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ORIGINAL PAPER

Exploring supply chain innovation

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Abstract Supply chain management promises competitive advantages for industrial organizations. The introduction of new products and services, or entry into new markets, is likely to be more successful if accompanied by innovative supply chain designs, innovative supply chain management practices, and enabling technology. This is a widely accepted premise in business practice today. However, systematic research and knowledge about supply chain innovation (SCI) is little developed. There is a lack of common terminology, of agreement about the conceptual understanding, and of related empirical work. This paper presents an exploratory study that aims to provide a better understanding of SCI, mirroring leading edge practice, and providing a sound terminological and conceptual basis for advanced academic work in the field. The research is based on an in-depth literature review and the analysis of a set of secondary data sources: 36 SCI cases, drawn from applications for the Council of Supply Chain Management Professionals' (CSCMP) Supply Chain Innovation Award. As results of the research, a new SCI definition, the construction of a descriptive model of its key elements, and discussion of implications are presented.

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1 From pragmatic applications to systematic investigations into supply chain innovation

The domain of supply chain management (SCM) offers new opportunities for creating competitive advantages. But to leverage these opportunities and to win the competitive landscape, a new mindset is required for understanding the global supply, logistics, and communication network of a business [74, p. 14]. This may be why every year the American Council of Supply Chain Management Professionals recognizes outstanding practice of innovative organizations through their "Supply Chain Innovation Award". Among the nominees have been prestigious organizations such as the U.S. Air Force, Motorola, Kellogg's, and Blockbuster Inc. The list of award winners includes companies like Intel, Cisco Systems Inc., and Hewlett-Packard. The winner is selected out of 45–50 submissions each year, based upon criteria related to the degree of innovativeness, impact on overall supply chain, and sustainability in results (revenue, cost savings, etc.).

While this illustrates the practical relevance and a pragmatic approach of bringing together a supply chain perspective with an innovation focus, relatively little academic attention has been paid to specific issues of supply chain innovation (SCI). Few contributions can be identified that explicitly deal with SCI. Those that do usually just refer to the term, but lack thorough consideration of its content and conceptual foundations. This seems to be the case despite the fact that the general concept of innovation in an economic context has been the subject of much literature since Schumpeter's times [4]. Significant factual innovations have been developed with relevance to logistics and process management during the second half of the twentieth century, such as industrial dynamics [40], materials requirements planning [73], the pull production systems within the Toyota production system [72], new forms of relationships and partnerships [62], and various incremental improvements to business processes [39, 95]. But these have not been systematically and specifically related to the issues of SCM, as it is being understood today: only some consideration has been given to innovations in other functional areas of the company, which then may necessitate changes in supply chain activities [36, p. 133]. Only limited empirical testing of those—and other kinds of logistics innovation—has been reported in the literature [45], despite an apparent need to respond to pressures and events such as the current global financial crisis, leading to an increased focus on cash flow through changes in payment terms and lead time reductions [33, 71]; the challenges of global warming leading to new rules and regulations for CO_2 emissions, putting pressure on means of transportation and the layout of the supply chain [13, 29], and the globalization of trade with resultant outsourcing and off-shoring manufacturing (e.g., lead times, transportation, corporate social responsibility [70, 71]). There is an obvious gap between the pragmatically recognized importance of innovation in the context of SCM and the state of systematic academic research on the concept. The purpose of this paper, therefore, is to bridge this gap. It aims to provide a better understanding of SCI, which correctly mirrors leading edge practice and provides a sound terminological and conceptual basis for advanced academic work in the field.

2 Organization of the paper and research method

The paper is organized in four main sections: the following part of this section outlines the research method applied. The third section provides a review of the general literature on SCM and innovation, as it relates to SCI. On the basis of this review, in section four, a model is proposed that suggests that the essence of SCI may be captured through the description of three conceptual elements and their interactions. A set of five illustrative case studies is then presented in section five to exemplify the function of the SCI model. The paper concludes with a discussion of the managerial and theoretical implications of the analysis and its findings.

Studying a very new phenomenon such as supply chain innovation calls for an exploratory research design, since this is "most appropriate in the early stages of research on a topic" [31, p. 548]. The ambition of this paper is to outline a systematic understanding of the SCI concept and then to apply the concept against a set of real-world cases. As a research approach, this is consistent with the method of abduction that is considered especially appropriate for creating new insights [58]. The main purpose of the abductive method is to develop new theory or refine existing theory by uncovering new variables and relationships [26]. In this research, the development of a model of SCI and identification of its conceptual elements is derived from an interplay between the literature reviewed and a sample of SCI award application cases, i.e., through a systematic dialogue between a theoretical construct and empirical observations [30]. Consistent with the abductive approach, reiterated analysis and interpretation has developed an analytical understanding of SCI.

The literature review was carried out in four steps. As a first step, 50 SCM-related journals as identified by Charvet, Cooper, and Gardner [16, see Table 1 in their paper], as potentially dealing with SCI, were chosen. The second step was a search for papers published in those journals where the word 'innovation' came up in conjunction with certain logistics and SCM-related terms. The journals were scanned with a specific search term in the EBSCO Host Research Database (business search premier). Searches took place in the field "all text (TX)", and there was no date limit for these searches. In light of discussions as to whether there is a difference between logistics and SCM [63], searches for both "supply chain innovation" and "logistics innovation" were performed. The searches also included the term "supply chain development," since development initiatives may relate to innovations. Furthermore, logistics/SCM activities [44] were searched for, as they appeared to be combined with innovation. All in all, the search processes identified 140 germane papers. As a third step, these 140 papers were screened in some more detail. Papers that obviously did not deal with innovation were eliminated, even though the search terms came up in some sentence or in the list of references. The screening reduced the total number to 29 papers, which appeared to be truly relevant (see Table 2). The papers were divided into seven thematic areas based on a collaborative grouping process among the authors of the paper. The fourth and final step of the review then encompassed a detailed content review of the remaining 29 papers.

