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Supply chain innovation research: content analysis based review

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Abstract

Purpose – The purpose of this paper is to analyze research methodologies and publication trends across geographical regions in the field of supply chain innovation (SCI) and provide a discussion of future research in the SCI.
Design/methodology/approach – Using a content analysis approach, this paper investigates 26 years of SCI research based on a sample of 473 journal articles published in 77 peer-reviewed international journals.
Findings – There has been an increasing focus on empirical quantitative research design as compared to empirical qualitative, conceptual quantitative and conceptual qualitative designs in the field of SCI. Continued research interest in SCI from all parts of the world including North America, Europe and Asia illustrates the importance of SCI in the broader field of management.
Research limitations/implications – The inclusion of a large number of journals provides greater confidence in the identified trends. However, as the top-tier journals publish only the most rigorous studies, considering all journals as equally weighted will give rise to a mixed pool of studies. Identifying trends from this mixed pool may provide more comprehensiveness at the cost of inclusion of non-core journals of the field.
Originality/value – The current study builds a holistic view of the methodological progress made so far in the field of SCI.

Keywords Research methodologies, Content analysis, Systematic literature review, Supply chain innovation, Publication trends

Paper type Literature review

1. Introduction

The field of supply chain innovation (SCI) has seen remarkable growth in the last few decades (Arlbjørn *et al.*, 2011). It is primarily due to the increased importance given to SCI practice due to international rules and regulations, social values and ethics and competition that requires constant changes in supply chains (Shibin *et al.*, 2018). The innovations taking place along various dimensions of supply chain management (SCM) including technology, information systems, network design, business processes and management practices have attracted the attention of scholars from various domains of management. Thus, the research on SCIs is published in different academic outlets, falling in the domains of operations, supply chain, logistics, distribution, technology and general management literature (Damanpour and Aravind, 2012; Croom *et al.*, 2000).

Notwithstanding the growth in the literature, there is no comprehensive and systematic study covering the developments in the field of SCI. The most recent literature review based on an analysis of a small number of papers in this area was published in 2011 (Arlbjørn

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et al., 2011). Moreover, the scope of analysis of Arlbjørn *et al.* (2011) is narrow, as they discuss only terminological aspects of the field of SCI. However, there has been continuous development in the field, widening both in scale and scope. Further, with the advent of various advanced methodological techniques, such as structural equation modeling (SEM), several empirical studies measuring the causes and effects of SCI have also emerged. Moreover, the scope of research in SCI has extended beyond technology and process aspect to include business models and administrative and network design aspects (Zhang *et al.*, 2015; Punniyamoorthy *et al.*, 2013). Given these developments, a vacuum exists in the understanding of research trends and the overall methodological developments in the field of SCI. The need arises for uncovering the latest developments in the field of SCI using a larger sample of papers. A content analysis-based literature review can fill the vacuum in this understanding, focusing on the exploration of emerging patterns in research, publication trends and the overall shape of research in SCI. Content analysis of SCI literature can provide a useful means to dig out trends and patterns in the literature and excavate the "nuggets of knowledge that lie buried underneath" (Kirca and Yaprak, 2010, p. 306). Indeed, an analysis of the methodological developments is pivotal to gain the epistemological insight into the field and to the growth, maturity and enhanced rigor of future SCI research. Accordingly, this paper addresses the gap by exploring the SCI literature to seek answers to the following questions:

(1) What research designs, methodologies and analytical techniques have been employed in SCI literature? What approaches have been used in the past and what is the current trend?

(2) What are the overall publishing trends in SCI literature?

The first question caters to the review of frequently used research design including data collection method, country of data collection, respondent type, response rate, sampling method and sample size. It also considers investigating the use of analytical technique applied in previous studies. The second question captures the overall trends in SCI literature, such as the origin of published papers regarding variables such as contributing authors, influential articles, journals publishing such studies, citation trend and publication trends along different time domains and across global regions.

For this purpose, the current study goes beyond Arlbjørn *et al.* (2011) in three main ways. First, this study covers a most recent and comprehensive list of articles. Second, this study compares a broader range of important categories of data, for example research design, methodology, analytical techniques and distribution of published papers vs time, geographical regions and combined time-geographical dimension. It also identifies the prolific contributing authors in the field of SCI, their affiliations, influential articles, journals publishing such studies and citation trends. Third, this study provides cross tabulations among various categories of data and provides results that cannot be obtained from the previous literature reviews. A comparison of the two studies is provided in Table I.

The paper makes use of content analysis, which is a research approach for the objective, systematic and quantitative description of a specific domain of literature (Chatha *et al.*, 2018). The discourse of content analysis is systematic, rule governed and theory driven. Content analysis is quite popular in supply chain research, for example Ibrahim *et al.* (2015). As a part of the content analysis, cross tabulations have been developed at both basic and advanced levels to depict trends and patterns that remained invisible to a common reader. The findings of content analysis portray a bigger picture of the status of SCI research, including research design, most commonly used research methodologies, influential papers, journals publishing research on SCI and the overall status of research along different time domains and geographical regions. These findings provide practical guidance for researchers in SCM, in general, and SCI, specifically. The key contribution of this study is

Research element	Current paper	Arlbjorn *et al.* (2011)
Publication counts by selected journals	X	X
Identification of publications by author(s)	X	
Identification of publications by year of publication	X	
Identification and development of frameworks and model		X
Identification of major theme		X
Publication counts by research methodology	X	
Research type – qualitative	X	
Research type – quantitative	X	
Research type – empirical	X	X
Research type – conceptual	X	X
Research design – sample size	X	
Research design – data collection method	X	
Research design – country of data collection	X	
Research design – respondent type	X	
Research design – statistical techniques	X	
Research design – reliability and validity	X	
Research design – response rate	X	
Research design – sampling methods	X	
Research design – pretest/pilot	X	
Research design – cross-section/longitudinal	X	
Research design – survey, model, experiments, simulations, etc.	X	
Publication trends – authorship type – academics vs practitioners	X	
Publication trends – authorship per study	X	
Publication trends – by journals	X	
Publication trends – most prolific authors	X	
Publication trends – most influential universities	X	
Publication trends – top-cited articles	X	

Note: X signifies checked

Table I.
A comparison of the current study with Arlbjorn *et al.* (2011)

that it uncovers those gems of knowledge that usually receive less attention in a routine research discourse. Further, it provides a broader overview of the research trends. As noted by Williams and Plouffe (2007), content analysis encourages researchers to "step back from their individual trees in order to assess the entire forest of knowledge generation" (p. 408).

2. Supply chain innovation

2.1 Developments in SCI field

The rising need for delivering products and services to the customer at least cost, right place and right time has made organizations realize that improving merely manufacturing capabilities in a supply chain is not sufficient, rather the whole supply chain ought to be made competitive. As a result, as it is generally said, the competition has shifted from between companies to between supply chains, and many organizations realize that sustainable competitive advantage hinges on effectively handling SCM processes. In other words, process differentiation is more sustainable than product differentiation, as products are easier to see and reverse engineer (Dubey *et al.*, 2012). However, current SCM processes and practices pose several economic, environmental and societal challenges (Jajja *et al.*, 2017; Shaw *et al.*, 2010) that can be addressed with an innovative mindset.

Scholars argue that SCI offers promising opportunities for creating competitive advantage in SCM (Dubey *et al.*, 2012; LaLonde, 1998; Lummus and Vokurka, 1999; Ho *et al.*, 2002; Silvestre, 2015). The areas of technology-related SCI include RFID, bar coding and enterprise resource planning (ERP) system. Process-related SCIs include integrated supply

chain networking, make-to-order processes, vertical integration, product standardization, postponement and continuous replenishment programs. SCIs can also emerge from a "customer-focused processes" by focusing on customer touchpoints, customer participation and customer control (Dubey *et al.*, 2012). Innovations related to supply chain network include service parts availability via an integrated network, upstream SCM, vendor-managed inventory, insourcing and outsourcing, and nearshoring. Finally, the examples of SCI within a company include Toyota Production System and Kanban system. These innovations have led to an increase in efficiency and value creation.

Recognizing the burgeoning importance of SCI, the Council of Supply Chain Management Professionals has set up a "Supply Chain Innovation Award" to recognize outstanding practices that have demonstrated excellence, innovation and return on investment in addressing significant supply chain challenges (CSCMP, 2016). As the emphasis on the need for SCIs has increased in practice, there has been a concurrent expansion in SCI literature. For example, institutional analysis of SCI in global marketing channels (Bello *et al.*, 2004), importance of strategic knowledge exchange in SCI (Nasr *et al.*, 2015), performance implications of SCI (Dubey *et al.*, 2012; Lee *et al.*, 2011), adoption and diffusion of SCI including human and technical enablers and inhibitors (Hazen *et al.*, 2012; Robert *et al.*, 2019) and sustainability and frugality in SCI (Shibin *et al.*, 2018) have been some of the emerging themes in the current research in SCI. This growth further highlights the need to explore trends in the SCI literature.

