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Guest editorial for NOFOMA 2018 conference special issue

Publisher’s note

The publisher would like to inform readers that the following Guest Editorial was mistakenly omitted from inclusion alongside the special issue papers it relates to. This error was introduced as part of the editorial process, and the publisher sincerely apologises for this error. The Guest Editorial was originally intended to publish as part of “NOFOMA 2018” guest edited by Jan Stentoft, Per Vagn Freytag, Kannan Govindan and Anne-Mette Hjalager. The publisher would like to take this opportunity to thank the Guest Editors for their time and effort.

This Special Issue of International Journal of Physical Distribution and Logistics Management (IJPDLM) contains the best papers from the 30th NOFOMA Annual Conference. The conference was organized by the Department of Entrepreneurship and Relationship Management at University of Southern Denmark and took place at the campus in Kolding June 14–15, 2018.

The theme for the 30 years anniversary NOFOMA conference was “Relevant logistics and supply chain management research.” Our discipline has always been tied closely to practice. However, during especially the last decade the pressure to publish in ranked academic peer-reviewed journals has become immense which both have positive and negative outcomes. For some it has become “publish or perish.” For others, it has become a game. Therefore, it is important to continue with reflections about whether this pressure to publish has contributed with more relevant and meaningful logistics and supply chain management research. The answer depends much on the eyes that look and the ears that hear. Relevance has both a theoretical and a practical angle (Stentoft and Freytag, 2018). Theoretical relevance in terms of providing new theoretical insights with rigor methodologies. Practical relevance in terms of having something to say to society. It is important to balance theoretical and practical relevance (Stentoft and Rajkumar, 2018).

There has been a great interest for this year’s NOFOMA conference. Initially, 150 abstracts were submitted for the conference. At the deadline for revised full papers and work-in-progress papers, 64 full papers have been accepted for the conference proceeding and 28 work-in-progress papers to be presented at the conference. All full papers have undergone a double-blind review process by using 55 reviewers. In all, 130 attended the conference.

This special issue contains three selected papers. An initial list of ten papers were selected by the NOFOMA 2018 Scientific Committee before the conference based on IJPD&LM review criteria, the committee’s reading of papers and the comments provided by reviewers in a double-blind process. During the conference, the ten papers were ranked in order to identify the winner of the DB SCHENKER Best Paper Award. The committee then shortlisted ten papers to four papers that to their knowledge had the best possibilities for developing their papers further to meet IJPDLM criteria of novelty, relevance, and rigor. Other criteria were also the degree of readiness to be final developed to a flow blown journal paper and the papers overall readability. If needed papers have been revised twice before their acceptance and this process reduced the number of accepted papers to three. We would like to thank IJPDLM for the continued support to publish a special issue of papers of the annual NOFOMA conference. A special thank goes to Professor Patrick Jonsson who has served as area editorial editor of this special issue.

The first paper in this special issue is “Logistics service triad for household waste: consumers as co-producers of sustainability” that is Co-Authored by Árni Halldórsson, Ceren Altuntas Vural and Jessica Wehner. Their conference version of the paper received the DB
The paper explores sustainability of waste supply chains regarding energy efficiency of first-mile waste collection systems and quality of waste. The paper is based on primary data collected from respondents including municipality officers, waste service providers and households through brainstorming sessions, semi-structured interviews, site visits and a focus group. Furthermore, secondary as official reports are included for validation. The paper finds that households are co-producers of logistic services providing important inputs in the form of sorting and moving waste and raw materials into new cycles of goods circulating in logistics systems.

The second paper "How the blockchain enables and constrains supply chain performance" is co-authored by Kim Sundtoft Hald and Aseem Kinra. This paper sets out to understand the enabling and constraining roles of blockchain technology in managerial work practices and to conceptualize the technology–performance relationship in supply chain management. A structured literature review is conducted and based on a theory-driven approach, a set of propositions are developed, suggesting how the use of blockchain technology in supply chains can be understood to simultaneously enable and constrain supply chain management and performance.

The third paper "Technology adoption by logistics service providers" is Co-Authored by Mathias Mathauer and Erik Hofmann. The paper reveals the effects of different technology access modes on the successful integration of technological innovations. From the perspective of logistics service providers, managerial and practical implications for the process of technology adoption are discovered. The paper is based in a structured literature review and an explorative case study covering ten technology projects.

Finally, we would like to thank the authors of the papers in this special issue for their collaboration. We would also like to thank the reviewers of the NOFOMA conference papers and the reviewers for the special process of these selected papers. Finally, thank you to all the NOFOMA participants for being present at this 30th year anniversary conference. It has been a great pleasure to organize the conference, and we look forward to seeing you all in Norway in June 2019 for the next NOFOMA Conference.