The methodological approach outlined and utilized to the literature review has two shortcomings with respect to the aim of the research: one limitation is that potentially relevant literature that did not meet the search criteria are not covered in the review, even though there may be more additional work about SCI, which does not use the specified terms. Secondly, publications in any other sources than those referred to above, like conference proceedings, textbooks, and trade journals that may contain relevant contributions, were also not considered in the review.

Table 1 SCM frameworks and models

Author(s)	Major SCM framework/model elements
Cooper et al. [19] and Lambert et al. [61]	Business processes, management components, and supply chain structure
Bowersox et al. [11]	Flows: product service value flow, market accommodation flow, information flow, and cash flow. Six integrative competencies: customer integration, internal integration, material and service supplier integration, technology and planning integration, measurement integration, relationship integration
Mentzer et al. [67]	Customer satisfaction, supply chain flows, inter-corporate coordination, inter-functional coordination, the global environment
Chen and Paulraj [17]	Environmental uncertainty, customer focus, top management support, supply strategy, information technology, supply network structure, managing buyer–supplier relationships, logistics integration, and supply chain performance measurement
Bowersox et al. [10]	Consumers, relationship management, flows, constraints, supply network, integrated enterprise (logistics, procurement, customer accommodation, and manufacturing), and market distribution network
Skjøtt-Larsen et al. [85]	Three perspectives on SCM: as an internal supply chain, part of a corporate company environment, part of an external environment. The supply chain system consist of: activities, processes and operations, and organizations
Supply Chain Council [90]	SCOR is based on five distinct management processes: plan, source, make, deliver, and return
Mentzer et al. [66]	An external view: the domain of SCM includes applying analytical tools and frameworks to improve business processes that cross organizational boundaries. An internal view: operations management includes applying analytical tools and frameworks to improve business processes that cross internal functional boundaries: time (logistics), marketing (planning), and physical transformation (production)

Table 2 Literature review on supply chain innovation

Focus	Relevant aspects highlighted	Representative authors
Defining and measuring supply chain innovation	Innovation is anything new to the beholder	[39, 45, 59]
Supply chain innovation areas	Implementing new supply chain technology	[4, 52, 59, 81, 83, 89, 91]
	Supply chain networks	[2, 88]
	Optimizing supply chain business processes	[4, 8, 21, 38, 39, 48, 49, 51, 57, 75, 80, 81, 87]
	Introducing new products or services (product development processes)	[21, 34, 39, 80, 84, 94]
	Modeling and scenario building for optimization	[4, 14, 59]
	The innovation process	[34, 35, 38, 39, 46, 84, 95]

The overall number of papers listed is higher than 29, because some papers relate to more than one focus and relevant aspect

The second type of data input to our research come from reviews of 36 applications for the CSCMP SCI Award (from 2005 to 2009), which were selected by the jury to be presented at the Annual CSCMP Conference. These data can be characterized as archival case studies based on secondary data sources [32, 96]. In general, case studies have been argued to be relevant when investigating a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident [5, 32, 96]. Applying secondary data sources has advantages for the purpose of this study, but also disadvantage of potential biases. Research on operations management based on secondary data sources is rising [79] and has been suggested to be used more in operations and SCM research [12, 37]. Benefits of secondary data sources include wide availability and low data collection costs [12]. Limitations include the fact that the researcher is dependent upon another party in data collection, lack of measures to tap the exact extent of the research, and the fact that data may be biased. However, the assumption is that the innovations selected this way meet criteria of obvious relevance, as defined by CSCMP [25], and they were chosen out of a much larger sample of application by an expert to be presented at the annual conferences:

– Educational intent of case study, not promotion toward a product, service, or organization.
– Level of significance with regard to the specific supply chain challenge and the solution's impact on the organization's overall supply chain.

– Quantifiable and sustainable results in: cost savings, revenue generation, and customer satisfaction.
– Practical information that would be helpful and relevant to today's supply chain practitioner.
– Structure and content: organization/clarity, quality/usefulness of visuals, and author's knowledge of subject matter.
– Innovativeness of solution.

A weakness of the 36 application documents for the CSCMP SCI Award is that they have been compiled by the candidate companies. Naturally, the applicants describe their innovations in the best possible way. On the other hand, for the purpose given here, the primary interest is the range of issues and arguments brought up by the applicants—which may be considered relevant elements of SCI—not so much in the actual execution and impact of the innovations.

The 36 application and award-winning cases of SCI, which dated from 2005 to 2009, were thoroughly analyzed to strengthen the precision, validity, and stability of the research findings. As the first step in the analysis, application documents were coded using interpretive coding [68]. Phrases reflecting elements of SCI as found in the literature were marked. This procedure included interpretations of the degree of novelty of innovations as well as deeper insights into the content of and relations between the SCI elements. An overview of coding results is presented in Appendix. In order to provide a thorough explanation of how elements of SCI are applied by different award candidates, brief descriptions of the five winners in the sample were compiled (see Sect. 5) to highlight variations and similarities across cases.

3 Literature review

This section, first, offers a brief introduction to the general concepts of SCM, as found in the extant literature. Then, a review of the general literature on innovation follows. Finally, those literature contributions that directly relate to SCI are reported and categorized. The purpose of the literature review is to identify essential dimensions and elements of SCI that may be used as building blocks for the construction of a new definition and a coherent model of the concept.

3.1 Supply chain management frameworks and models

In the literature, numerous frameworks and models related to SCM have been developed in order to substantiate the concept and relationship between subconcepts and variables within the SCM domain. In Table 1, a listing of frequently quoted SCM frameworks and models is listed.

An initial interpretation of these frameworks and models reveals agreement in several respects: there is consensus that an essential element of SCM is its inter-organizational nature. It is concerned with chains and networks of companies that collaborate across several tiers to produce some product or service. In spite of a dissimilar vocabulary, there is consensus on SCM's basic intention—to provide superior end-customer value. Another common thread is the focus on processes that cut across traditional internal functions (or silos). Common output measures considered are improved efficiency, improved services, or reduced costs. Still other common denominators include their focus on customer demands, relationship management, integration, and IT.