2.2 Definition of SCI

Previous research has defined innovation in the supply chain context from different perspectives, for example size and scope of innovation (Arlbjørn and Paulraj, 2013; Dubey *et al.*, 2012), innovativeness (Hult *et al.*, 2002, 2004; Hurley and Hult, 1998) and innovation capability (Calantone *et al.*, 2002). However, there seems to be a lack of consensus. The following are few definitions of SCIs in the literature:

> An incremental or radical change in process, structure, and/or technology that takes place in the supply chain network so as to create value for all stakeholders. (Arlbjørn and Paulraj (2013)

> Supply chain innovations combine developments in information and related technologies with new logistic and marketing procedures to improve operational efficiency and enhance service effectiveness. (Bello *et al.*, 2004)

> Supply Chain Innovation is a set of activities undertaken by an organization to promote effective innovation of its supply chain. (Malekshahi *et al.*, 2014)

> 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. (Arlbjørn *et al.*, 2011)

> […] improvements in the way that supply chains operate, and more specifically, in the way that products, information, work, and funds flow (and are temporarily stored) throughout the supply chains by using technology or approaches like ECR (Efficient Customer Response), VMI (Vendors Managed Inventory), ERP (Enterprise Resource Planning), RFID (Radio Frequency Identification Device) chips, and postponement strategy. (Dubey *et al.*, 2012)

These definitions bring forth three key aspects critical for conceptual clarity of SCI concept. First, the size of innovation in SCI could vary from incremental to radical. Second, the scope of innovations may spread over areas such as business processes, application of technology, network and logistics operations and customer interaction, within the company or at the inter-organizational level. Finally, SCI results in increased value creation for a variety of stakeholders, not just for one entity in the supply chain.

Based on these characteristics, a comprehensive definition of SCI is proposed and used for this research:

> A supply chain innovation is an incremental or radical change in SC processes, network structures, and/or SC technology that yields economic, environmental, or social value for different stakeholders in the supply chain.

3. Methodology

3.1 Database search

SCI literature was searched on "Web Discovery," which is a service for searching all specialized external resources provided by EBSCO information service. It includes major databases like Emerald Insight, ScienceDirect, Business Source Premier, the Scopus and Springer Link, among many others. The search included keywords "Supply Chain" and "Innovation" in title and/or abstract and/or keywords. Thus, nine combinations were used as a Boolean expression to thoroughly search the term "SCI" (Table II). The search returned a total of 2,116 articles, spanning over a period of 66 years: 1949–2016. Only ten articles were published from 1949 to 1990, which were removed from the list to make search period 1991–2016, leaving behind 2,106 papers.

The search results from Web Discovery were exported to Microsoft Excel via RefWorks, a bibliographic management software. Exporting results helped us in arranging data in columns with specific headings.

3.2 Journal selection and shortlisting of articles

We followed the work of Chatha *et al.* (2015) to guide the process of shortlisting relevant papers from the pool of 2106 articles identified in the initial search, for this research. The papers were shortlisted in two steps on the basis of two main criteria: the quality of the journal and the relevance of the article. Among 2,106 articles, only those papers were retained that appeared in peer-reviewed international journals mentioned in either of the rankings of journals given by Thongpapanl (2012), Linton and Thongpapanl (2004), Barman *et al.* (2001), Vastag and Montabon (2002), Watson and Montabon (2014), Olson (2005) and Petersen *et al.* (2011). Out of these seven journal rankings, two were of innovation management field and five were related to operations management and SCM. These rankings were based on different factors such as impact factor, relevance, perceived quality and the number of citations. Hence, all journals that appeared in the aforementioned rankings were included in the list. This step was meant to include only high-quality articles from reputed journals. This approach of making a union of all the rankings gave a set of 130 international journals.

Table II. Combinations of keywords used for searching literature

No.	Title	Abstract	Keywords
1	Supply chain	Innovation	
2	Supply chain		Innovation
3	Innovation	Supply chain	
4	Innovation		Supply chain
5		Innovation	Supply chain
6		Supply chain	Innovation
7	Supply chain, Innovation		
8		Supply chain, Innovation	
9			Supply chain, Innovation

After finalizing the list of 130 peer-reviewed international journals, filters of these journals were applied on our initial search that had given 2,106 articles, matching ranked journals with journals exported from RefWork software. Applying these filters resulted in a list of 840 articles. These 840 papers were further screened by two researchers, having prior experience in supply chain and innovation management research, in more detail by reading their titles and abstracts to assess their relevance to the field of SCI. This step was meant to ensure the relevance of the articles. As a result, a final usable sample of 473 high quality and relevant SCI articles from 77 peer-reviewed international journals emerged for an in-depth analysis. This ratio of shortlisting (from 2,106 to 473) is comparable to that of Chatha *et al.* (2015) (from 2,185 to 512).

3.3 Research design categorization and reliability

Codes to different categories of the data were assigned, such as the "research design" of a published study may fall in one of the four categories: empirical quantitative, empirical qualitative, conceptual quantitative and conceptual qualitative (Nakata and Huang, 2005; Page and Schirr, 2008).

Empirical studies focus on the validation of concepts and testing theories by developing hypotheses and using data analysis techniques. These studies are based on empirical (primary or secondary) data and the research process in the study proceeds so that they can be verified and replicated by other researchers. Conceptual studies, however, build ideas, concepts and theories, and usually build on published literature (Meijboom *et al.*, 2011). The insights developed by conceptual studies can further be a subject of empirical research. Quantitative studies are based on variables that can be measured in numbers; they involve data collection and data analysis using statistical procedures (Creswell, 1994). Qualitative studies are meant for an in-depth understanding of a social phenomenon; they build upon non-numerical data usually collected through interviews, observations, document reviews and ethnography (Yin, 2003).

Accordingly, "empirical quantitative" studies use quantitative data to investigate research problems whereby data collection usually takes place through surveys, experiments or other quantitative methods. "Empirical qualitative" studies use qualitative data in investigating a research problem; data collection usually takes place through interviews, case studies and observations. "Conceptual qualitative" studies develop model, frameworks, propositions or explain a research problem using qualitative data usually derived from published literature. Finally, "conceptual quantitative" designs develop models based on secondary quantitative data using advanced mathematical models (Nakata and Huang, 2005; Page and Schirr, 2008; Ho *et al.*, 2002). All the selected papers were reviewed to determine the type of their research design.

The data were coded by three researchers, and conflicts among them in the coding process were resolved through regular discussions. Reliability of the coding method for various categories of data was checked through two techniques: simple percentage agreement (Hayes and Hatch, 1999) and Cohen's k coefficient (Landis and Koch, 1977). First, a random sample of 100 articles belonging to four research designs was given to an external researcher for the coding of 473 data points. The assessment of external rater agreed with 83 percent of the assessments of the internal team. For the rest of 17 percent data points, extensive discussions between the internal team and the external rater made the external rater agree with further 9 percent of the internal team's assessments, resulting in agreement on 92 percent data points.

Second, Cohen's k coefficient, using a random sample of 100 articles, was 0.88. There is no strict value suggesting an acceptable value of k, but 0.88 comes in the range of substantial agreement (Landis and Koch, 1977; Fleiss, 1981). Moreover, this level of agreement is statistically significant at 99 percent, suggesting that the inter-rater agreement is beyond mere chance.

3.4 Analysis

The research team analyzed the data for the categories mentioned above. The team members met regularly and presented the findings in meetings. During these meetings, the findings and emerging issues were discussed, and the best ways to present findings were explored. The final presentation of the results takes the form of multiple figures and tables.

4. Results

4.1 Overall research types – empirical, conceptual, qualitative and quantitative

The number of published empirical studies far exceeds the number of conceptual studies, the former being 61 percent, whereas the latter being 39 percent. Empirical studies are primarily based on data and support their claim with empirical evidence. It involves a rigorous process involving a scientific approach employing measures to reduce bias. However, a reasonable proportion of conceptual studies (39 percent) in SCI literature indicates that these studies are still relevant in providing rich insights, providing the overall conceptual clarity and highlighting emerging issues.

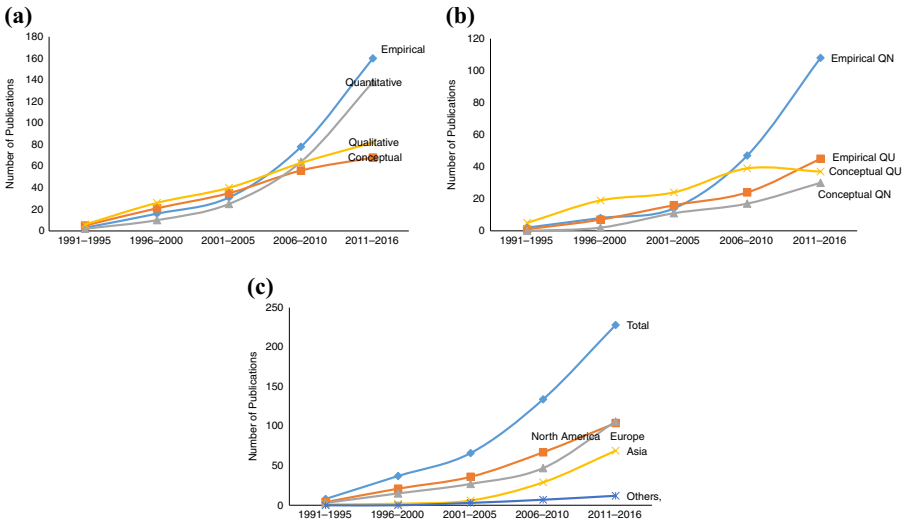
Regarding the mix of research types, empirical quantitative studies are the most popular (38 percent). The observed surge in using quantitative methods may be attributed to three key factors. First, empirical quantitative studies represent the positivist paradigm where seeking validity and objectivity through scientific methods is the prime concern. Empirical quantitative studies provide the required means for this paradigm. Second, there have been tremendous developments in statistical methods (e.g. SEM) and tools (e.g. SPSS, LISREL and AMOS) that encourage the use of empirical quantitative methods. Third, the increase in the number of quantitative studies can also be seen as an attempt toward building theories of SCI, conforming to the call of some authors during the early 1990s (Amoako-Gyampah and Meredith, 1989; Swamidass, 1991; Flynn *et al.*, 1990).