Jan Stentoft and Per Vagn Freytag
Department of Entrepreneurship and Relationship Management, University of Southern Denmark, Odense, Denmark
Kannan Govindan
Department of Technology and Innovation, University of Southern Denmark, Odense, Denmark, and
Anne-Mette Hjalager
Department of Entrepreneurship and Relationship Management, University of Southern Denmark, Odense, Denmark

References
The impact of multinational corporations’ socially responsible supplier development practices on their corporate reputation and financial performance

Prema Latha Subramaniam
Graduate School of Business, Universiti Sains Malaysia, Gelugor, Malaysia
Mohammad Iranmanesh
School of Business and Law, Edith Cowan University, Perth, Australia, and
Kavigtha Mohan Kumar and Behzad Foroughi
Graduate School of Business, Universiti Sains Malaysia, Gelugor, Malaysia

Abstract

Purpose – In the literature on sustainable supply chain management, the social pillar of sustainability has received relatively little attention, especially in developing countries. The purpose of this paper is to test empirically the impacts of supplier development practices on suppliers’ social performance. Furthermore, the impact of suppliers’ social performance on MNCs’ social performance was investigated and corporate reputation was proposed as a potential explanation for the relationship between MNCs’ social and financial performance.

Design/methodology/approach – Data were obtained from a survey of 141 multinational companies (MNCs) in Malaysia which were listed in the Federation of Malaysia Manufacturers’ directory 2017. Data were analyzed using partial least squares structural equation modeling.

Findings – The results show that among the four proposed practices, supplier development and supplier collaboration have significant effects on suppliers’ social performance and consequently on the multinational companies’ social performance. According to these results, multi-national companies’ corporate reputation mediates the relationship between their social and financial performance.

Practical implications – These results will be useful in helping managers of MNCs to realize that simply monitoring suppliers and giving them incentives are not effective ways of enhancing social responsibility among suppliers; instead, supplier development and collaboration such as technical support and training are needed.

Originality/value – The results extend the literature on socially responsible supplier development practices by testing empirically the impacts of four popular practices in the literature and showing that supplier monitoring and incentives have no effect.

Keywords Financial performance, Social sustainability

Paper type Research paper

Introduction

There is intense complexity in supply chains (SC) due to growing globalization and continuous outsourcing, especially to firms in developing countries (Rodriguez-Serrano et al., 2017). At the same time, although the demands for strong economic performance of the SC are on the rise, companies should also take responsibility for their partners’ and suppliers’ environmental performance and social performance (Seuring and Müller, 2008). Previous studies have shown that problems in companies’ social and environmental practices have negative effects on their financial performance (e.g. DiSegni et al., 2015; Yawar and Seuring, 2018). This effect is more prominent in organizations such as multinational companies (MNCs) which market consumer-brand products, due to their proximity to the public eye (Hartmann and Moeller, 2014). Furthermore, Sancha et al. (2015) found that suppliers’ poor sustainability practices will not just damage the buying firm’s reputation but also impact the operation’s
performance in the long run. As such, this raises the need for MNCs to re-evaluate both social
and environmental issues that are present in their SC. In light of this, attention is subsequently
starting to turn to methods in which suppliers can be encouraged to engage in social and
environmental practices (e.g. Klassen and Vereecke, 2012; Yang and Zhang, 2017).

There is a significant stream of literature that has focused on sustainable SC practices that
may promote sustainability among suppliers. However, the literature suffers from several
important limitations, which this paper aims to address. First, most of the studies have
focused primarily on the environmental dimension (e.g. Lee and Klassen, 2008; Vachon and
Klassen, 2008), and there has been very limited focus on the social dimension (Morais and
Silvestre, 2018; Sancha et al., 2015). Hojemose and Adrien-Kirby (2012) reviewed 188 articles
on sustainable responsibility and found that 51 percent of these articles focused on the
environmental dimension and only 26 percent considered the social dimension, while 23 percent
considered both social and environmental dimensions. As such, there is limited
understanding of how MNCs can promote social sustainability among their suppliers.