3.2 Dimensions of innovation relevant to supply chain management

Research on innovation has a long tradition and can be traced back to the early work of Schumpeter [82]. Innovation, he argued, is the introduction of new products and production methods, the opening of new markets, the discovery of new raw materials, and the implementation of new organizations. Some initial correspondence between Schumpeter's classical definition and supply chain research is given through its focus on production methods, raw materials, and organization. However, the academic field of innovation and the understanding of the term "innovation" are too comprehensive and multifarious to cover with a general definition or simple perception. Therefore, our quest is to cover those innovation dimensions that are relevant in a SCM perspective in order to provide a more concrete definition of supply chain innovation.

Drawing further on Schumpeter's work, the distinction between invention and innovation [42, p. 22] is helpful: invention relates to new ideas, novel breakthroughs, and new discoveries. The key feature of an invention is its newness and the fact that, as such, it is not normally immediately ready for the market. Accordingly, innovations include not only the invention itself, but also the activities and processes designed to commercialize these new ideas. In this sense, innovation is the successful exploitation of new ideas. Furthermore, innovations may become widely used and spread to other fields through the process of diffusion [65]. Innovation processes not only relate to processes of commercializing new ideas, but innovation also refers to the broader capability of an organization to continuously renew itself [6, 92, p. 54]. Companies engaged in innovation have to build a process that facilitates their pursuit of turning new ideas into products, services, processes, etc. This is in accordance with Baumol's [3] definition of innovation as: "The recognition of opportunities of profitable change and the pursuit of those opportunities all the way through to their adoption in practice." This is relevant to SCM as it relates to the focus of proving commercial significance by creating superior end-customer value.

For some time, the innovation concept has lead to further differentiation. There may be varying degrees of novelty—dividing innovations into incremental and radical changes [41, p. 421] and more subtle distinctions by the degree of innovation [47]. For the present purpose, the use of the distinction between radical and incremental innovations is sufficient. The degree of newness may be related to both technological innovations (new products or processes) and non-technological innovations (organizational innovation or market innovation) [7, 64, p. 8]. The distinction between organizational and market innovations conveys a structural dimension within discussions of newness. In a supply chain context, the distinction between the organizational level and the market level can also be defined as an intra-organizational or inter-organizational focus for the innovation. An intra-organizational innovation might be the application of new technologies for planning and forecasting, whereas an example of inter-organizational innovation might be the application of integrated product development in which suppliers and customers become part of the product development process or the implementation of advanced planning tools [81].

Another categorization relates to the field of application or use of the innovation. There are product-, process- and service-innovations. Correspondingly, there are further distinctions in the field of application and context, within which innovations take place, such as organizational innovation, management innovation, production innovation, and commercial/marketing innovation [93, p. 17].

Some of the dimensions of innovations that have been identified so far may be determined independently from the perspective of an observer, such as the intended uses of innovation. Others, such as rating of an innovation on a scale of newness as incremental or radical, are contingent upon the eyes of the beholder [39, 54, 78, p. 11].

3.3 Interpretation of publications specific to supply chain innovation

In our research, 29 papers were identified that are dealing explicitly with some aspect of SCI. A total of 7 relevant aspects of SCI were identified by carefully reading and categorizing the 29 papers. Two general themes emerged dividing the papers into whether they explicitly define and/or measure SCI, or deal with certain activities that have relevance in the SCI process (Table 2). By comparing and contrasting the content and research of the identified paper, it was possible to deduce additional aspects related to various areas of SCI—e.g., implementing supply chain technology leading to innovation, the introduction of new products or processes or models intended to optimize the supply chain setup. Our characterization suggests that there are relatively few papers explicitly dealing with the issues of definition and measurement, and that there is a lack of specificity in the definitions provided. The characterization of the relevant innovation activities, which are dealt with in the papers, appears to be a rather disjunctive collection of aspects.

In summary, the SCI literature review leads to the following five findings. First, the literature reviewed seems to agree on the importance and potential of SCI in improving the performance in the supply chain [39, 59]. Second, there is a lack of a coherent classification scheme for the different types of SCI. Academic research so far has not yet provided elaborate definitions of SCI beyond a basic agreement that SCI is concerned with developments in technology and processes [4]. Third, the present SCI contributions are focusing mostly on technology development and application. The existing literature on SCI specifically points to information technology (IT) as an important driver for innovation [52]. Such IT technologies are, for example, radio frequency identification technology (RFID), pick-by-voice, and advanced planning systems (APS) [81]. They have been suggested to serve as enablers of a closer cooperation between vendors and customers over the last 10–15 years [81]. Fourth, some authors describe the measurement of innovation performance in terms of the performance of the product development process (R&D process) [1, 20]. However, as with the general innovation literature, there seems to be a lack of work related to measuring innovation in the supply chain. Instead, the issue of measuring degrees of innovation has been evaded as being based on "the eyes of the beholder" [39], which mean that the degree of innovation is not related to a fixed scale, but is a relative concept depending upon the beholder (person, organization, etc.) of that change. To one person, a change could be a radical innovation, but to another person the same change could be an incremental innovation. This begs the questions as to how one can compare innovations, as well as how one can rate innovations and how to judge what the best innovation is. Finally, current contributions are mainly conceptual because empirical studies on the SCI practice are under-researched; supply chain literature does not seem to focus on innovation [39]. At the same time, the literature on innovation does not seem to have any focus on SCM. This may be one reason why it is difficult to find solid definitions of SCI, classifications of innovation (i.e., radical or incremental), and drivers for innovation.