Other categories of SCI research emerging in this study are empirical qualitative (20 percent) and conceptual qualitative (26 percent). The emergence of empirical qualitative studies is understandable, as these studies, such as empirical quantitative, contribute to theory development, yet through a different research design. Empirical qualitative studies are particularly useful for the exploration of new ideas and for providing new insights that can later be tested using empirical quantitative studies. Thus, empirical qualitative and empirical quantitative studies work in a complementary fashion whereby the former explores and develops new insights and proposes relationships, whereas the latter tests such insights and propositions through a rigorous scientific process. The emergence of conceptual qualitative studies as a notable entity is also understandable, as these studies bring conceptual clarity, define and elaborate concepts, identify trends and define agenda for future research (Nakata and Huang, 2005; Page and Schirr, 2008). Other research mix types (conceptual quantitative (13 percent) and empirical mix (3 percent)) constitute a relatively smaller portion of the total SCI studies.

Empirical (quantitative and qualitative) studies, which are 61 percent of the SCI research studies, put a greater emphasis on methodological issues as a prerequisite for the rigorous theory development process and seem to demonstrate their relevance to this paper. As compared to conceptual studies, empirical studies have a set methodological criteria to pass; thus, a multitude of methodological issues need to be considered. Thus, methodological developments of these two types are discussed in more detail in the subsequent sections.

4.2 Chronological and regional trend

Overall, findings show that research on SCIs is on the rise in all research types and regions (Figure 1). In the order of empirical, quantitative, qualitative and conceptual categories, the number of studies is increasing in SCI literature; however, empirical and quantitative



Notes: (a) Trend in types of research; (b) trend in mix of research types; (c) research publication trend across different geographical regions

Figure 1.
Research types and geography

studies have seen higher growth since 2005 (Figure 1(a)). A further categorization in Figure 1(b) shows that empirical quantitative studies have by far exceeded the other categories since 2005. Region wise, the highest number of SCI-related studies have been published in North America, followed by Europe and Asia (Figure 1(c)). Research in Europe and Asia from 2005 onwards shows a remarkable increase and catches up with the number of publications in North America in 2015 (Figure 1(c)). The last few decades have witnessed a shift in manufacturing operations and subcontracting to suppliers in Asia. This shift in search of low-cost operations highlights the need to explore SC aspects in the Asian context to seek improvement opportunities (Jajja *et al.*, 2017; Jajja *et al.*, 2016).

The increased participation in global supply chains from the bottom of pyramid countries, modern technological developments in the realm of SC and the popular initiatives of professional bodies, such as Supply Chain Innovation Award, indicate that research in SCI will continue to expand, and there are opportunities for building theories and filling the gap in the current SCI literature.

4.3 Research developments – empirical quantitative studies

4.3.1 Countries of data collection. A large percentage of empirical quantitative studies have collected data from the USA (19 percent), followed by China (9 percent), Germany (6 percent), the UK (5 percent), Taiwan (4 percent) and Italy (4 percent), with the combined contribution being 47 percent (Figure 2(a)). Data were collected by 48 percent studies from a large number of countries, including Australia, Sweden, Japan, South Korea and Spain, among many others. The contribution of each country in this category is less than 3.5 percent. A small number of studies (5 percent) did not provide adequate information to identify the country of data collection.

The data collection of a large number of empirical quantitative studies from the USA and some European countries (Figure 2(a)) could be due to a number of factors. First, it is more convenient to collect data from a country like the USA, as it offers a large sample of globally operating firms. Second, the USA is also home to a large number of renowned firms, which

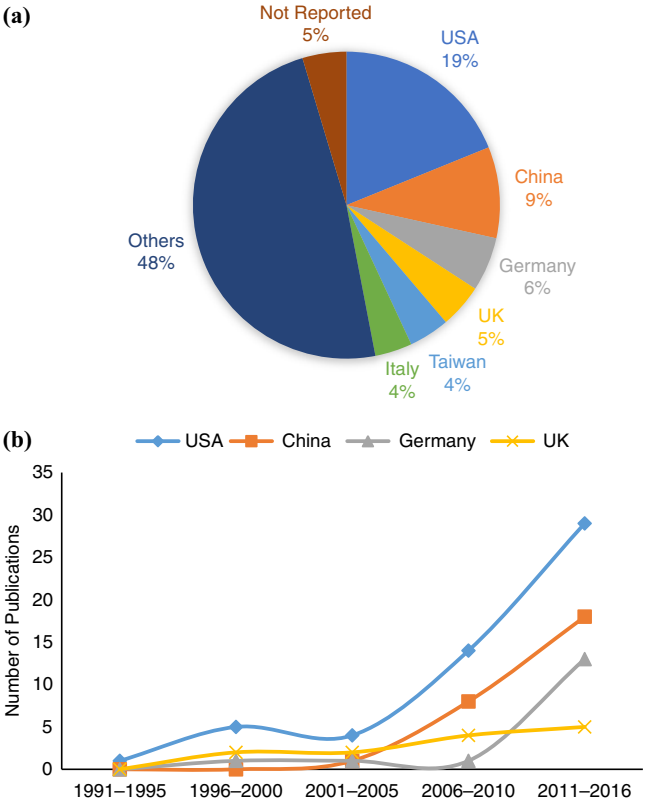
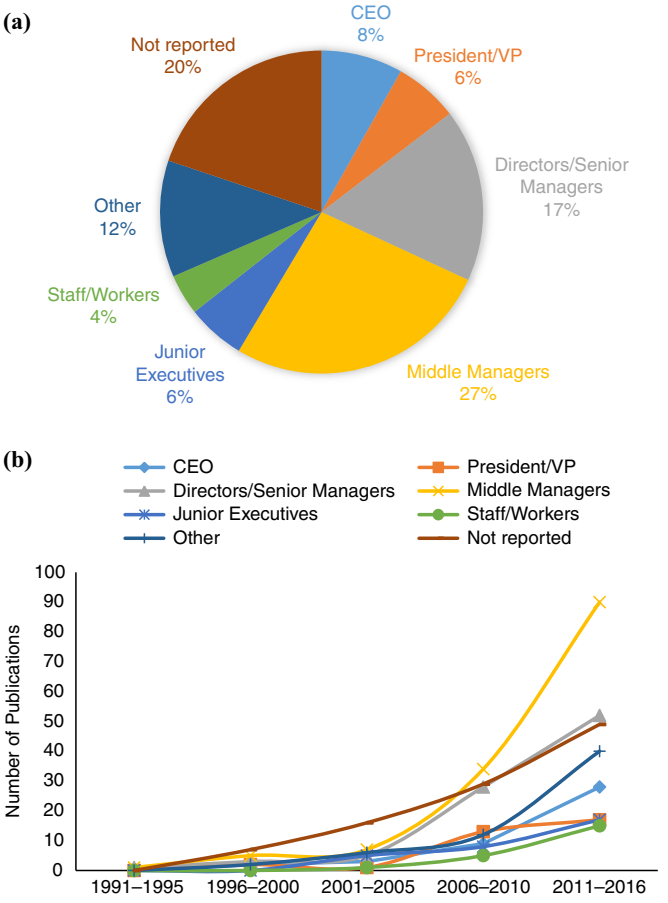


Figure 2.
Data collection

Notes: (a) Country of data collection: overall distribution; (b) country of data collection vs time and region for empirical quantitative studies

may provide abundant opportunities to study and disseminate the best-in-class practices. Finally, the regulatory, normative and cultural–cognitive factors in the US favor institutionalization of SCIs, as these factors play vital roles in shaping the contractual, ownership and social elements of institutional arrangements favoring innovation (Bello *et al.*, 2004). Moreover, the outgrowing representation of China in the countries of data collection could be due to shifting of manufacturing and outsourcing to China and the emerging role of Chinese companies in global supply chain issues (Figure 2(b)).