Second, many of the previous studies are in the context of developed rather than
developing countries (Hoejmose et al., 2013; Sancha et al., 2015). Yawar and Seuring (2017)
reviewed articles related to social issues in SC and found that 74.6 percent of these studies were
conducted in Europe and North America, which are mostly developed countries. Following the
World Bank classification, in the present study, developing countries refer to middle- and
low-income countries whose Gross National Income (GNI) per capita does not exceed $11,905
(Guo and Li, 2018). Many firms in developed countries outsource their functions or products to
suppliers in developing countries; consequently, suppliers are located in distant developing
countries (Busse et al., 2016). Government and social policies and regulations tend to be more
unstable in developing countries in comparison to developed ones (Akamp and Müller, 2013).
Furthermore, such countries are often characterized by health and safety, human rights and
child labor issues (Delavallade, 2006). For instance, many researchers have stated that social
responsibility in Malaysia is still in its infancy (Joseph et al., 2019). As the MNCs extend their
suppliers to developing countries, the social problems of suppliers in these countries may put
MNCs’ reputation and performance at greater risk (Klassen and Vereecke, 2012). Stakeholders,
especially customers, do not distinguish between various SC partners (Seuring and Gold,
2013), and hence, in the eyes of these stakeholders, buying firms are also responsible for their
suppliers (Seuring and Müller, 2008). As such, studies on the impact of socially responsible
supplier development practices are important in developing countries, including Malaysia.

Third, as highlighted by Quarshie et al. (2016), the majority of the research on the
relationship between supply chain management (SCM) best practices and the social
responsibility of suppliers has been qualitative in nature (e.g. Yawar and Kauppi, 2018;
Yawar and Seuring, 2018) and also has been limited to one or two main practices in each
study. For instance, Sancha et al. (2015) investigated the impacts of supplier development
practices on suppliers’ social performance and buyers’ financial performance. Akamp and
Müller (2013) tested the impacts of supplier selection, monitoring, development and
integration on supplier performance and buyer satisfaction. Pakdeechoho and Sukhotu
(2018) found that SC collaboration has a positive effect on sustainability performance, and
that incentives moderate this relationship in a positive direction. Porteous et al. (2015) also
indicated that incentives and penalties by buyers motivate the supplier to implement social
practices. As the previous studies of socially responsible supplier development practices
have focused on just one or two practices, it is not clear which practices have more effect on
suppliers’ social responsibility. Furthermore, the qualitative nature of these studies limits
the generalizability of their results. Based on the gaps we have mentioned, the aim of our
study is to analyze empirically the impacts of supplier monitoring, supplier development,
incentives and supplier collaboration on suppliers’ social performance. Although supplier
selection has been shown to play an important role in the performance of both suppliers and
buyers (Akamp and Müller, 2013), supplier selection was not considered, as the focus of the research was on the post-supplier selection stage. Fourth, although studies have shown that firms’ social performance has an effect on both corporate reputation (Mani et al., 2018) and financial performance (Yawar and Seuring, 2018), the inter-relationship of these factors is less studied. In this study, corporate reputation was proposed as the explanation for the relationship between social performance and financial performance.

Drawing on agency theory and resource-based view (RBV) theory, this paper makes two main contributions to the literature. First, four socially responsible supplier development practices are derived from agency theory to answer the question of which practices have more effect on the social performance of suppliers in developing countries. Second, drawing on RBV theory, it provides a better understanding of the relationships between social performance, corporate reputation and financial performance. An investigation of SCM in developing countries is important, since the SC in the current globalized economy usually operate in developing countries where suppliers and governments probably possess lower social standards than those working in developed countries (McCarthy et al., 2013).

A review of the literature on sustainable SCM, social sustainability in SC and underlying theories – namely, agency theory and RBV theory – is provided in the next section. Later, the conceptual framework of the study is illustrated and the hypotheses are supported by the literature. An outline of the research methodology follows, including measurement of constructs, sample and data collection, common method variance (CMV) and data analysis. The results are then presented, and finally, the discussion, theoretical and practical implications, limitations and directions for future studies are provided.

Literature review

Sustainable supply chain management

Stakeholders exert substantial pressure on firms to conduct business in a sustainable manner, thereby requesting that firms pay attention not only to economic concerns but also to improving the social and environmental conditions (Busse et al., 2017). Environmental initiatives include waste management, environmental product design, resource efficiency, reverse logistics, green purchasing and eco-efficiency in operations (Hsu et al., 2016). Social sustainability is fundamentally related to quality of life, well-being, labor conditions, equality, connectedness and diversity both inside and outside the community (Mani et al., 2016). Today, stakeholders’ attention to sustainable responsibility extends beyond individual firms’ operation and also includes their suppliers (Foerstl et al., 2010; Hartmann and Moeller, 2014). In response to the importance of sustainability in the current SCM, topics related to sustainable SC have received attention from scholars (Busse and Mollenkopf, 2017; Roy et al., 2018). Hoejmose and Adrien-Kirby (2012) reviewed articles on sustainable SCM and found that being socially and environmentally responsible has financial and non-financial benefits for firms, including visibility of business, public image, long-term self-interest, legitimacy by responding to stakeholders’ expectations, avoidance of government legislation and sustainable performance.