4 A definition of supply chain innovation and a model of its three interacting content elements

4.1 Construction of an SCI definition

Based on the dimensions and content identified in the literature review earlier, a definition of supply chain innovation is constructed, which is intended to be more specific and comprehensive as the earlier ones referred to in Table 2:

> "A supply chain innovation is defined as a change (incremental or radical) within the supply chain network, supply chain technology, or supply chain processes (or combinations of these) that can take place in a company function, within a company, in an industry or in a supply chain in order to enhance new value creation for the stakeholder."

This definition of SCI highlights several characteristics: first, SCI is dynamic in nature because of a change process. Second, SCI may range from incremental to radical in terms of its innovation effect. An incremental SCI is an optimization of current practices within networks, technology, and processes. A radical SCI must have a "wauw" effect—something that sets new rules for the game within its application area. Third, SCI can take place within different business functions, such as forecasting, distribution, and procurement. It can take place at an intra-company level, in dyads, chains, and networks of companies, as well as cut across entire industries. Accordingly, these different functions and levels may look differently at the same innovation. Fourth, the definition of SCI is considered more than an invention or idea in and of itself, but is perceived as the actual implementation of that idea in a supply chain. An SCI is more than an invention because it also has to prove its commercial value [6]. Fifth, the innovations must encompass new value creation—such as new markets, new products, new services, and new network structures. This also implies that the goal of the SCI is to create value for the company or any other stakeholder (partner in the supply chain or end customer).

4.2 An SCI model of interacting content elements

Based on the literature review and as an implicit critique of the lack of coherence and conceptualization in existing studies on SCI, these sections suggest a new SCI model. The interacting content element of the SCI was found by comparing and contrasting frequently used SCM frameworks (listed in Table 1) and the literature review of SCI (see Table 2). First, there is a consensus that SCM is concerned with the management of relationships in business networks and deals with both intra- and inter-organizational business processes. Furthermore, implementing supply chain technology has an explicit usage in the SCI contributions, while also mentioned in the SCM frameworks. Thus, the three interacting content elements of SCI, to be discussed in more detail later, are the following: (1) Supply chain business processes, (2) Supply chain network structure, and (3) Supply chain technology.

Compared with the division of the strategy literature into process, content, and context [28, p. 5], the SCI model presented in this paper applies a content perspective. The product of an innovation process is referred to as the innovation content. Formulated as a question, innovation content can be perceived as being the 'what' of innovation—what is the innovation for the company? In contrast, a process perspective is concerned with 'how' innovations are carried out. The process and content perspectives influence each other—for example, the content of an innovation may influence the way in which the process will be organized, and vice versa—whereby if we begin with the processes, this may also influence the specific content. Although this dual interplay between content and processes exists, this paper is focused solely on the content piece—on a search for the contents of supply chain innovation. Thus, this paper aims to clarify the way in which the content of SCI can be operationalized. Therefore, the management area of SCM and the process element of implementing innovations are not included. The SCI model proposed in this paper consists of three elements as shown in Fig. 1.

Supply chain innovations are not static elements but will typically be triggered by the companies' dynamic interaction with their business environments. Figure 1 also recognizes a dynamic process in and around the interplay between the three elements in recognition of a need for change in a company's business model. Typical problems triggering SCI may be long lead times, high supply chain

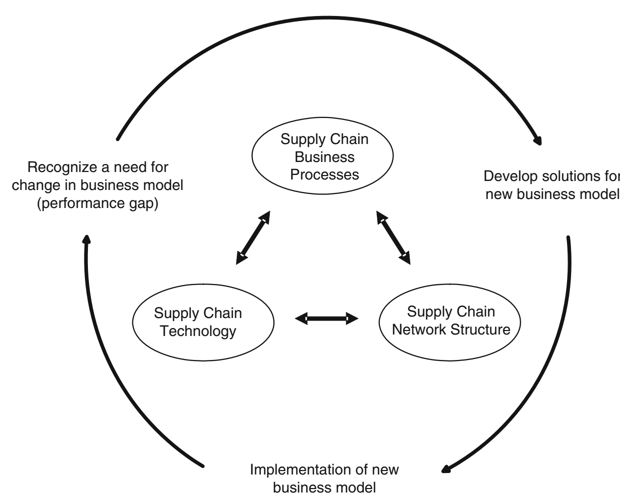

Fig. 1 Elements of supply chain innovation

costs, and low service levels, but they also may be resulting from efforts to better articulate a company's value proposition, to identify new market segments, to redefine the structure of the value chain in order to gain advantage over rivals [18]. The recognition of a need to change should then lead to a process of analyzing current practices and proposing new solutions that will improve the performance. New solutions adopted must then be implemented, and after some time, the need for improvements will arise again. Referring to the definition of supply chain innovation stated earlier, the work is done in order to enhance new value creation for the customer.

4.3 Supply chain business processes

The first element in the SCI model is supply chain business processes. Business processes are the activities that produce a specific output of value to the customer [19]. Business processes can be defined as: "a structured, measured set of activities designed to produce a specified output for a particular customer or market" [27, p. 5]. The motivation for implementing customer-oriented business processes within and across members of the supply chain is both to make transactions more efficient and effective and to structure inter-firm relationships [60]. The Global Supply Chain Forum has identified eight SCM processes with subprocesses that are listed below, including their academic clarification:

- Customer Relationship Management [24]
- Customer Service Management [9]
- Demand Management [23]
- Order Fulfillment [22]
- Manufacturing Flow Management [43]
- Supplier Relationship Management [24]
- Product Development and Commercialization [76]
- Return Management [77]

In theory and in practice, there can be other SCM processes than those listed here (e.g., sequencing activities as listed in [44, p. 4], into processes. For further examples of process models on supply chain efficiency, we refer to the SCOR Model by the Supply Chain Council [90, p. 10], the process classification framework by APQC [69], and the Supply Chain Best Practices Framework by the Supply Chain Consortium [69].

