when the environment is complex and dynamic. Thus, to retain customers, companies must be able to adapt to rapidly changing customer requirements and constantly improve their service delivery.

The second gap between SCM and SSME is that supply chains are characterized by multilayered supplier–buyer relationships. Because of their prevalence in the global supply chain, they have the potential to cause disruptions in service delivery. Each node in the supply chain plays a dual role, i.e., buyer and supplier. Hence, each node must integrate the partly finished services/products derived from upper layer suppliers with its own value-added service/product, and then deliver the latter to its customers. This characteristic makes it more difficult to guarantee the quality of goods and on-time delivery to final customers. The traditional supply chain perspective suggests that suppliers should reduce their inventories as much as possible. Although most studies argue that information sharing and customer satisfaction are critical, the concept is a top-down planning strategy. In other words, it does not incorporate *ex-ante* service planning, so it is difficult to devise a global plan, especially in the presence of uncertainty and the long-whip effect. Therefore, lead times and inventories make a long supply chain more unpredictable.

The third key gap is that each node in the current global supply chain works in an isolated manner. As a result, each node's strategy is based on a micro rather than a global perspective. This aspect is highlighted by the following questions, which were posed by Simchi-Levi, Kaminsky, and Simchi-Levi (2003): (1) Should manufacturers be responsible if their retailers run out of stock? (2) After shipping their products, should manufacturers be responsible for on-time delivery to the final customers? (3) Should retailers be responsible if their suppliers' inventories are too small/too large? These questions show the nature of the supply chain and provide a basis for rethinking how SSME can be integrated into a supply chain framework.

In our literature review, we found that SSME provides a complementary, perspective of the supply chain field. The gaps between SSME and SCM are multidimensional. The first gap is the relationship between buyers and suppliers. The traditionally supply chain management perspective regards customers as the last stage of the whole commercial process. This point of view, combined with the traditional mindset of suppliers that their total costs must be minimized, does not always give customer service a high priority. From the customers' perspective, the traditional supply chain views selling as the end of the trading process. In contrast, SSME considers that customer satisfaction and addressing customers' needs are of paramount importance. This approach differs from the *duality* view that is deeply rooted in the traditional supply chain.

The production process is another dimension that reflects a gap that is in the structure of the traditional SCM mindset. The traditional supply chain views the process as a standard, mechanical process, but the SSME approach rethinks all roles and boundaries. Table 1 details the gaps between SCM and SSME.

Based on our study of the gaps between the two concepts, we examine the reengineering of the traditional supply chain mindset before presenting our framework. Fig. 1 shows the re-engineering required to bridge the concepts between SCM and SSME. In the traditional supply chain, the consequence flow is strict and well-defined from the supplier to the organizations downstream and then to the final customer. Customers are receivers of upstream products and services. Although some organizations do consider customer satisfaction, such evaluations are by nature *ex post*, and they are not part of an organization's flow/product/service design. Therefore, reengineering of the customer-dominant mindset is necessary. That is, end customers must *push* their requirements so that upstream suppliers understand their needs precisely, instead of simply being passive recipients of the products/services offered by suppliers. The same situation exists in everyday life. If a customer orders a book from an online e-bookstore, they do not care about the complex electronic process used by the supplier. The customer only wants to obtain the desired product, and the process involved constitutes their buying experience. Thus, a dialogue must be fostered so that the supplier can learn the customer's needs. In this way, the traditional push from suppliers to customers would be reversed, i.e., from customers to suppliers.

For the quality dimension, it is critical that the complex supplier hierarchy be *invisible* to customers. Essentially, customers need a single contact window to provide quick and comprehensive

Table 1
The gap between supply chain management (SCM) and service science, management, and engineering (SSME).

	SCM view	SSME mindset	Gaps
Customer	All sales final	Customer satisfaction is paramount.	Duality/bipolarity
	Tangible goods	Intangible services	Re-engineering of services
	Cost oriented	Value added	Benefits shift to value
	Hard issues	Soft issues included	Feeling/psychology re-engineering
	Ex-post customer satisfaction	*Ex-ante* customer satisfaction	Mutual consequence (mutual cause and effect) concept
Process	Mechanism/standard	Rethink roles/boundaries	Removes boundaries and changes roles
	Mass production/cost minimization generates revenue	Services generate revenue	Customer needs being the first priority
	Customer excluded from process design	Customer included in the process design	Customer-driven process
Technology	User requirement	Customer requirement	Re-defines the concept of users and customers
	System standardization	Service innovation	Provides technology as a service to customers