Considering the benefits of sustainable SCM, academicians have tried to identify factors that may promote the extent of sustainability in SC. The drivers of adoption of sustainable practices from the perspective of an individual firm, either supplier or buyer, can be categorized into internal and external factors (Hoejmose and Adrien-Kirby, 2012; Zhu et al., 2013). Hoejmose and Adrien-Kirby (2012), by reviewing 188 articles, identified external stakeholders, institutional pressure, industry type, regulation and competitive environment as external drivers, and competitive strategy, reputational issues, performance desire, employees, and resources and capabilities as internal drivers of the implementation of socially and environmentally responsible procurement. These types of study primarily focused on the sustainability of individual firms rather than taking a more integrated approach (Winter and
Knemeyer, 2013). Furthermore, Timmer and Kaufmann (2017) found that firms can achieve traceability without any pressure from stakeholders, and that governance mechanisms, including monitoring and collaboration, are the main determinants of firms’ capacity to meet traceability requirements.

Codes of conduct are the most common way of ensuring and extending CSR practices in the buyer–supplier relationship (Hoejmose and Adrien-Kirby, 2012). According to Klassen and Vereecke (2012), monitoring is needed to control suppliers’ behavior in relation to buyers’ expectations and code of conduct. Gimenez and Sierra (2013) and Foerstl et al. (2010) believed that the monitoring approach may work more effectively alongside collaboration with suppliers. Canzaniello et al. (2017) also found that sharing or co-development of resources or capabilities is important in reducing suppliers’ sustainability risk. Furthermore, Van Tulder et al. (2009) acknowledged the significant role of penalties and incentives in implementing codes of conduct. However, Normann et al. (2017) interviewed suppliers and found that they believed monitoring may hurt buyer–supplier relationships. In order to understand which socially responsible supplier development practices have more effect on social performance of suppliers, this study tests the impacts of the proposed practices in the literature together.

Winter and Knemeyer (2013) reviewed articles on sustainable SC and found only that 12 out of 196 articles looked specifically at the social dimension of sustainability, and also that conceptual and case studies have been the most common methodological approaches in previous studies. Furthermore, Zorzini et al. (2015) also reviewed 157 articles and found a lack of empirical research with an explicit focus on developing countries. Accordingly, they highlighted the need for empirical studies with a particular focus on the social dimension of sustainability, which is the aim of this study. In the next section, a literature review on the social dimension of sustainability in SC is provided.

Social sustainability in the supply chain

Many authors in the area of the sustainable supply chain (SSC) believe that the appropriate management of social issues could enhance firms’ economic performance (Sancha et al., 2016; Lu et al., 2012). As buying firms should be responsible for their suppliers’ social problems, they have two main options: to identify and select only sustainable suppliers and to exclude those suppliers that do not comply with certain standards (Thomas et al., 2016); or to promote the social responsibility of existing or new suppliers to achieve greater degrees of sustainability (Vachon and Klassen, 2008). As maintaining long-term relationships with suppliers is vital for enhancing firms’ financial performance (Talluri and Narasimhan, 2004), the present research is based on the assumption that the buying firms intend to improve the suppliers’ social sustainability performance via socially responsible supplier development practices. This study views socially responsible supplier development as a certain range of practices that buying firms carry out in order to develop the suppliers’ capabilities and promote their social and financial sustainability performance.

Although many scholars suggest that social sustainability improves corporate performance, suppliers in developing countries lag behind in the adoption of sustainability practices (Tong et al., 2018). Huq et al. (2016) examined different aspects of social issues in developing countries, focusing on Bangladesh’s apparel industry. Their findings revealed that the suppliers’ social issues consist of health, safety (worker wellness, occupational diseases, working conditions, fatalities and emergency preparedness), quality of life for workers (minimum wage, overtime, job satisfaction, working hours, stress) and workers’ rights (freedom of association, humane treatment, forced labor, paid maternity and sick leave). Further, they also discovered that in the absence of effective regulatory mechanisms and stakeholders’ pressure, buyers are forced to act as regulators for suppliers’ social issues. To do so, the buyers need to know the practices that may enhance their suppliers’ social
performance. However, recent studies have highlighted the imbalance between the numbers of studies among developed and developing countries on the practices that may promote social sustainability among suppliers (Yawar and Seuring, 2017). To address this issue, the present study was conducted in Malaysia.