4.4 Supply chain technology

The second element of the SCI model is supply chain technology. By this element, we mean technologies that can be applied in isolation or in combination with other technologies or the two other elements in the model to create SCIs. As an example, consider the practice of the Swedish car manufacturer VOLVO [50]. VOLVO has implemented an innovative mobile RFID solution using cellular networks with data package communication (GSM/GPRS) together with web technology. The practice reveals that a "smart goods" and mobile RFID solution can be easy to use and learn, thus facilitating widespread adoption among supply chain actors with a "get pull" effect. Another example is the application of advanced planning systems in supply chains that enable innovations in cross-company collaboration, speed in information flow, and demand visibility [55]. A third example is the way in which the application of e-procurement auctions can improve market structure, market behavior, and market performance [86]. Thus, in this context, it is not the technology in and of itself that is an innovation, but merely its application in a supply chain context.

4.5 Supply chain network structure

The third element of the SCI model focuses on the supply chain network structure—both vertical and horizontal—of the company and its supply chain partners where innovations materialize. Thus, this element [61] divides the structure of the supply chain into three distinct factors: (1) Members of the supply chain; (2) Structural dimensions, and (3) Different types of process links. Supply chains are complex business systems that often consist of many members. Not all suppliers or customers attract the same strategic awareness; therefore, a differentiation must be made. The membership element draws attention to activities related to mapping the supply chain structure and then, based on differentiation models, classifies suppliers and customers into different degrees of importance. The structural element is concerned with the horizontal structure (number of tiers across the supply chain), the vertical structure (the number of suppliers/customers represented within each tier), and the horizontal position of the company (e.g., close to the point of origin of raw material as opposed to close to private consumers). Process links are concerned with different degrees of resources spent on integrating and managing processes within and across members of the supply chain. Again, differentiation is the key word. Some process links need to be managed, while others do not. The network structure element can also be unfolded through virtual networks in which new value creation relies on knowledge assets. Such core competences develop the firm's ability to nurture long-term relationships with customers and suppliers [56]. Another example of this is the way in which intercompany collaboration can stimulate continuous innovations in supply chains [15]. A final example of innovations within the supply chain network structure is the emergent practice of inter-outsourcing—with its focus on a round-way process in which the vendor is its customer's customer and the customer is its vendor's vendor [53]. As a final remark, it should be noted that the degree of SCI novelty (incremental to radical) may be perceived differently by the members of a supply chain. An example of this could be a company that is incrementally developing existing processes that facilitate the development of radical processes by other members of the supply chain. In Table 3, examples of content elements of the three SCI are listed.

An important characteristic of the SCI model suggested is its ability to provide both a more holistic and a more nuanced view of what might be labeled an SCI. Thus, an SCI can be both the implementation of one or more elements within one of the elements and a composition of more elements from two or all three elements. Each of the three elements can vary in innovation effect along the axis—from incremental to radical. In order to make this dimension operational, a suggestion by Davenport [27, p. 11] is followed: (1) Starting point (existing processes vs. clean slate); (2) Frequency of change (one-time/continuous vs. one-at-a-time); (3) Time required (short vs. long); (4) Participation (bottom-up vs. top-down); and (5) Typical scope (within functions vs. cross-functional). Incremental innovations are, for example, small continuous improvements, master data management, and process optimizations. Examples of radical innovations include the implementation of direct distribution by using the principles of postponement, reengineering business processes by using state-of-the-art information technology, and the implementation of cross-functional teams in order to speed up the time-to-market processes. Furthermore, the degree of novelty may vary across functions internally and across dyads, chains, and networks.

5 Illustrative cases of supply chain innovation

Following the abduction research approach (as outlined in Sect. 2 of the paper), this section contributes to a verification of the appropriateness of the definition and model of SCI using the SCI essential elements identified in Sect. 4. An overview of all 36 case applications for the CSCMP SCI Award, classified against the SCI elements and degree of innovation, is found in Appendix. Out of these, the five cases that actually won a CSCMP SCI Award during the period 2005–2009 are characterized in Table 4 and discussed later in some detail. The cases were analyzed against the developed SCI elements and the degree of innovation (incremental vs. radical). An overview of all 36 case applications for the CSCMP SCI Award, classified against the SCI elements and degree of innovation, can be found in Appendix. The classification of the case companies should uncover the kinds of SCI in focus and the degrees of innovation that they have made. Table 4 shows the five winning cases classified against the elements of SCI. A detailed description and classification of the winning cases are presented in the following sections highlighting the innovation type of each supply chain element. Based on Appendix, the findings across all the cases are that the innovation takes place as both radical and incremental changes in business processes, and most of the cases have made radical innovations in the supply chain technology. However, only a few cases have made changes in their supply chain network structure, which corresponds to the organizational perspective that the changes were found to be inter-organizational for most of the cases, i.e., they focus inside their own organization.

As Table 4 shows, there is a significant focus on innovation in supply chain business processes and supply chain

Table 3 Examples of content elements of SCI

Supply chain business processes	Supply chain technology	Supply chain network structure
Customer relationship management	Global positioning systems (GPS)	In- and outsourcing
Customer service management	Bar coding	Partnership
Demand management	Radio frequency identification (RFID)	Collaboration
Order fulfillment	Pick-by-voice technology	Distribution channels
Manufacturing flow management	Electronic data interchange (EDI)	Type of links to supply chain actors
Supplier relationship management	Advanced planning systems (APS)	Third-party logistics providers
Product development	Warehouse management systems (WMS)	Fourth-party logistics providers
Return management	Enterprise resource planning (ERP)	Joint ventures
	Manufacturing execution system (MES)	Complexity in supply
	Product life cycle management (PLM)	
	Business intelligence	
	Internet	
	E-auctions	

Table 4 Five winning cases classified against the elements of SCI

Year	Company	Title	Supply chain business process		Supply chain technology		Supply chain network structure		Organizational perspective	
			Increm.	Radical	Increm.	Radical	Increm.	Radical	Intra	Inter
2009	Intel Corporation (winner)	Just say yes: innovating customer responsiveness at Intel		×		×		×		×
2008	Cisco Systems Inc. (winner)	Unlocking value from product returns		×		×				×
2007	Aidmatrix (winner)	"FreeClinic link—empowering a supply chain of giving"		×		×				×
2006	Mercy ROI (winner)	ROI, resource optimization and innovation		×		×				×
2005	Hewlett-Packard (winner)	Procurement risk management (PRM) at HP company		×		×			×	

technology, while innovation in the supply chain network structure was the focus for only one of the winning cases. In the following, the five winning case companies will be described with regard to their innovations in supply chain business processes and supply chain technology. Each case description is structured into four sections: (1) Background and initial problem, (2) Case description, (3) Characteristics of the innovation and (4) Findings.