4.3.2 Respondent type. In empirical quantitative studies, it is of utmost importance to approach the most suitable respondent having required information because the selection of respondents can profoundly influence research findings (Fowler, 2013; Saunders and Lewis, 2012). The findings show that there has been a greater tendency to collect data from middle-level managers (27 percent) (Figure 3(a)). Data collection from directors/senior managers is the second popular choice in empirical quantitative studies (17 percent) (Figure 3(a)). In addition, studies sourcing data from these two categories have significantly outgrown other categories that too have increased over the years (Figure 3(b)). One possible reason for a higher proportion of the middle-tier respondents (i.e., directors, senior managers and middle managers, with the total being 44 percent) is that they have sufficient knowledge of the organizational strategy, tactical processes, short- and long-term planning, day-to-day



Notes: (a) A profile of respondents – the overall distribution; (b) trend in data collection from different respondents

Figure 3.
Respondents

execution and are usually easier to access than top-level management. Moreover, these middle-tier respondents are more familiar with SC operating practices, their outcomes and effectiveness (Choi and Eboch, 1998).

Top managers (CEOs, presidents and vice presidents), constituting a total of 14 percent, are less popular choices among respondents. Data collection from top managers indicates that many SCI studies base their findings on strategic direction-related information. Whereas 10 percent studies have focused on data from junior executives, and staff and workers, 12 percent studies collect data from a source other than those mentioned above, such as purchasing professionals, supply chain professionals, sourcing professionals, corporate buyers, engineers and project leaders. Surprisingly, 20 percent studies reported the nature of target respondents ambiguously.

4.3.3 Statistical techniques. SEM is the most popular technique employed in empirical quantitative studies (43 percent), followed by regression analysis (41 percent) (Figure 4(a)). The use of other techniques such as ANOVA (3 percent), cluster analysis (2 percent) and descriptive statistics (7 percent) is much dwarfed than the use of SEM and

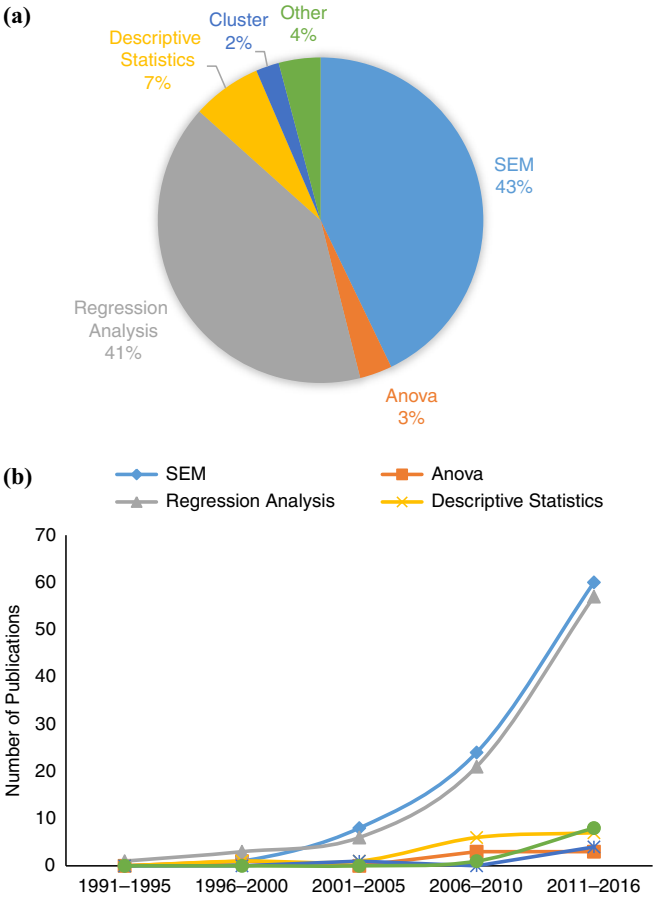


Figure 4.
Statistical techniques

Notes: (a) Use of statistical techniques: the overall distribution; (b) trend in the use of different statistical techniques

regression analysis. Trend analysis also indicates the growing use of SEM and regression analysis compared to other almost stagnant techniques (Figure 4(b)).

SCI research in the last decade has focused on modeling the causal relationship between various supply chain variables and different aspects of performance, including financial, operational, quality performance, customer satisfaction and productivity (Ho *et al.*, 2002; Dobrzykowski *et al.*, 2015; Dubey *et al.*, 2012). These types of relationships can best be explored through modern statistical techniques such as SEM and regression analysis, which predict the strength of the relationship between the variables of interest, thus explaining the greater use of these statistical tools and techniques. The information about the trend in the use of statistical techniques is particularly important for future researchers in determining choices about analytical methods. The use of popular techniques (such as SEM and regression analysis) may bring legitimacy to a study and a sense of alignment with the prevalent research norms.

4.3.4 Data type – primary/secondary. A large number of empirical quantitative studies (87 percent) are based on primary data. A relatively small number of studies (9 percent) are

based on secondary data. The rest 4 percent either use a mix of the two types or do not provide adequate information to identify the data type. Primary data are collected firsthand by researchers, whereas secondary data are borrowed from other sources (Roth, 2007). If the cost of data collection is not taken into consideration, primary data are preferred over secondary data, as they give researchers more flexibility. Researchers can also take measures to ensure the reliability and validity of data. In case of secondary data, researchers have to generally content with what is available, and in most repositories of secondary data, the data are not available at firm or supply chain level that is needed for SCI research. Therefore, primary data collection is more popular in SCI studies.

4.3.5 Sample size. Sample size reflects the rigor of empirical quantitative studies, and those with larger sample size make a stronger case for external validity (Shah and Goldstein, 2006). Conversely, one needs to be careful in generalizing the findings of studies with smaller sample size. A vast majority of SCI studies (54 percent) used a sample size ranging from 101 to 300, 12 percent studies used a sample size of 301–500 and 17 percent employed a sample size greater than 500. Overall, 83 percent studies used a sample size greater than 100, which is quite reasonable, given the fact that data collection in quantitative studies (such as a survey) is a challenging task. Further, a large sample size (> 100) is also preferred for the use of advanced statistical methods such as SEM and regression analysis. A sample size of up to 100 was used by11 percent studies and 6 percent did not provide adequate information about sample size. The use of large sample size (> 100) by 83 percent of studies is encouraging and sets a high bar for future SCI studies in terms of required sample size.

The studies, with a sample size greater than 300, usually use secondary data sources such as International Manufacturing Strategy Survey and Council of European Social Science Data Archives that provide data on firms from various countries. Such studies usually explore either global issues in SCIs (Roh *et al.*, 2014) or provide comparative findings of multiple countries (Yazdifar and Askarany, 2012). On the contrary, studies with small sample sizes (< 100) mostly explore strategic issues and interfirm supply chain linkages within a country context (Blome *et al.*, 2013). Such studies employ sophisticated statistical techniques like PLS to reduce the small sample bias (Gualandris and Kalchschmidt, 2014).

4.3.6 Response rate. A large number of studies (39 percent) have noted a response rate ranging from 11 to 30 percent. Studies that have reported a response rate of less than or equal to 10 percent are relatively few. Since primary data collection usually consumes time, demands resources and presents difficulties in approaching relevant people, a response rate of 11–30 percent by a significant number of studies is understandable. Surprisingly, a large number of studies (30 percent) did not provide adequate information about response rate. In general, these studies discuss their sample size in absolute terms, that is mentioning only the number of final useable responses.

The tendency to avoid mentioning the response rate has gradually decreased over time. In 1991–1995, the percentage of not reporting response rate was 50 percent, but in 2010–2016, this figure dropped to 31 percent, indicating a significant improvement in the presentation of research methodology. Moreover, there seem to be no significant regional differences in the response rates. It is primarily due to the fact that it is becoming a standard to have an adequate response rate to justify the results of the studies. Thus, empirical quantitative studies from various regions converge on response rates.

4.3.7 Sampling method. The proportion of different sampling plans used in SCI studies is shown in Figure 5(a), which indicates that "random sampling" is the most popular choice (56 percent) in empirical quantitative studies. Random sampling has certain advantages over others: it reduces bias and yields an equal probability of selection of units (Saunders and Lewis, 2012). Further, it is also time and cost saving, thus being the most popular in SCI research. Purposive or judgment sampling is the second largest category (9 percent).