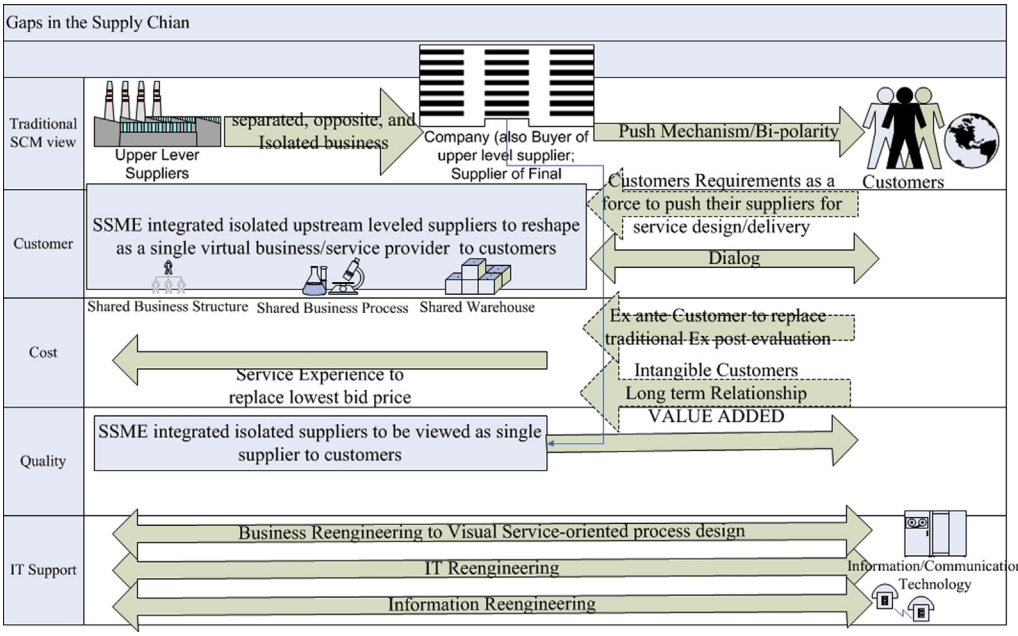

Fig. 1. How boundaries in the traditional value chain are removed and the differences in a service science, management, and engineering (SSME)-based supply chain are addressed.

service. This requirement transforms the supplier into a single contact window and virtual service provider for customers.

To meet the reengineering requirement of information and communication technology (ICT) for an SSME-based supply chain, the traditional boundary design approach must be broken down. At the intraorganization level, the boundaries between different units must be removed to meet the requirement. Meanwhile at the interorganization level, geographical boundaries are being broken down and the ways that buyers and suppliers conduct business are changing to enable the service-oriented units of different suppliers to work together. As a result, customers are central to the design of the whole supply chain.

We have identified the gaps that exist between the traditional and the SSME-based supply chain perspectives, and examined the reengineering requirements. Next, we link the supply chain and SSME to service characteristics via the proposed framework, as shown in Fig. 2.

The following aspects of the framework are especially noteworthy:

1) *The concept of mutual construction replaces the bipolar distinction of dualism.* An SSME-based supply chain encourages more effective and efficient *ex-ante* interaction and engagement, and also fosters proactive dialogue and cooperation with customers. This is because the exchange of experiences requires collaboration between various parties to design the configuration of the service-based supply chain. Suppliers and users enter into a dialogue to facilitate mutual understanding, and to define the nature and extent of the exchange. They then continue this dialogue to ensure that the exchange is effective. Moreover, by maintaining this ongoing discussion of the client's requirements, both parties can extend and strengthen their relationship. In this sense, the customer is one of the dual components of a supply chain, and thus contributes to its construction. The two-way dialogue must begin before the design of the products, services, and structures that support all the necessary activities. The traditional linear and one-way relationship thus becomes a *mutual cause and consequence* type of relationship, where the customer actually participates in the production process. Service-centered supply chains differ from manufacturing-centered supply chains because of the intangible nature of services, and the difficulty of gauging customers' true needs. For example, there are numerous cases where suppliers fail to meet their customers' true requirements, even though they provide high-quality products. Therefore, researchers and practitioners must recognize that customers are critical components in an SSME-based supply chain, and adopt an innovative approach to meeting customers' needs.
2) *Single solution provider: the complex supplier network is invisible to customers.* Customer-centered service design ensures that an enterprise acts like a *service provider.* For example, a company may want to offer different procurement functions, such as searching for a rare item, as *services on demand.* This requires that business processes should be rendered as services that can be integrated dynamically to meet changing customer requests. The ability to create or restructure such services means that a company can react quickly in a dynamic environment. For example, when customers visit a bank, they care more that their needs are met quickly on the spot rather than background technology such as interbank transfers; they just want. Therefore, service quality in a global supply chain must be coordinated to satisfy each customer's particular needs.
3) *Melting of intraorganization and interorganization boundaries.* It is crucially important that a supply chain can provide prompt, correct services to final customers. The SSME-based approach redefines the boundaries between and within organizations by linking divisions, and thereby shortens the supply chain. The redefinition of boundaries can be implemented both intra- and interorganizationally, as shown by the arrows between the circles in Fig. 2.
4) *Virtual/organic concept of supply chain partners.* In Fig. 2, the service process links one atom with another directly, and breaks the mechanically designed organizations and original functions into smaller atoms. This recombination of atoms turns isolated organizations into virtual service-oriented providers for different customers. Thus, based on the virtual design, the

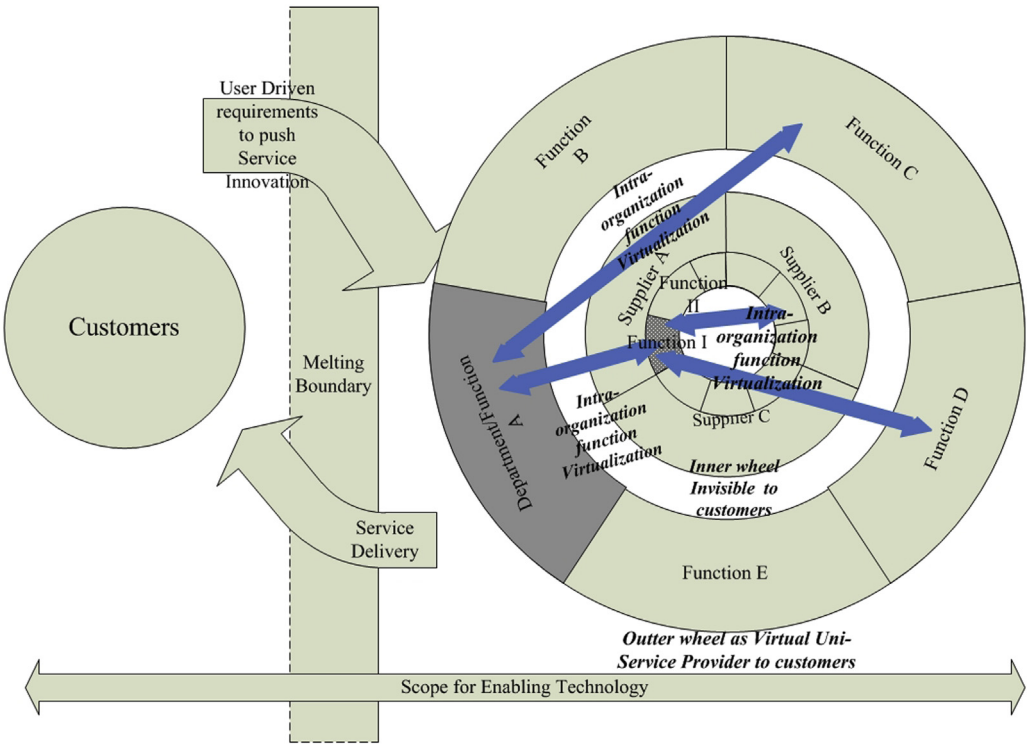

Fig. 2. The service science, management, and engineering-based supply chain framework.

whole supply chain becomes an organic structure that coordinates functions and atoms. In Fig. 2, the components in the outer circle work dynamically with those in the inner circle to meet rapidly changing customer needs.