5.1 Intel—the SCI Award winner in 2009

Background and initial problem. Due to the growth of the computer industry in the 1990s, the demand for microprocessors increased exponentially and exceeded the available supply. In the same period, the design and technological complexity of the products increased and resulted in manufacturing cycle times of up to 90 days or more. After the "Internet bubble" burst, the demand for microprocessors became more in line with the supply. Intel's product, manufacturing and process complexity, as well as cycle times, improved significantly. Customers were still required to place orders in due time; however, the long lead time led to situations where a large portion of the order changed close to shipment dates. In 2004/2005, Intel required seven to 9 days to respond to a customer request for supply, and as a result of an IBM Global Services study benchmark, Intel was rated "worst in class."

Case description. In 2005, Intel launched the "Just Say Yes" campaign, recognizing that a significant cultural change, in addition to various tool and process enhancements, was required to reverse their perception issues. The first initiative was to improve the ability to respond quickly and positively in order to change order requests. Second, efforts were initiated to increase the Committed Dock Date (CDD) performance to competitive levels and then a reduction in inventory levels was completed, and, finally, a program was instituted to reduce demand forecast errors.

Characteristics of innovation. The Intel innovation can be characterized by: (1) Development and implementation of a new mindset and processes, setting new business rules and developing efficient IT applications to support collaboration; (2) The Intel innovation consists of a number of changes, it is not a one-time change but a continuous change process; (3) The innovation process has been ongoing since 2005 and is, therefore, a long-term process; (4) The overall change process was initiated as a top-down approach; however, in the various change projects, there have been both top-down and bottom-up participation; and (5) The practical scope of the Intel innovation is cross-functional. In this case, Intel made changes inter-organizationally; for example, the changes involved both suppliers and customers in their implementation of VMI supply models and sharing forecast information.

Findings. This case shows the radical innovations made in their supply chain in terms of all the parameters: processes, network structure, and technology. In a highly complex business setting, Intel has managed to set new standards for customer response time and delivery service through the innovation of cross-functional business processes for order handling and communication with suppliers and customers. Intel has implemented technology to support the management of the new supply chain setup and changed the usual patterns of cooperation by implementing VMI solutions and collaborative solutions with their customers and suppliers.

5.2 Cisco—the SCI Award winner in 2008

Background and initial problem. In the logistics operation of Cisco, handling product returns had traditionally been geared toward efficiency in the handling processes and optimizing the cost of the operation. A shift in management in 2005 changed the focus to that of seeking new ways to maximize the value obtained from the returned products. With the new focus on value recovery, the logistics organization handling product returns had to change their way of working and of understanding the processes. They then started projects to increase recovery rates and define and implement a profit-based business model to capture the highest value for Cisco from the returned products.

Case description. Based on the changes in leadership, the reverse logistics team created a reuse program. The objective was to give returned and excess equipment a second—or even a third—life, before responsibly recycling it. Originally, the recycling process was outsourced, but Cisco found this setup led to management and compliance gaps, increased expenses, and created risk. The solution was to bring these core processes back in-house while outsourcing non-core work. The result was tighter control of operations and increased productivity, which enabled rapid growth. A key element of these changes was the establishment of automated data sharing processes, which reduced losses from stocks and excess and obsolete parts. However, Cisco found that there was no 'off-the-shelf' SCM product available to support the new operational model, and they decided to custom-build the IT architecture to manage its stock, evolving from exchanging spreadsheets to utilizing a central database to track stocks and take requests from internal customers.

Characteristics of innovation. The Cisco innovation can be characterized by: (1) Development and implementation of new processes; (2) A one-time change that created the basis for continuous improvements; (3) A relatively long development and implementation period; (4) Top-down and bottom-up participation; and (5) A cross-functional scope. The degree of inter-organizational change in this case was that Cisco made inter-organizational changes, which involved suppliers in terms of in- and outsourcing of processes.

Findings. In this case, the company made radical innovations in supply chain business processes by establishing a whole new business model for handling product returns and implemented the teams and performance measurement elements necessary to accomplish this. Looking at supply chain technology, Cisco could not find standard IT solutions to support their new business model, so they developed a new IT architecture to support the special needs of the returns business for keeping track of the products.

5.3 Aidmatrix—the SCI Award winner in 2007

Background and initial problem. The Aidmatrix Foundation and the National Association of Free Clinics (N.A.F.C.) developed an Internet-based collaborative network servicing free clinics. The initial problem was that many small service organizations do not have the necessary resources to be able to meet the needs of their ever-growing client base; therefore, there was a need for coordination across the parties in the supply chain.

Case description. The web-based tool "FreeClinic Link" is a system connecting each member of the free clinic supply chain of care. The value proposition for each participating stakeholder is maximized through full capture of benefits as well as minimization of transaction costs. The FreeClinic Link allows free clinics across the United States to come together 'virtually.' The system enables each stakeholder to behave in a manner that maximizes value for the other stakeholders, creating a truly collaborative supply chain by leveraging supply chain collaboration solutions based on products and services from leading industry supporters such as Accenture, i2 Technologies, and Sun Microsystems.