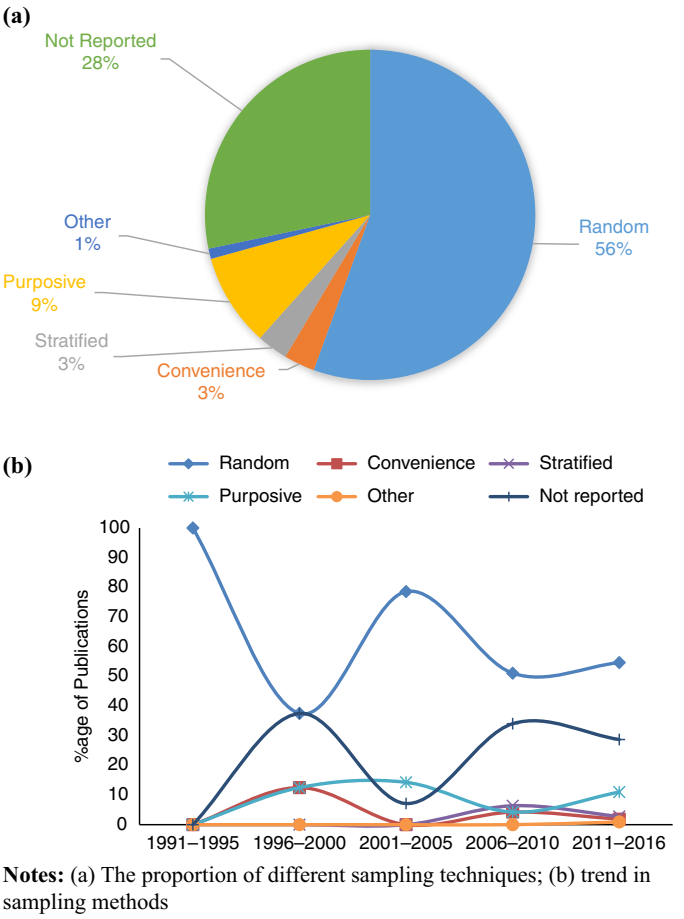


Figure 5.
Sampling techniques

Notes: (a) The proportion of different sampling techniques; (b) trend in sampling methods

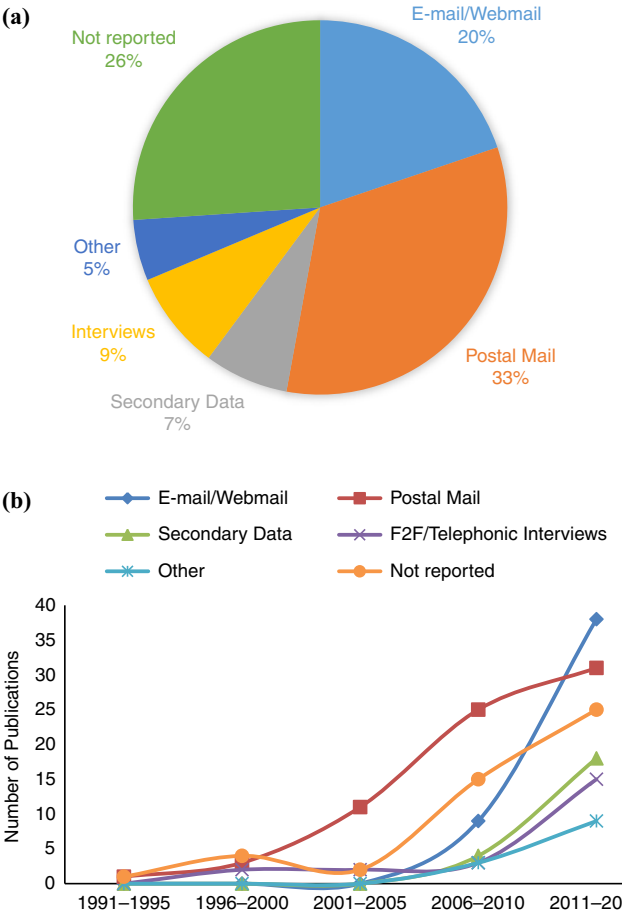
Purposive sampling is a non-probability sampling in which researcher consciously selects a particular group. Convenience and stratified sampling each constitute only 3 percent of the total. Other sampling methods such as snowball sampling method are not popular in SCI research. Adequate information about sampling method is not provided by 28 percent studies.

The chronological trend shows that random sampling has decreased from 79 percent in 2000–2005 to 55 percent in 2010–2016 (Figure 5(b)). Although purposive sampling is a non-probability sampling, there is a notable appearance of purposive sampling (11 percent in 2011–2016) because these studies explored different aspects of SCIs where the sample was chosen on the basis of its SCI-related characteristics. In other words, researchers wanted to explore SCI characteristics in a particular sample, for example Schoenherr and Swink (2015). Convenience and stratified sampling have started to appear in studies after 2006–2010. The overall prevalence of random sampling may be due to its broad acceptance, as it improves the generalizability of a study. Finally, although the trend of not reporting sampling method has decreased from 34 percent in 2006–2010 to 29 percent in 2011–2016, which is encouraging but still raises concerns about the rigor of research methods used in SCI research.

4.3.8 Data collection means. A large number of studies (33 percent) collected data through postal mail (Figure 6(a)), 20 percent collected data through e-mail/webmail and 9 percent studies collected data through interviews (face to face and telephonic). Secondary empirical data were used by 7 percent studies and 26 percent studies did not report data collection means. Data collection through postal mail and e-mail together constitutes 53 percent of the total studies. A higher proportion of these two means can be attributed to their cost, convenience and reliability.

The use of postal mail has been widespread since 2000 (Figure 6(b)). However, after 2006, there has been a sharp increase in the use of webmail, which surpasses the use of postal mail in 2011 onwards. The growing use of webmail in data collection is intuitive as it is quicker, cheaper and more convenient than postal mail. Further, the ability of webmail to contain rich information in a single message makes its use particularly attractive to researchers.

4.3.9 Reliability and validity. The findings show that a significant number of studies (54 percent) reported the reliability test results. Reliability is the ability of a measure to



Notes: (a) Different methods for data collection – the overall distribution; (b) trend of data collection means in empirical quantitative studies

Figure 6.
Means of data collection

repeatedly yield similar results across similar situations (Mentzer and Kahn, 1995). The tendency to report reliability results has increased over time. During 2001–2005, only 33 percent studies reported reliability results, but this ratio increased to 62 percent in 2011–2016. For the validity tests, overall 54 percent have reported validity results. Similar to reliability tests, the tendency to report the validity test has significantly increased over the last decade. Validity is defined as the extent to which a measurement instrument measures what it is intended to measure. During 2001–2005, only 50 percent of the studies reported validity testing, but this ratio increased to 64 percent in 2011–2016. This tendency to report reliability and validity results indicates a significant improvement in the scientific rigor of studies.

4.3.10 Pretest/pilot test. Overall, 31 percent studies reported pretest/pilot test, whereas the rest 69 percent did not. For the studies that reported pretest, a large number of studies employed advanced statistical methods such as SEM (56 percent) and regression analysis (27 percent). The rest 17 percent used other methods such as cluster analysis, ANOVA and descriptive statistics. The trend of not reporting pretest is similar across various regions, including North America, Europe, Asia and others. When research is based on primary data collection, such as in the survey, pretests can add significant value by refining a research instrument (Dubey *et al.*, 2012; Roth, 2007). A data collection instrument without pretest carries the risk that a respondent may perceive a question different from that intended by the researcher, leading to errors in data collection. Therefore, the absence of reporting pretest indicates a weakness, either in research design or its presentation in publications, and warrants the need for improvement.

4.3.11 Time horizon – cross-sectional/longitudinal. Cross-sectional studies collect data from a population at one specific point in time, whereas longitudinal studies comprise multiple observations over time. A large number of empirical quantitative studies (62 percent) are cross-sectional, whereas 10 percent are longitudinal. The rest 28 percent do not provide adequate information about time horizon. Given the trend of more quantitative than qualitative studies in SCI research (discussed earlier), it is easier to imagine why the proportion of cross-sectional studies exceeds the longitudinal one. Combining this information (i.e. a higher proportion of cross-sectional studies) with other findings discussed earlier such as the higher proportion of quantitative studies, survey-based research and data collection through postal mail and e-mail suggests that SCI has been regarded mainly as a short-term process rather than a longitudinal process. This indicates that SCI problems are studied in short time frames. Alternatively, cost and time factor associated with execution of longitudinal research design can be a reason for its limited use (Robert *et al.*, 2019).

4.4 Research developments – empirical qualitative

4.4.1 Research design. The predominant research design in empirical qualitative studies is company-specific case studies (74 percent). The rest 26 percent use other research designs such as literature review and secondary qualitative data. Case studies are especially useful in SCI when researchers aim to understand a complex organizational phenomenon embedded in the socio-technical context of the organization (Yin, 2003). Case studies are also effective when research area is relatively new and less explored, as is the case of SCI.

Within the case study research design, about 45 percent studies used a single case, whereas the rest 55 percent employed multiple cases. Further, there is also a trend showing the increased use of multiple cases and the declining use of single cases since 1991. From 2011 onwards, the use of multiple cases catches up and then exceeds the use of single case studies. The growing use of multiple case studies can owe to their robust design in terms of internal and external validity (Yin, 2003).