5) *Virtual and physical integration.* Designing a supply chain from the microcomponent level to the macro level requires that the chain should be integrated both virtually and physically. From the virtual aspect, virtual R&D alliances, virtual service-oriented architecture integration, and virtual joint production all improve the supply chain's ability to respond to the changing business environment.
6) *The role of ICT.* Understanding the evolution of service systems is a central problem in service science studies. Although the service industry has implemented IT and service-related processes for decades, redefining the scope of ICT to ensure that it is fully utilized is a critical issue. The importance of ICT in the supply chain has been well-documented; however, in a service-oriented supply chain, it is critical that ICT should be used to implement the concept of the virtual service provider. Traditionally, IT systems have been limited to support roles and functions instead of being seen as service autonomies; thus, they have tended to function in isolation both within organizations and between organizations. The new definition of ICT expands its role to support the link between service autonomies outside traditional boundaries. In other words, ICT becomes the central neural network that enables the SSME supply chain to provide fast responses. In Fig. 2, the ICT design breaks the boundaries between customers and suppliers in the outer and inner circles to provide two-way information exchanges, thereby reducing uncertainty and the whip effect. This sharing of information streamlines the service procedure and facilitates the preparation of the bill of materials, ordering and assessing customers' needs. These services use ICT to support the network of suppliers, the enterprise, and customers. Delivering interconnected service units is difficult under a monolithic ICT architecture. Consequently, services based on a new architecture are essential to ensure that the supply chain is flexible.

4. Case study

To assess the validity of the proposed framework, we applied it to three international companies that belong to different real-life supply chains. We chose different sized companies that belong to different industries to guarantee research validity. After interviewing relevant managers, we explained our framework in detail, the rationale behind our approach, the gaps between SCM and SSME, and the scope of our study.

The first company (Supplier A) specializes in the design, production and marketing of fitness and medical equipment. Founded in 1975, it now sells a range of products under four brand names through 18 marketing companies that it has established worldwide. The high quality products, which are sold in 60 countries including the USA, target the commercial and home-use fitness markets. Supplier A is a worldwide manufacturer, and its brands target different levels of customers. This feature can help us investigate the global supply chain. The director of the Taiwan factory is responsible for purchasing materials from suppliers, processing the materials, and providing partially assembled products to the company's customers. Because of expanding overseas business, thousands of components need to be ready for assembly. Quality suppliers, on-time delivery of goods, and service are the keys to smooth processing of the heavy loading factory.

The second company (Supplier B) is a major bicycle manufacturer that specializes in high-end bicycles and electric bicycles. The company is currently Taiwan's second largest bicycle manufacturer. Since it was founded 30 years ago, Supplier B has been committed to producing high-quality bicycles. It has also provided high value-

added services, to create an international market and expanding territory; the company now markets its products in 62 countries. In the product after-sales service, Supplier B combines dealers from around the world, to provide consumers with convenient, precise service at any time. The company's global marketing network wishes to quickly capture worldwide changing market trends, product information, and feedback from customers in order to immediately develop fashionable models for consumers and provide a wide range of bicycle accessories.

The third company (Supplier C) focuses on tabletop cooking devices, water heaters, and kitchenware. The company was founded in 1979, and is now one of the most famous brands in China. Because it is concerned about after-sales service and making customers feel comfortable towards its products, the company offers free safety checks. Although Supplier C was affected by the global recession and had to resolve other difficulties, such as an aging brand, its products now account for 45% of the water heater market. Supplier C has accumulated more than 300 million served households, and the voice of these customers provides the direction of product design. To ensure customer satisfaction, the company launched a series of business innovations and business reengineering projects. In addition to efforts to promote *total quality management*, *six sigma full movement*, *net promoter system process improvement* and other reforms, Supplier C has joined forces to develop more high-quality products in response to customer feedback.

The managers from the three companies were asked to quantify their suitability towards the six dimensions of the proposed framework. Each evaluation stands for how realistically the item speaks for their needs. The scores were 1 (strongly disagree), 2 (slightly disagree), 3 (neutral), 4 (slightly agree), and 5 (strongly agree). The results are shown in Table 2.

The interviewees' evaluations show their level of agreement with the six dimensions in the supply chain framework. Overall, the evaluations of all six dimensions are positive. Information technology and the virtual/organic concept of supply chain partners were given the highest and lowest ratings, respectively. Following the evaluation, the three managers were asked to share their views on the dimensions of the framework in an open interview. We report their responses below.

1. The concept of mutual construction: Company A's manager commented that incorporating customer requirements needs solid tools. Quality Function Deployment (QFD) might be extended to this setting by helping bring the requirements list into practical design, and even more specifically into manufacturing.