Characteristics of innovation. The Aidmatrix innovation can be characterized by: (1) The development and implementation of new processes; (2) A one-time change, however, that created a basis for continuous improvements; (3) A relatively long development and implementation period; (4) Top-down and bottom-up participation; and (5) A cross-functional scope. Degree of inter-organizational change: the Aidmatrix solution must be characterized as an inter-organizational solution spanning a number of organizations.

Findings. This case illustrated made radical innovations in supply chain technology and supply chain processes through the development of a web portal by combining different state-of-the-art technologies. The basic business processes are standard supply chain processes; however, through the IT integration, it is possible to automate the collaboration between the parties in the supply chain and thereby gain significant results.

5.4 ROi Mercy—the SCI award winner in 2006

Background and initial problem. Health-care supply chains exist to support clinical operations, yet the supply chain can rarely be directly linked to improved clinical performance. The St. Louis-based Sister of Mercy Health System created a new supply chain division called Resource Optimization and Innovation (ROi) to establish the supply chain as a strategic imperative for the business.

Case description. ROi has simplified the health-care supply chain of Mercy Health Systems by reducing its dependence upon third-party intermediaries. The result of the changes was truly a new way of working that closely linked the makers and users of health care products in a way that provides greater value for the essential trading parties. The scope of the changes was cross-functional and contained process development and technology development and application. The changes were driven in a new team structure with competences from inside the hospital and from outside resources that were hired from the logistics and supply chain industry.

Characteristics of innovation. The ROi Mercy innovation can be characterized by: (1) Development and implementation of new processes; (2) A one-time change; (3) A relatively long development and implementation time; (4) Top-down and bottom-up participation; and (5) A cross-functional (inter-organizational) scope as the changes involved more organizations.

Findings. This company has made radical innovations in their supply chain business processes and supply chain technology and has changed the view of the supply chain in terms of being an important element in optimizing the total business.

5.5 Hewlett-Packard (HP)—the SCI Award winner in 2005

Background and initial problem. Around the year 2000, electronic component market prices were increasing due to increased demand. A procurement risk management (PRM) project was initiated that led to the implementation of new tools and processes to handle the risks of increasing prices and material shortages.

Case description. The innovation is the use of tools and processes from the financial risk management processes on Wall Street. HP developed a framework to quantify the impact of product demand, component pricing, and availability uncertainty on revenue, costs, and profits. It is a software tool designed to support the risk management process and to proactively manage procurement uncertainties and risks. The PRM business process is cross-functional and links and defines the roles and responsibilities of procurement, planning, supply chain operations, finance, and marketing.

Characteristics of innovation. The HP SCI can be characterized by: (1) Development and implementation of new processes; (2) A one-time change; (3) Relatively long development and implementation period; (4) Participation was both top-down and bottom-up; and (5) The scope cross-functional and intra-organizational.

Findings. Like the previous award-winning cases, this company has made radical innovations in their supply chain business processes and supply chain technology.

5.6 Comparing findings from the winner cases to the entire sample of 36 cases

The findings across all 36 cases, as summarized in Appendix, suggest that the patterns of innovation content from the small illustrative sample of five "winner" cases is quite similar to the patterns and insight found in the larger sample: that innovation takes place as both radical and incremental changes in business processes, and that in most of the cases, radical innovations were undertaking in the area of supply chain technology. Only a few cases related to changes in the supply chain network structure, suggesting that more changes were found to be intra-organizational, i.e., they focus on change inside their own organization.

6 Conclusion and implications

The aim of this paper has been to provide a better understanding of SCI, mirroring leading edge practice and providing a sound terminological and conceptual basis for advanced academic work in the field. A first effort was the review of the extant literature to identify relevant elements and contents of SCI: it identified a limited number of papers that dealt explicitly with SCI; however, this does not mean that the existing literature is without contributions dealing with SCI, but merely that the conceptualization and consciousness of SCI is less developed. Numerous papers exist on SCM and innovation as separate topics, but there are only a few on the combined issue of the innovation of a supply chain. The focus of many of those papers specifically about SCI is on the application of new technology in the supply chain. However, in most cases, the technology applied is already known in one industry and is then applied to another industry. Other areas in focus are theoretical contributions concerning innovation in various processes, integration of suppliers or customers, and faster order handling, etc. [52]. Two topics in particular under the SCI umbrella seem to be much less researched: the first area is the structural part of a supply chain (or the architecture of the supply chain) and the supply chain network. Another less researched area was found to be the measurement of the SCI and the scale or rating of an innovation in terms of being an incremental or radical innovation. No clear definition was found with regard to how one measures the degree of an innovation. A number of papers [39, 59, 78, 82] state that innovation should be rated subjectively through the eyes of the person or organization seeing or experiencing said change. However, this challenges any capacity for comparisons of innovations in supply chains. A more objective scale is needed to be able to point to the "best in class" supply chain solutions. This explorative piece of research has resulted in proposing an SCI model that consists of the three elements: supply chain processes, supply chain network, and supply chain technology.

The second exertion of this research was an analysis of 36 SCI applications nominated for the CSCMP SCI Award.

These cases have illustrated the SCI model as a starting point for obtaining and establishing a common language for the contents of an SCI. Findings were that some of the companies have actually been implementing innovation in the supply chain network and achieved radical performance improvements by applying postponement principles to products and logistics. Changes in the supply chain network were identified as an important element in the understanding but still applied only to a limited extend. Here is an indication for possible future developments of SCI.