Agency theory
Agency theory explains the relationships between the principal, who outsources a product or service to the agent, and the agent, who performs the work on behalf of the principal (Jensen and Meckling, 1976). Agency theory is applicable to the buyer–supplier relationships because the buying firm is ultimately responsible for social issues, irrespective of what proportions of the product and/or service are outsourced to suppliers (Dayton, 2008). According to this theory, the probability of suppliers’ default is determined by power and information asymmetries, goal incongruence and self-interested behavior (Prosman et al., 2016). To deal with potential suppliers’ default, the agency theory suggests using either outcome-based or behavior-based contracts (Rungtusanatham et al., 2007). In outcome-based contracts, the buyer uses incentives or penalties to make defaults unprofitable. For instance, MNCs rewards suppliers based on their social sustainability performance. The challenges of the outcome-based contracts are that they put risks on the suppliers and require a method for monitoring suppliers’ social performance. In order to reduce or eliminate suppliers’ defaults, buyers can utilize behavior-based mechanisms to ensure that the practices of suppliers are consistent with the buyers’ goals (Whipple and Roh, 2010). These behavior-based mechanisms focus on improving supplier capabilities, establishing closed relationships or supplier integration (Prosman et al., 2016).

In order to promote social sustainability practices among suppliers, MNCs can provide incentives for suppliers based on their social sustainability performance (Klassen and Vereecke, 2012; Yawar and Seuring, 2018). Incentives could be offered in the form of an outcome-based contract in which the supplier receives financial or non-financial incentives on the basis of social sustainability performance. Supplier development and supplier collaboration are two behavior-based mechanisms that help to align the goals of buyers and suppliers. The underlying assumption is that improving suppliers’ capabilities and cooperating with them on social sustainability activities will lead to higher social performance. Monitoring of suppliers is necessary in both outcome-based and behavior-based contracts. The difference is that in outcome-based contracts, suppliers’ social performance is monitored by the suppliers, and in behavior-based contracts, the processes of social responsibility implementation, such as supplier certification programs and compliance with the standards and specifications set by buyers, are monitored.

Resource-based view theory
RBV theory emphasizes that rare, valuable, imperfectly sustainable and imperfectly imitable resources cause competitive advantages, which in turn lead to higher performance (Barney, 2001). Supplier social sustainability is considered as a valuable resource that can create competitive advantage for buyer firms (Hollos et al., 2012). Due to labor cost advantages, many firms in developed countries outsource products, components and functions to firms in developing countries (Ehrgott et al., 2013). Such countries are frequently characterized by poor social sustainability conditions such as poor social and ethical attributes (Busse et al., 2016). While in the past the quality and the price of purchased goods were important factors for selecting suppliers and establishing long-term relationships with them, today suppliers’ social sustainability-related condition is also a critical factor. Stakeholders can punish MNCs when they become aware of unacceptable social-related practices by suppliers (Hofmann et al., 2014),
arguing that MNCs are able to prevent such wrongdoing (Klassen and Vereecke, 2012). As a result, suppliers’ social responsibility is a valuable resource in the current market, in which MNCs outsource products and functions to firms in developing countries that can create competitive advantage and consequently enhance the financial performance of the MNCs.

Conceptual framework and hypothesis development

To address the gaps in the literature, the present study investigated the impacts of supplier monitoring, supplier development, incentives and supplier collaboration on suppliers’ social performance. The study also proposed corporate reputation as a factor that may explain the relationship between MNCs’ social performance and financial performance (Figure 1). The rationales for the proposed relationship are elaborated based on the literature in the next sub-sections.

Supplier monitoring

Supplier monitoring refers to buyers’ regular assessment of suppliers’ activities and performance to ensure that they comply with social requirements and practices (Sancha et al., 2015). Monitoring includes auditing, assessing suppliers’ compliance with health and safety requirements and reviewing the manufacturer’s labor standards in terms of documentation such as companies’ polices, labor contracts and working hours (Huq et al., 2016). As part of an SSC, regular supplier monitoring activities such as inspections, audits or surveys are necessary to ensure that suppliers are really practicing sustainability (Yang and Zhang, 2017). Recent research has stressed the key role of monitoring in improving the management of social issues as well as environmental issues in the SC (Klassen and Vereecke, 2012). Because of the recent attention to social issues, supplier auditing or monitoring has become a fundamental policy of MNCs, particularly when suppliers are located in developing countries (Huq et al., 2016). Gimenez et al. (2012) suggested that in respect to sustainable supplier monitoring, buying firms should conduct on-going supplier monitoring on environmental and social aspects. Suppliers can behave unethically, such as deliberately employing child labor,

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**Figure 1.** Model with hypotheses results