Table 2
Evaluation of the dimensions of the proposed framework.

Dimension	Company A (Fitness and Medical Equipment)	Company B (Bicycles)	Company C (Heaters)
1) The concept of mutual construction replaces the bipolar distinction of dualism.	4	5	4
2) Single solution provider: complex supplier network is invisible to customers.	5	4	5
3) Melting of intraorganization and interorganization boundaries.	5	4	4
4) Virtual/organic concept of supply chain partners.	3	4	3
5) Virtual and physical integration.	5	4	4
6) The role of information and communication technologies (ICT).	5	5	5

Manager B felt that because his company produces high-end bicycles, customer needs are critical to this top of the pyramid market for capturing customized demands. The company conducts market surveys to gauge functional demand. However, the manager noted that nonfunctional requirements, such as stylish designs, the demand for fashionable auto-gear transmission, and the tire width of a product, are implicit and difficult to observe from a mere questionnaire survey. Customer surveys conducted by experienced market analysts are therefore necessary to learn about implicit customer demands.

The manager of Company C also supported the customer feedback approach. He argued that by taking note of customer feedback, the first dimension can be realized and put into practice more easily.

2. Single Solution provider: From Supplier A's perspective, the one solution concept is a good idea. However, he noted that the concept has yet to gain wide acceptance in his industry. It seems that, currently, the only similar concept is a joint bank loan to the IC (integrated circuit) industry. The banking industry uses this concept to share risks among all participants, rather than a customer-oriented service design concept. Therefore, it is a good direction to improve supply chain design. To this end, the nodes and networks in the global supply chain need to collaborate closely to implement the one solution concept.

This dimension is supported by the manager of Supplier B, who stressed that his company provides on-site service specialists to help customers. The working processes Supplier B uses for production and logistics, which are not customer concerns, serve as background processes.

Manager C agreed that customers should not be bothered with details of the complicated background supply chain process, because how the supply chain works is irrelevant to them.

3. The melting of intraorganization and interorganization boundaries: Manager A commented that, in his industry, QFD can easily transform business functions into a process-oriented strategy. Thus, QFD can be used to implement the proposed model from the reference level to the operational level.

Supplier C expressed his concern about the lack of proper tools to put this dimension into practice, but he acknowledged that the dimension could improve the efficiency of the supply chain. Supplier B did not comment on this dimension.

4. Virtual/organic concept of supply chain partners: Supplier A noted that the concept could expand the use of supporting tools, such as the Supply Chain Operations Reference model, a proposed standard for supply chain management that requires supply chain players to co-plan a framework. To realize the virtual/organic concept of supply chain partners, future supply chains should be designed to take advantage of the collaborative blueprint, processes, best practices, and performance metrics. Moreover, people must be organized into an integrated structure for defining and linking, in order to achieve the service-oriented design aim.

Supplier C expressed his concern about the lack of proper tools to put this dimension into practice, but he acknowledged that Dimension 4 could improve the efficiency of the supply chain. Supplier B suggested a way to make this dimension work. He explained that, in the bicycle industry, a similar *A-team* strategy is used to integrate upstream-downstream resources, and to encourage cooperation between the various suppliers. The objective is to strengthen the partnerships between factories, suppliers, warehouses, and distributors. Fostering upstream–downstream integration will improve a company's global competitiveness so that it has a strategic position in the global market.

5. Virtual and physical integration: Manager A noted that to satisfy rapidly changing customer needs, flexibility in improving the global supply chain is critical. New era technology must satisfy

relevant needs to make technology-aided customer-oriented service redesign possible. In practice, we have to make choices between quality control policy and economic policy. A bill of material is subject to every change from manufacturers and should not be subject to a fixed link with any supplier. Delivery deadlines, prices, and quality between candidate supplies must be powered by a flexible efficient communication technology. This is another issue that must be addressed in the design of customer-oriented supply chains.

Supplier B did not comment on this dimension, but Supplier C posited that the concept is realizable in his industry because cross-divisional meetings are held regularly to discuss the design of new gas-operated hot water heaters. However, he noted that more could be done to break down the divisional boundaries and exploit the synergy of virtual/physical integration.