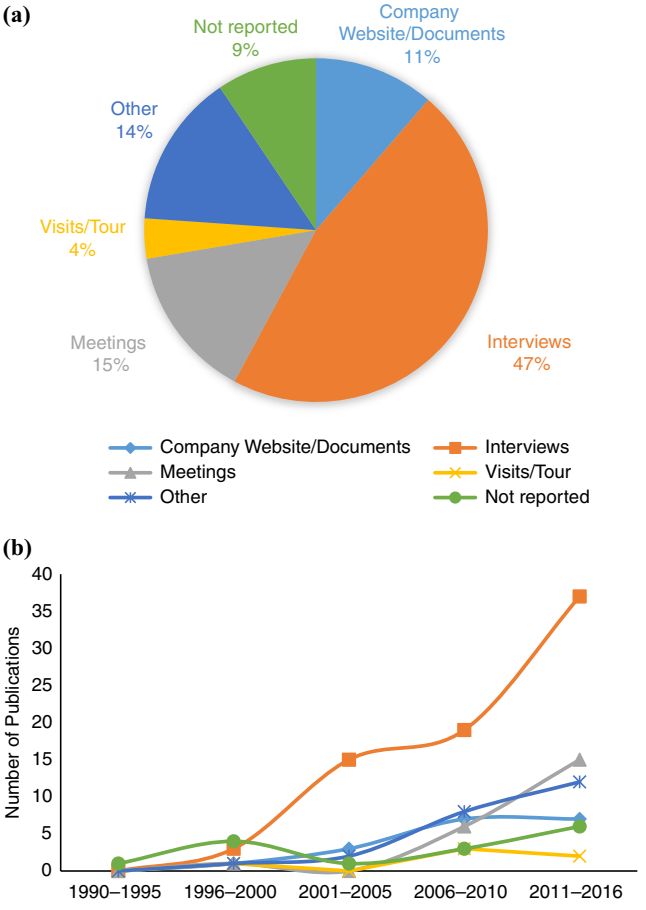
Overall, case studies offer a structured process of exploration and developing new insights that can later be tested using quantitative methods. Therefore, case studies are

complementary to the overall theory building process, thus making them a cornerstone of research designs in SCI (Robert *et al.*, 2019).

Other empirical qualitative studies use secondary data and literature review as two additional prominent research designs. The empirical qualitative studies employing secondary data are of exploratory nature. Studies using literature review as a primary research design mostly undertake practice-oriented research.

4.4.2 Data collection method. The predominant method of empirical qualitative data collection is "interviews" (semi-structured, structured, unstructured and open-ended interviews) (47 percent). Regarding data collection, 15 percent involved meetings, 11 percent collected data through companies' documents and website reviews, 4 percent used plant tour and 14 percent used some other methods including webmail, secondary data and postal mail. Finally, 9 percent of the studies did not provide this information (Figure 7(a)).

Overall, interviews constitute the biggest category in qualitative data collection means. A key benefit of interviews is that they offer rich insights into the problem, and researcher can clarify unclear points at the spot. Meetings with employees are the second biggest



Notes: (a) Data collection approaches in empirical qualitative studies – the overall distribution; (b) research methodology vs time

Figure 7.
Sources of data

category of qualitative data collection. Whereas interviews usually involve a single respondent at a time, meetings may involve multiple participants and are meant to discuss issues needing further clarification. Data collection through a company's documents and website visits mainly provides secondary data. This is particularly useful in understanding the documented knowledge of and about the company. Website reviews reveal information about the type and the extent of information a company discloses to its stakeholders. This type of secondary data collection is particularly useful in content analysis and also in supporting qualitative data collected from interviews, meetings and observations. A researcher can triangulate findings from different sources to seek an answer to the research question. This approach also increases the internal validity of the research (Yin, 2003; Saunders and Lewis, 2012).

The trend of data collection means employed in qualitative studies shows that the use of interviews is on the rise (Figure 7(b)). Indeed, due to several advantages – such as firsthand (primary) data collection, on spot clarification of conflicting issues and ability to glean rich insights – interviews followed by meetings may continue to remain a valuable and popular method of data collection in qualitative SCI studies.

4.4.3 Countries of data collection. The biggest proportion of qualitative data collection comes from the UK (14 percent), followed by the USA (12 percent), Germany (6 percent) and China (5 percent). Also, 46 percent share is distributed in a large number of countries, each with a small share, including Italy (3.5 percent), Australia (2.5 percent), Brazil (2.5 percent), France (2.5 percent), India (2.5 percent), Sweden (2.5 percent) and Taiwan (2.5 percent), among many others. The country of the data collection is not mentioned by 17 percent studies. Most of these studies did not mention the country of data collection to maintain the anonymity of company and respondents. Moreover, the substantial share of Europe is quite intuitive to understand since qualitative research has been an integral part of European research traditions (Näslund, 2002).

The data on country wise research trends show that qualitative research had been on the rise in almost all the main geographical regions from 1991 to 2005. From 2005 onwards, the USA and UK have noted a decline in qualitative research, which continues to date. In Germany, there appears a plateau after some increase from 2005 to 2010. Compared to the other countries showing either decline or a plateau in trend in 2006 onwards, China shows a consistent increase in qualitative data collection, which continues to date.

The finding of recent relative decline or stagnation in empirical qualitative research in SCI outside China and the continued rise of the same in China, combined with the earlier finding of relative rise in empirical quantitative SCI research in all countries, is meaningful. It can be inferred that in recent years, the trend of theory building, which requires empirical qualitative research, is rising in China-based SCI studies, whereas theory testing, which requires empirical quantitative research, is rising in all countries.

4.5 Overall publication trends

4.5.1 Authorship patterns. A large number of SCI studies are multi-authored: 40 percent studies are by two authors and 28 percent by three authors. The proportion of studies by single authors and more than three authors is relatively low (16 percent each). The trend in publishing SCI studies shows that multi-authored studies continue to grow, reflecting growing academic collaborations, whereas single-authored studies showed a slight decline in 2010 onwards. Working in groups yields more opportunities for researchers to capitalize on diverse competencies and resources. Collaborations in academic publishing can also create opportunities for increasing research rigor (Dooley and Kirk, 2007). Based on these promising advantages, the trend of multi-author studies may continue in SCI research. However, a decline in the number of studies with four or more authors might indicate that

large groups may not be productive, as failures in coordination follow. Thus, future academic collaborations may need to carefully determine the optimal number of members in the group to ensure productive participation opportunities from all.

4.5.2 Authorship patterns – academicians/practitioners/collaborations. Findings show that research in SCI is mainly driven by academicians (85 percent); contributions by practitioners alone and collaboration of practitioners and academicians (referred as collaborations) are quite low, 6 and 9 percent, respectively. The trend in publishing shows that whereas the contributions by academicians are on the rise, collaborations are on the decline. The trend of publishing more by academicians is consistent across different regions, including North America, Europe, Asia and others.

The greater proportion of academicians in publishing could be because academic publishing has grown into a rigorous scientific process requiring a critical review of the literature, knowledge of the state-of-the-art research methodologies, systematic research execution and academic writing style. In short, writing academic papers requires an academic orientation, which may favor academicians. However, contributions by practitioners can also offer certain unique advantages as practitioners have hands-on experience, in-depth information of SC processes, knowledge of adoption of innovations, challenges in the adoption of innovations and performance-related outcomes of the adoption of innovations (Dooley and Kirk, 2007; Robert *et al.*, 2019). The role of practitioners is of particular importance in action research or case studies. Action research requires interventions in processes, whereas case studies involve data collection through observation of processes, meetings, interviews, visits and from other channels within the organization. In both cases, practitioners are more familiar and knowledgeable about the actual processes and the particular context.

Indeed, these findings highlight two research opportunities for future researchers. First, there is a need for greater collaborations with practitioners to build on diverse expertise and to develop novel insights into SCIs. Second, there is a need for more action research, which is currently lacking in SCI literature repositories (Näslund, 2002).

4.5.3 Number of appearances of authors. The number of appearances of an author in the academic papers of a given field helps to ascertain the author's depth of accumulated knowledge. When researchers continue to publish in a given field, it indicates a sustained interest in that area. It also implies that the field is growing and emerging problems are continuously addressed. Conversely, a single or few papers in a given field may imply discontinued interest or changed preferences and may imply an abandoned field.

The maximum number of "total appearances" of any author in SCI papers is 6, and a maximum number of adjusted appearance is 2.5 (Table III). The adjusted appearance here refers to distributing the credit of authorship in case of multi-authored papers so that if there are n authors in a paper, each author will have an adjusted appearance of $1/n$. Patricia J. Daugherty has the highest number of appearances (i.e. 6) and adjusted appearance of 2.25. In her research on SCIs, she mainly discussed innovations in logistics and the role of technological turbulence in logistics and reverse logistics performance. Tobias Schoenherr, who has 4 total appearances and 2.5 adjusted appearances, focused mainly on buyer–supplier relationship and supply chain performance besides investigating the role of supply chain intelligence in new product launch success. Bowon Kim, having 4 total appearances and 2.5 adjusted appearances, studied different aspects of SCM, including coordination of innovations in SCM, configuring SCM network, new product development and value chain sustainability. Similarly, R.I. van Hoek, having total appearances of 3 and adjusted appearance of 2.5 in SCI, is also a prolific writer in the field of operations management. In his research, van Hoek discussed mainly the importance of logistics system in the SCM. Other influential authors in SCI are shown in Table III.