**Notes:** The dotted lines indicate non-significant paths. *p* < 0.05; ***p* < 0.001 (one tail)
having poor health and safety conditions, or making employees work long hours in order to reduce costs (Sancha et al., 2016). Sancha et al. (2015) showed that the implementation of audits to suppliers contributes to improvement of the suppliers’ social performance. In general, supplier monitoring is expected to enhance suppliers’ social performance by ensuring adherence to specific social standards. In that sense, we hypothesize that:

**H1.** Supplier monitoring has a positive effect on suppliers’ social performance.

**Supplier development**
Supplier development refers to the practices that entail a more direct involvement of the buying firm with the supplier, such as technical support, training, and providing feedback and suggestions (Sancha et al., 2015). In this study, we define supplier development as providing the supplier with training and technological support, equipment and professional personnel in terms of social issues (Yang and Zhang, 2017). Implementation of supplier development practices by the buying firms helps to improve their environmental performance by reducing the suppliers’ use of un-environmental practices (Foerstl et al., 2010). Most studies on sustaining SCM with an environmental focus have shown that supplier development programs have a positive relationship with suppliers’ performance (Sancha et al., 2015).

Acknowledging that the core of supplier development is creating awareness of social issues, buying firms should ensure that suppliers are more prepared to handle social issues by developing their capabilities through training and knowledge transfer (Yawar and Seuring, 2018). This increases the capabilities and concurrently enhances the supplier’s efficiency, and may result in improved social performance for both suppliers and buyers (Lu et al., 2012; Sancha et al., 2015). Enhancing capabilities by implementing supplier development such as technical support can increase the supplier’s ability to handle social issues and result in improved social performance (Akamp and Müller, 2013; Sancha et al., 2016).

Based on Yang and Zhang (2017), sustainable supplier development demonstrated the strongest positive link with supplier performance. Supplier development will enable partners – in this case, supplier and buying firms – to exchange valuable knowledge and capabilities in adherence with the social standards of the SC. Hence, the knowledge developed as an outcome of the buying firm’s training of the supplier’s staff will result in better management of social issues at the supplier’s premises. Therefore, we believe that supplier development is able to foster better social performance for the supplier, similar to environmental performance. Accordingly, we hypothesize that:

**H2.** Supplier development has a positive effect on suppliers’ social performance.

**Incentives**
Incentives refer to appreciation of suppliers in the form of financial and non-financial incentives, which has a positive effect on the buyer–supplier relationship, leading to improved sustainability performance for both firms (Epstein and Roy, 2001). It is necessary for SC partners to provide more incentives to overcome barriers and promote sustainability practices in firms, especially in emerging economies (Vijayvargy et al., 2017). Klassen and Vereecke (2012) found that financial incentives to suppliers encourage much speedier improvement by the suppliers on social issues in the SC, directly improving the suppliers’ social performance. Non-financial incentives, such as annual awards to suppliers that best contribute to the firm’s sustainable strategy, also have positive effects on suppliers’ social performance, as they serve as encouragement tools to ensure suppliers’ compliance to social standards (Huq et al., 2016). Other than improving the suppliers’ process, product and financial performance, according to Yawar and Seuring (2018), rewards have a positive effect on suppliers’ social performance.
Incentives from buyers to suppliers in return for social compliance reduce suppliers’ social violations and directly improve their social performance (Porteous et al., 2015). Incentives such as long-term contracts that include social criteria of a supplier’s products influence the supplier’s practices (Pugell and Wu, 2009). Therefore, as previous research shows a positive relationship between incentives and performance, we believe that in the context of developing countries, incentives play a key role in encouraging suppliers to achieve better social performance. In that sense, we hypothesize that:

H3. Incentives have a positive effect on suppliers’ social performance.

Supplier collaboration
Supplier collaboration refers to the cooperation between buyers and suppliers to achieve sustainable goals (Ni and Sun, 2019). A close supplier collaboration reduces information asymmetries and enhances mutual trust, which enables firms and suppliers to maintain and forge a long-term relationship (Beske, 2012). Klassen and Vereecke (2012) showed that supplier collaboration as a part of social management capabilities has a positive relationship with the supplier’s social performance. Based on Gimenez et al. (2012), assessment alone is insufficient, and collaboration is much needed in order to improve both environmental and social performance, as assessment is only the first step to identity problems, while collaborative practices with suppliers improve overall sustainability. Collaboration allows the exchange of knowledge through the formation of interaction routines and enables effective improvement of both environmental and social performance throughout the SC (Gualandris and Kalchschmidt, 2016). Sancha et al. (2016) showed that supplier collaboration improves the supplier’s social performance, as collaboration results in increased knowledge for both suppliers and firms. Therefore, both suppliers and firms will be able to improve their own social performance, as the new knowledge will allow them to develop specific capabilities. Furthermore, collaboration is a method to encourage suppliers to implement social standards such as autonomous work practices, equal wages, reasonable limits on overtime, and practical job structures to reduce stress (Huq et al., 2016). In that sense, we hypothesize that:

H4. Supplier collaboration has a positive effect on suppliers’ social performance.