Building on the literature review and the cases, at least six implications for future research can be deduced. First, the model for SCI provides the foundation for theory building within SCI. The next step is to continue to refine the model for SCI by conducting empirical qualitative and quantitative studies. Second, the SCI model contains the three elements of business processes, structure, and technology. Future research needs to dig a little deeper in order to investigate the interplay between the elements from a process perspective (process and structure; structure and technology; and process and technology). Third, measuring the degree of SCI is an area for future research. This paper has found that changes in technologies, processes, and also in supply chain networks are areas for SCI. Such changes can be either incremental or radical. However, this raises the basic question of whether everything has to become an innovation. What about general continuous optimization of procurement lead time, for example? Is this an incremental innovation? Within the current body of knowledge, the answer would be "yes." This is also closely related to the scale of measurement of SCI. Future research must address the question of whether there is some work and basic improvements to be done before entering a degree of innovation scale. Fourth, future research may also address second-level metrics to evaluate the degree of innovation. These metrics should be more supply chain focused than the generic ones applied in this paper [27, p. 5]. Through this, we would be able to avoid the risk of being too subjective in the evaluation of case material, and also provide the basis for more quantitative studies of supply chain innovation, which would give the opportunity to perform a test of the proposed model for supply chain innovation. Fifth, more research is needed to explore the way in which an SCI evolves during the life cycle of a product and the development of a market. Does an SCI have a life cycle? In a case where market, demand, and supply characteristics shift to become more predictable, it would be reasonable to think that radical innovations in supply chains would no longer be the objective; the focus should be solely on incremental innovations. Next, as the technologies for integration and communication in supply chains become more and more developed, an interesting area for further research is how virtual network organizations are going to lead to innovation opportunities in supply chain management. Finally, there is a need to investigate SCI across industries. Are radical SCIs in one industry merely incremental SCIs in another industry? Future research appears to be necessary to address the relationship between life cycles of products and markets across industries and the types of SCI developed.

In conclusion, this paper provides a language for conceptualizing SCI. It provides the basis for sharpening the view of the meaning of SCI, which is a central element in the process of theory development and is a prerequisite for later tests. The paper can be used to stimulate discussions on what to do with and how to do SCI in various companies. Finally, it can be used to map and position ongoing and/or intended SCI projects in a company. It provides a basis for an assessment of current activities to carry on, and what to look for when creating new development initiatives within the domain of SCM. In other words, it can create more consciousness about the types of innovations needed and developed, and how these sustain the creation of competitive advantages.

Appendix

See Table 5.

Table 5 An overview of applications nominated for the CSCMP supply chain award

Case Nr.	Company	Title	Supply chain business process		Supply chain technology		Supply chain network structure		Organizational perspective	
			Increm.	Radical	Increm.	Radical	Increm.	Radical	Intra.	Inter
2009										
1	Intel Corporation (winner)	Just say yes: innovating customer responsiveness at Intel		×		×		×		×
2	Tellabs	Achieving agility and responsiveness with an outsourced supply chain	×			×	×			×
3	Dresser-Rand, D&B	Keeping supplier risk at bay				×				×

Table 5 continued

Case Nr.	Company	Title	Supply chain business process		Supply chain technology		Supply chain network structure		Organizational perspective	
			Increm.	Radical	Increm.	Radical	Increm.	Radical	Intra.	Inter
4	Liberty Property Trust Presents Johnson Diversey	The largest LEED gold certified distribution center in the United States				×			×	
5	Kraft Foods	Improving transportation management through real-time visibility	×			×	×			×
2008										
6	Cisco Systems Inc. (winner)	Unlocking value from product returns		×		×				×
7	Dynamic Worldwide Logistics Inc. and Instaknow.com, Inc.	Instaknow-ACE synchronized global supply chains				×				×
8	Genco and Sky-Trax, Inc.	Tracking solutions				×			×	
9	Lockheed Martin Aeronautics Company	Forecasted raw materials (FoRM)	×							×
10	OceanGuaranteed with APL Logistics, Con-Way Freight Inc.	Creating the industry's first day-definite, guaranteed ocean LCL service	×		×		×			×
11	Party Lite Gifts and Chicago Consulting	Optimal packaging			×				×	
12	US Air Force with Booz Allen Hamilton and Morgan Borszs Consulting	Transforming the United States air force supply chain: expeditionary logistics for the twenty-first century (Elog21)		×	×				×	
2007										
13	Aidmatrix (winner)	"FreeClinic Link—empowering a supply chain of giving"		×		×				×
14	Bakers Footwear Group, Inc.	"Fashionably late is not fashionable when dealing with trendy footwear"	×		×		×			×
15	John Deer and SmartOps			×		×		×		×
16	Kraft Foods and IDEO	"Customer supply chain innovation and collaboration model"	×							×
17	Liquor Control Board of Ontario	"New item submission system"	×		×					×
18	Motorola	Supply chain transformation drives high-performance results	×		×				×	
19	OceanSchedules.com,	Innovation for the ocean-transportation industry				×				×
2006										
20	CEAG/FRIWO	A quantum leap in reducing working capital	×							×
21	Hewlett-Packard	Buy sell process	×							×
22	IBM	The road to an on demand supply chain		×	×					×
23	Kellogg's and CSCS	A closed-loop returns management system, turning failures into profits		×						×
24	Mercy ROI (winner)	ROI, resource optimization and innovation		×		×				×
25	P&G	Forces of business and forces of nature—building and agile supply network	×						×	

Table 5 continued

Case Nr.	Company	Title	Supply chain business process		Supply chain technology		Supply chain network structure		Organizational perspective	
			Increm.	Radical	Increm.	Radical	Increm.	Radical	Intra.	Inter
26	The Dow Chemical Company			×		×	×			×
2005										
27	Blockbuster Inc.	Rental DVD packaging supply chain		×		×			×	
28	Campbell Sales Company and Food Lion	"Secondary packaging redesign"		×		×				×
29	Hewlett-Packard	Design for supply chain program	×					×		×
30	Hewlett-Packard (winner)	Procurement risk management (PRM) at HP company		×		×			×	
31	Kraft Foods	Elevating supplier value: the kraft foods supplier relationship management bridge		×						×
32	Lexmark	Cash to cash cycle time improvement	×					×		×
33	NOV	National oil well Varco		×		×			×	
34	United Technologies	Supplier insight for better business performance				×				×
35	USTRANSCOM	Bridging the gap between strategic and theater distribution		×	×				×	
36	LCBO	CPFR—partnerships and profits	×			×				×

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