Sr. No.	Author name	Total appearances	Sr. No.	Author name	Adjusted appearances
1	Daugherty, Patricia J.	6	1	Kim, Bowon	2.5
2	Grawe, Scott J.	5	2	van Hoek, Remko I.	2.5
3	Kim, Bowon	4	3	Daugherty, Patricia J.	2.25
4	Schoenherr, Tobias	4	4	Schoenherr, Tobias	2.17
5	Knoppen, Desiree	4	5	Lippert, Susan K.	2
6	Hazen, Benjamin T.	4	6	Grawe, Scott J.	1.92
7	Sarkis, Joseph	4	7	Knoppen, Desiree	1.5
8	Zhu, Qinghua	4	8	Singhal, Jaya	1.5
9	Lai, Kee-Hung	4	9	Singhal, Kalyan	1.5
10	Autry, Chad W.	4	10	Park, Chulsoon	1.5
11	van Hoek, Remko I.	3	11	Swaminathan, Jayashankar M.	1.5
12	Lippert, Susan K.	3	12	Swink, Morgan	1.5
13	Singhal, Jaya	3	13	Yang, Jie	1.45
14	Singhal, Kalyan	3	14	Hazen, Benjamin T.	1.42
15	Park, Chulsoon	3	15	Sarkis, Joseph	1.33

Table III.
Most published authors in SCI research

4.5.4 Journals. Since academic journals are the main outlets for publishing research, the identification of the journals publishing SCI research is important for understanding the overall developments in SCI research. The top 10 journals publishing at least 15 SCI studies are provided as follows:

(1) *International Journal of Production Economics* (*IJPE*) (10 percent).

(2) *Supply Chain Management: An International Journal* (*SCM: IJ*) (9 percent).

(3) *International Journal of Production Research* (*IJPR*) (6 percent).

(4) *International Journal of Logistics Management* (*IJLM*) (4 percent).

(5) *Journal of Supply Chain Management* (*JSCM*) (4 percent).

(6) *International Journal of Operations and Production Management* (*IJOPM*) (4 percent).

(7) *Journal of Business Logistics* (*JBL*) (4 percent).

(8) *Production Planning and Control* (*PPC*) (3 percent).

(9) *Journal of Product Innovation Management* (*JPIM*) (3 percent).

(10) *International Journal of Physical Distribution and Logistics Management* (*IJPDLM*) (3 percent).

The findings clearly show that the studies on SCI are widely distributed in different journals, most of which are renowned journals in the field of operations and SCM and fall in A or A* category as per the Australian Business Deans Council Ranking 2016. From these journals, *IJPE* has published the largest number of studies (10 percent), followed by the *SCM: IJ* (9 percent) and then *IJPR* (6 percent). Other renowned operations and SCM journals have each published 3–4 percent of the total SCI studies. In total, 50 percent research in SCI has published in these ten journals of operations and SCM.

The remaining 50 percent research studies in SCI have published in a long list of journals. In general, these journals belong to the fields of technology, operations management, engineering management, supply chain, project management, R&D, information systems, strategy and general management journals. In addition, coverage of SCI studies in other journals and lines of research suggests that SCI issues are being investigated from multiple perspectives, thus making the SCI literature rich and comprehensive.

Further analysis of the regional trends of the published studies in the journals mentioned above shows that most of the published studies come from North America and Europe (Figure 8). The share of studies from the Asian countries is significant in some selected journals such as *IJPE*, *IJPR* and *SCM: IJ*. Overall, this information about journals guides researchers in SCI field about where to look for SCI studies and also where to publish SCI research.

4.5.5 Citation analysis. Citation analysis is a powerful means to evaluate the quality of published papers (Moed, 2005). Studies contributing toward theory generation or providing novel insights are usually cited more often, thus signifying greater scientific contribution of a study. Thomson Reuter Social Science Citation Index, CiteScore, Google Scholar and many other programs provide information about citations of a publication. For this study, two measures for the citation analysis were used – the total number of citations and citations per year. A limitation of the former is that it does not show the number of years during which citations have accumulated. Research with citations accumulated over several years is less influential than the one with the same number of citations in a relatively shorter period. This limitation is addressed by the number of citations per year, which is calculated by dividing the total number of citations of a paper by the number of years since its publication.

Top 5 papers with the highest number of citations are Quinn (1999), Ragatz *et al.* (1997), Choi *et al.* (2001), Handfield *et al.* (1999) and Malhotra *et al.* (2005) (Table IV). Quinn (1999) argued that strategically managing knowledge, innovation and outsourcing together can create a company's greatest future challenge. Remaining four papers focus on the role of suppliers and supplier integration in bringing innovation in the products. The dominant key theme emerging in these top-cited papers pertains to networking and integration within the supply chain, followed by the knowledge management capabilities.

Top 5 papers with the highest number of citations per year are Nieto and Santamaría (2007), Quinn (1999), Malhotra *et al.* (2005), Gawer (2014) and Dedrick *et al.* (2010). Out of these, two papers were also in the list of top 5 papers with the highest number of citations. The remaining three papers revolved around the idea that the most significant positive impact on the degree of innovation novelty comes from collaborative networks comprising different types of partners, for example suppliers, clients and research organizations, and that each partner, in turn, benefits from it.

5. Discussion

Recently, several editorials and research articles, published in the reputed journals, have necessitated robust research design in future studies in supply chain research (Flynn *et al.*, 2018). This review provides a comprehensive understanding of the methodological

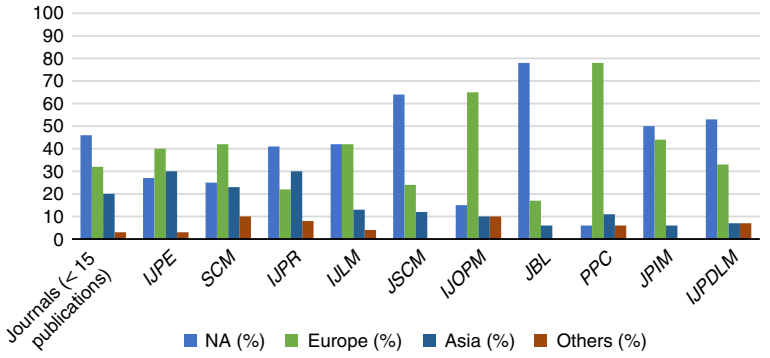


Figure 8.
Regions vs journals – the overall distribution

Sr. No	Author (year)	Journal	Cumulative citations	Sr. No	Author (year)	Journal	Citation per year
1	Quinn (1999)	*SMR*	1,073	1	Nieto and Santamaría (2007)	*TECH*	77.25
2	Ragatz *et al.* (1997)	*JPIM*	923	2	Quinn (1999)	*SMR*	67.06
3	Choi *et al.* (2001)	*JOM*	830	3	Malhotra *et al.* (2005)	*MISQ*	65.9
4	Handfield *et al.* (1999)	*CMR*	704	4	Gawer (2014)	*RP*	64
5	Malhotra *et al.* (2005)	*MISQ*	659	5	Dedrick *et al.* (2010)	*ICC*	63.4
6	Nieto and Santamaría (2007)	*TECH*	618	6	Choi *et al.* (2001)	*JOM*	59.29
7	Gobble (2015)	*RTM*	593	7	Choi and Krause (2006)	*JOM*	52.11
8	Lee and Billington (1995)	*INTER*	574	8	Ragatz *et al.* (1997)	*JPIM*	51.28
9	Novak and Eppinger (2001)	*MS*	528	9	Fawcett *et al.* (2008)	*SCM*	50.29
10	Choi and Krause (2006)	*JOM*	469	10	Handfield *et al.* (1999)	*CMR*	44
11	Handfield *et al.* (2000)	*SMR*	448	11	Wang *et al.* (2010)	*TFSC*	44
12	Malhotra *et al.* (2001)	*MISQ*	390	12	Roh *et al.* (2014)	*IJPE*	43
13	MacDuffie and Helper (1997)	*CMR*	387	13	Fitjar and Rodríguez-Pose (2013)	*RP*	41
14	Roper and Love (2002)	*RP*	378	14	Alcacer and Oxley (2014)	*SMJ*	40
15	Power *et al.* (2001)	*IJPDLM*	355	15	Chiou *et al.* (2011)	*TRE*	39.5

Notes: *SMR*, *Sloan Management Review*; *JPIM*, *Journal of Product Innovation Management*; *JOM*, *Journal of Operations Management*; *CMR*, *California Management Review*; *MISQ*, *MIS Quarterly*; *TECH*, *Technovation*; *RTM*, *Research Technology Management*; *INTER*, *Interfaces*; *MS*, *Management Science*; *RP*, *Research Policy*; *IJPDLM*, *International Journal of Physical Distribution and Logistics Management*; *IJPE*, *International Journal of Production Economics*; *SMJ*, *Strategic Management Journal*; *ICC*, *Industrial and Corporate Change*; *TFSC*, *Technological Forecasting and Social Change*; *TRE*, *Transportation Research Part E*

Table IV.
Citations analysis

trends of the existing work in the field of SCI and highlights the specific research design elements that need to be improved. It presents overall publication trends that will help potential SCI researchers to position their work in the SCI literature.

The dominant types of studies in SCI are empirical quantitative, empirical qualitative and conceptual qualitative. Empirical quantitative studies outnumber all other categories. Since empirical quantitative studies are mostly used in testing theory, it indicates that the field of SCI is gradually advancing toward theory development stages. Geographically, more empirical quantitative SCI studies have originated from North America. However, studies originating from Europe and Asia have also increased significantly in the last decade (Dubey *et al.*, 2012; Shibin *et al.*, 2018). In particular, the rise in Europe is remarkable, as it catches up North America. A vast majority of published empirical quantitative studies have collected data from the USA, which may indicate greater accessibility to data resources in the USA compared to the other countries.