Supplier social performance
There is agreement among experts about Wood’s (1991) definition of social performance. Wood (1991) described social performance as a firm’s configuration of social responsibility rules, social responsiveness procedures, policies, plans and observable outcomes as they are connected to the company’s societal responsiveness. The performance of the buying organization can be damaged due to suppliers’ actions in terms of operational performance, financial performance and reputation (Foerstl et al., 2010). This suggests a direct relationship between a supplier and the firm in terms of performance, as the supplier’s poor performance might jeopardize the firm’s performance as well.

La et al.’s (2012) study revealed that buying firms’ performance can be critically affected by ethical incidents due to the suppliers’ lack of concern for social responsibility. Mani et al. (2018) showed that the adoption of social sustainability by suppliers can enhance the SC’s performance, especially in developing countries. Supplier good practices, such as better working conditions, compliance with human rights and safety measures, help to improve the supplier’s social performance, and this directly impacts the buying firm’s social performance. Hence, we believe that suppliers’ social performance will lead to better social performance for the firm. We thus hypothesize that:

H5. Suppliers’ social performance has a positive effect on their social performance.
MNC’s social performance and corporate reputation

Corporate reputation refers to “stakeholders’ perception and evaluation of how a company conducts its business” (Wang and Wang, 2007, p. 135). Social responsibility is one of the institutional signals that determine corporate reputation, and there is no dispute that a firm’s reputation is influenced by its corporate social performance, and that social expectation by society is a key factor in reputation (Pires and Trez, 2018). Brammer and Pavelin (2006), in their empirical research, provided evidence that social responsiveness is positively related to corporate reputation. Social issues in the SC put the firm at severe reputational risk: therefore, it is important to manage and mitigate social issues (Klassen and Vereecke, 2012). Organizations engage in socially responsible practices in order to protect their brand image and their reputation (Lemke and Petersen, 2013). There is a strong significant relationship between ethical corporate social performance and reputation among public stakeholders (Wang and Berens, 2015). Mani et al. (2018) indicated that SC social sustainability improves the buyer’s reputation and operational performance. Therefore, we believe that the social performance of a firm will enhance its reputation or corporate image, especially when the firm emphasizes social practices in its SC. Firms that practice social standards such as working conditions, workers’ rights and good health and safety practices, and which extend the same standards to suppliers, will gain a competitive advantage. In that sense, we hypothesize that:

H6. MNCs’ social performance has a positive effect on their corporate reputation.

MNCs’ social and financial performance

Financial performance refers to a firm’s performance as regards total assets, sales growth and income growth in comparison to its closest competitors (Lee et al., 2013). Scholars have argued that a positive reputation can provide an organization with a competitive advantage, much like brand equity (Fombrun, 1996). Orlitzky et al. (2003) found a positive relationship between CSR and financial performance. Gimenez et al. (2012) showed that buying firms that implement environmental supplier development programs are more likely to gain better economic results. Yawar and Kauppi (2018) found that financial or economic performance is a key factor in dairies’ engagement in supplier development practices that address social issues in the SC. Social performance by a firm that engages in supplier development can have a direct impact on the firm’s financial performance. Organizations with higher social standards set and expect the same from their suppliers, and this will improve the entire SC in terms of reducing disruption and ensuring smooth productivity, which translates to better financial performance. Hence, the following hypothesis was developed:

H7. MNCs’ social performance has a positive effect on their financial performance.

Corporate reputation

Some scholars have found that firms with high reputation are perceived as providing greater value, allowing them to charge a higher price for their products, and that their customer are loyal (Keh and Xie, 2009). Scholars believe that the reputation effect of engaging in social practices provides a critical link between social initiatives and profitability (Orlitzky et al., 2003; Surroca et al., 2010). Surroca et al. (2010) showed that as a result of corporate responsibility performance, corporate reputation is an intangible resource that generates competitive advantages, thus impacting the financial performance of the firm.