6. The urgent need for more intelligent and more flexible ICT: Supplier A suggested a way to enhance Dimension 6 in the framework. He argued that feedback tools, such as key performance indices, could be used to periodically evaluate dynamic reconfiguration. Moreover, he believes that enterprise resource planning enables this dimension to meet different logistical deadlines from a variety of suppliers and cross upstream and downstream real-time work.

Factory director B offered his viewpoint of the practical processes in their supply chain, suggesting that the just-in-time system is useful for their bicycle industry to facilitate background supply chain work and to render these processes invisible from final customers.

The input of the three supply chain players demonstrates the differences between their respective industries. For Supplier A in the fitness and medical equipment industry, faced with numerous layered supply chains, a single solution is critical. This contrasts with Supplier B in bicycle manufacturing, where fashion trends and learning customers' needs are the major concerns. For Supplier C in the kitchen equipment industry, traditional cross-function meetings remain the major way for designing new products. More function-breaking mechanisms could be further explored.

Despite these industry differences, the three factory directors agreed on the importance of supporting technology. This shows that the critical nature of information technology, or more explicitly, a cross intra/inter function/organization collaborative mechanism, should be considered in the design of supply chains.

5. Conclusion

In this paper, we have explored the opportunities that SSME provides to improve SCM. Essentially, SSME enables a supply chain that involves service intensive activities to respond quickly to changes in the business environment. SSME provides opportunities to close the gaps that exist between resource reengineering, boundary reengineering, process reengineering, technology reengineering, and most importantly, mindset reengineering. As a result, service-oriented businesses can respond to the need for dynamic configuration of resources to reduce the boundaries between organizations, as well as between organizations and customers.

This study offers a new and interdisciplinary perspective of SSME and SCM. We provide insights on how to incorporate SSME theories to broaden and deepen interdisciplinary discussion in the supply chain field. In addition, we present a framework to help suppliers meet their customers' needs more efficiently, and thereby gain a competitive advantage. In fact, to gain business competitiveness, the relationship between SCM and SSME should be emphasized. These concepts are not alternative strategies for management. SSME is about recognizing the duality of all relationships in a service system, and that the quality of services is an outcome of co-production. Hence, managing by principles of SSME is not really a choice. Supply chains are and should be service systems. The choice is rather whether to identify and address service system gaps or to work solely to meet internally set and unilaterally oriented performance specifications without understanding customer perspectives.

Despite these achievements, the limitations of this research should be acknowledged. It would obviously be necessary to replicate the research in different organizational settings for further validation. The dramatic and ongoing changes in the service environment present a number of opportunities for further research. It has been suggested that management scholars run the serious risk of functional irrelevance if they fail to adjust to these changes (Metters & Marucheck, 2007). The small number of respondents in our research indicates research limitation and future direction. For researchers, our study synthesizes, integrates, and formalizes the findings reported in recent SSME literature, highlights the gaps in the field of supply chain management, and tries to close those gaps. In addition, the proposed framework aligns SSME with the supply chain concept, and integrates emerging SSME knowledge into supply chain management strategies. Our study is one of the first to focus on the topic; thus, we hope that it will stimulate further discussion of SSME based on SCM.

For practitioners, how to respond to the dramatic changes and incorporate SSME into a multilayered supply chain has long been an issue. Our study provides some guidelines for the design and management of supply chains, and helps practitioners rethink their supply chain strategies. Most importantly, mindset reengineering helps managers change their traditional attitudes and methods, adapt to the modern supply chain environment, and explore opportunities to provide new services. Specifically, practitioners can use the first dimension of the framework (dual construction) to rethink their service design. The concept allows customers to actively design services rather than passively accept designed services. This contrasts with the traditional supply chain design, which only allows customers to passively choose from provided services that may or may not suit them. The first dimension enables customers to design their own services according to their true needs without any unwanted parts. The second dimension (single solution provider) facilitates better customer service and therefore improves customer satisfaction. For practitioners, our study helps managers better understand that not only mechanical workflow designs, but customer needs, can improve supply chain design. Overall, our study provides practical suggestions to improve business management in a competitive world.

In future research, scholars could conduct case studies by using the proposed framework to compare the supply chain operations of various companies. Future studies should also exploit interdisciplinary knowledge, and stress the need for practitioners and academics to address issues unique to the field of supply chain management. Moreover, it is necessary to expand service science knowledge by analyzing how service socio-systems evolve over time, what factors are critical to sustaining service excellence, and how best to use unprecedented opportunities to facilitate business-service science alignment.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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