In the published empirical quantitative studies, three notable weak points are as follows: a lack of reporting of reliability/validity test, pretest and low response rate. A large number of studies (46 percent) did not report reliability and validity results. This represents a weakness in research design/presentation. Similarly, a large number of studies did not report pretest or pilot test. A rigorous quantitative research design must take into consideration reliability and validity measures and pretest. The issue of the academic rigor of the published studies has further been exacerbated by a poor response rate (i.e. 10–30 percent in 39 percent of studies). This response rate is disappointing compared to the response rate in other fields. For instance, Baruch and Holtom (2008) studied the response rate in different studies in the field of organizational research and found that average

response rate was 52.7 percent, which is much higher than the average response rate in SCI studies (Shibin *et al.*, 2018).

Many editorial calls for employing rigorous research design in empirical quantitative work have highlighted the preference of using multiple respondents in survey data collection (Ketchen *et al.*, 2018; Flynn *et al.*, 2018). However, nearly one-fifth of the existing SCI research using empirical quantitative design has not adequately reported the nature of target respondents. Since the survey of respondents' perceptions is the prime method of data collection on which the results are dependent, the exact nature of the respondents along with the involvement of multiple and relevant respondents is an essential element for the scholars to consider. Besides, many SCI constructs are by nature polyadic, and SCI issues are often related to organizations, not individuals, both supporting the claim for using multiple respondents.

Empirical qualitative studies in SCI (20 percent) also embody a significant amount of knowledge. Their distinctive value lies in furnishing novel insights and, together with quantitative studies, they complement the theory development process. A large number of qualitative research appears in the form of case studies. The trend of studies based on multiple cases is on the rise worldwide, which indicates greater research rigor and comparative analysis.

Regarding the country wise trend, the USA, the UK, Germany and China have published a large number of SCI studies. When comparing the trend, across the USA, the UK and Germany, the trend of publishing qualitative studies declines; however, quantitative studies are still on the rise. This shows that modern SCI research is being shaped more by quantitative studies. This information complements the findings discussed earlier, which show that SCI research is now advancing toward the maturity stage.

The current dominance of USA and several European countries in SCI research is not surprising. The USA and Europe are home to a large number of renowned SCM practicing firms (e.g. Amazon, UPS, Intel, Walmart, Dell and CISCO in the USA and Unilever, H&M, Inditex, Nestle, BASF, GlaxoSmithKline, Schneider Electric, L'Oréal and Reckitt Benckiser in Europe). The presence of a large number of globally operating firms may provide abundant opportunities to study the best-in-class practices. Finally, the regulatory, normative and cultural–cognitive factors in these countries also favor institutionalization of SCIs, as these factors craft the contractual, ownership and social elements of institutional arrangements of innovation (Bello *et al.*, 2004).

Surprisingly, a large treasure of SCI knowledge is published in journals not considered mainstream journals as per common journal rankings. As noted earlier, reliability, validity, pretest reporting and low response issues have been identified in several SCI studies; this may explain why a large number of studies fail to make a place in top-tier journals. In any case, this indicates that any attempt to seek knowledge only from top-tier mainstream journals would yield incomplete results. Moreover, the identification of most influential and prolific authors has implications for future SCI research in a way that it can help junior researchers in seeking mentorship, setting future research direction and establishing collaborations.

An analysis of the citations shows relatively fewer citations to the existing body of literature. The top-cited SCI papers are much less cited than their counterparts in the field of operations management, SCM or innovation management. Citations to the papers usually grow when new research builds upon the existing theories. Low citation rate might imply that researchers have explored different innovations or different facets of the same innovation. It may also indicate that the expansion in SCI body of literature has been more horizontal rather than vertical.

On the whole, the methodological and publication trends show the state of the current SCI research in employing a multitude of approaches to explore the various facets of SCI. It also identifies methodological weaknesses and gaps between the nature of existing and expected work in SCI research (Bono and McNamara, 2011; Flynn *et al.*, 2018).

6. Conclusions and future research opportunities in SCI

There are very few content analysis-based studies in the field of SCIs (Arlbjørn *et al.*, 2011). As a result, our understanding of different aspects of SCI is very limited. Addressing this loophole is necessary to understand the overall state of knowledge about SCI and to set future research directions. As one of the initial steps toward this direction, the current study provides the methodological and publication trends in SCI research. Based on the findings, following research opportunities and corresponding research implications were developed.

Research in SCI seems to lack the depth that is characteristics of a mature field. The main progress in this field happened only during the last two decades, as most of the studies started appearing after 2000. Further, low profile of citations to the existing studies, methodological issues such as lack of pretest, reliability and validity reporting by a large number of studies show that the field of SCI is yet to mature further. This leads to the following research opportunity:

> Research opportunity 1: Understanding the phenomenon of SCI requires developing theories of SCIs. Although the field of SCI has expanded in the last few years, there is still much potential for growth both horizontally and vertically. The areas of improvement identified in earlier studies present an opportunity for future research. Future studies need to pay particular attention to the methodological issue to increase the reliability and validity of SCI studies.
>
> Implications: It is envisaged that theoretically rigorous research efforts in SCI field will help in advancing towards maturity stage and will subsequently shape the formation of SCI as an important sub-discipline within the broader area of SCM. This builds confidence that the knowledge and guidance that managers seek from SCI research is well founded and reliable. Moreover, methodologically robust and longitudinal studies in the field of SCI will help in understanding SCI dynamics over the longer horizon.

The findings also alluded to some academic isolation manifested in fewer collaborations with practitioners and the least number of publications from practitioners. Also, the trend to publish survey-based studies is on rise. In survey-based studies, researchers usually collect data through postal or mail surveys, with little interaction with the practical setting. Such an approach may make a researcher blind to the actual practice. Thus, researchers need to engage more with practice and practitioners to glean novel insights and problem-driven research solutions:

> Research opportunity 2: Engaged scholarship can create opportunities for new knowledge exploration. Researchers need to engage with practitioners, in particular, operations & supply chain professionals, procurement managers, and information systems managers to explore new facets of SCIs and to determine their possible economic, social, and environmental impact.
>
> Implications: This kind of research will have serious implications in developing a holistic understanding of SCI field that is more interesting and meaningful for researchers as well as managers. Moreover, the joint academic-practitioner investigations may create synergies emerging out of sharing of unique experiences of the two and could define the future course of action and research in SCI field.

It is also noted that the trend to publish quantitative studies surpasses the qualitative and other formats of research. This trend leads to another research opportunity:

> Research opportunity 3: Case studies can generate novel insights which are not possible with the survey-based research. Further, action research can generate new perspectives into SCI research. Currently, both these formats of research have been dwarfed by survey-based research.
>
> Research opportunity 4: Mixed qualitative and quantitative research designs are capable of producing more robust results and may generate theories that have greater internal and external validity. Different types of evidence in such cases make a stronger case for internal validity upon triangulation. With greater internal validity comes greater confidence in research findings.

Similarly, higher external validity means that findings can be generalized to other contexts with greater confidence.

Implications: It is believed that the methodological triangulation would assist in getting a more nuanced understanding of the SCI context and practice thus creating pathways for prescriptive research in SCI. Moreover, triangulation coupled with mixed data sets will help in discerning more complex patterns of innovations in the supply chains that have blurred organizational boundaries (e.g. open innovation) and traversed through inter-industrial frontiers (e.g. big data and internet of things).

Finally, in the last decade, the organizational design has undergone several fundamental changes. Among these changes, one of the most important is the elimination of unnecessary hierarchies and development of flat organizations where responsibility and job specialization matter more than control and authority. In these types of setups, the role of employees at the operational level assumes significant importance. However, our findings show that the data in most of the studies come mostly from the middle level and senior managers, ignoring employees at the operational level:

Research opportunity 5: Data collection from only middle and senior managers runs the risks of failure to capture the perspectives of other relevant sources. Data collection from job floor employees can yield valuable insights, including workplace dynamics, the role of the team, communication structures, and work values which is helpful in understanding SCI management.

Implications: It is implied that an understanding of the perspective of lower management of all the major stakeholders in the supply chain will deepen our current understanding of SCI and will provide novel ways of thinking about innovations in supply chains. Since lower management has a relatively less direct role in supply chain level innovation decisions but has to bear the implications of any SCI effort, understanding their perspective will complement the current SCI research.

7. Limitations and extensions of current research

There are certain limitations of the current research that provide opportunities for future literature review-based studies in SCI. This research is based on papers published in 77 peer-reviewed international journals appearing in renowned rankings. On the one hand, the inclusion of a large number of journals provides greater confidence in the identified trends. On the other hand, there is also a downside of this approach. As the top-tier journals publish only the most rigorous studies, considering all journals as equally weighted will give rise to a mixed pool of studies, both rigorous and lacking rigor. Identifying trends from this mixed pool may provide more comprehensiveness at the cost of inclusion of non-core journals of the field. Moreover, the focus of the current study is to identify the research methodologies and publication trends in the field of SCI. An immediate extension of the current study would be to conduct a thematic and theoretical analysis of the field of SCI that may provide topical and content classifications and theoretical lenses applied in the SCI field. This kind of research will be helpful in identifying opportunities for linking SCI research with contemporary and innovative practices and capabilities such as applications of big data and Internet of Things in supply chain processes.

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