Favorable reputation supports the introduction of new products, the effectiveness of the sales force and recovery strategies in the event of crisis or threat, and consequently leads to better financial performance (Roberts and Dowling, 2002). Corporate social performance is
an effective means by which to establish a good overall reputation, which, in the long run, can bring financial benefit to the firm (Orlitzky et al., 2003). Regardless of industry context, overall corporate reputation has a positive relationship with the firm’s performance (Lee and Roh, 2012). Furthermore, with regard to the social dimension of reputation, a firm’s stand on a particular social issue carries a weight on its reputation and certain groups may either endorse or boycott the firm’s products, as in the case of Nike, and thus influence the firm’s sales. The evidence from real social incidents such as Nike, Apple, Foxconn and Walmart provides a very clear indication of damaged reputation which negatively affects the firm’s financial performance. As evidence from past studies demonstrates a positive financial outcome due to firms’ social reputation, we hypothesize that:

H8. MNCs’ corporate reputation has a positive effect on their financial performance.

H9. MNCs’ corporate reputation mediates positively the relationship between their social performance and financial performance.

Research methodology
Measurement of constructs
In this study, a questionnaire survey was used to measure the variables, as this method enables respondents to express their opinions, experience, or knowledge, and also enables researchers to acquire highly reliable outcomes that can be generalized extensively (Churchill and Iacobucci, 2005). Items measuring supplier monitoring, supplier development, supplier collaboration and suppliers’ social performance were adapted from Sancha et al. (2015). Items measuring incentives, MNCs’ social performance, MNCs’ corporate reputation, and MNCs’ financial performance were adapted from Ağan et al. (2016), Paulraj (2011), Rettab et al. (2009) and Lee et al. (2013), respectively. A five-point Likert scale (1 = strongly disagree to 5 = strongly agree) was used to measure all items. The items are provided in Table II.

Sample and data collection
MNCs which produce and sell consumer products in Malaysia form the unit of analysis for this study. Hoejmose et al. (2013) showed that buyer power is an important determinant of socially responsible SCM. In this study, the sample is limited to MNCs which mostly have high power. Furthermore, data were collected from MNCs which sell consumer products to ensure that the selected MNCs were at the same level in the SC and were in the eye of customers. The MNCs that participated in this study were foreign-based. As such, the parent companies of the selected MNCs were located in different regions of the world, which can enhance the generalizability of the results. The sampling frame for the study was taken from the Federation of Malaysia Manufacturers’ (FMM) directory 2017. There is a total of 481 MNCs selling consumer-branded products listed in the FMM directory. The respondents were managers involved in the SC, including business managers/directors, purchasing managers and SC managers of multinational corporations in Malaysia. The data were collected from them because they have information on their firms’ supplier management practices and financial performance. We called the target companies to obtain the names and e-mail addresses of the appropriate respondents. A link to the online survey was sent to all 481 respondents, with follow-up phone calls at two-week intervals. An online sampling method was used to collect data by sending each participant an e-mail containing a link to a web-based survey. Because of the small sampling frame of the study and the low response rate of online surveys, we included all 481 MNCs in this research. The web-based survey was considered as an appropriate technique to collect data because it enables researchers to reach a broader and more diversified population at a relatively low cost. The data collection process lasted roughly
two months. In total, 141 useful responses were collected from the 481 distributed surveys, providing an acceptable response rate of 29.3 percent. In light of this response rate, the collected data were subjected to non-response bias analysis in the form of wave analysis. The data set was split into subsets, namely, “early responses” (questionnaires returned during the first two weeks) and “late responses” (questionnaires returned during the last two weeks). Using an independent t-test, the findings demonstrated no significant differences between the two groups on all measures, revealing that the data set did not suffer from non-response bias.

Common method variance
CMV in self-report surveys is one of the methodological sources of measurement error with the potential to lessen the reliability and validity of underlying constructs and hypothesized relations in a model (Fuller et al., 2016). To minimize and assess CMV, the current research used several techniques in two ways, namely, procedural and statistical remedies. First, we tried to enforce procedural remedies by keeping the items concise and simple, reducing item ambiguity, and presenting a confidentiality and anonymity statement at the beginning of the questionnaire (Podsakoff et al., 2003). Second, we performed statistical remedies through a more rigorous marker variable technique (Lindell and Whitney, 2001), in which a marker variable (i.e. “attitude toward buying green products”) theoretically is not linked to any of the constructs included in the research model. We did not detect any significant correlation, indicating that common method bias is not a concern in the current study.

Data analysis
As proposed by Hair et al. (2019), we tested the normality of the collected data using software available on the Webpower website[1], and the results indicated that the data were not normal. Hair et al. (2019) indicated that in social science, data is almost always abnormal. According to Hair et al. (2019), if the data are abnormal and the size of the data set is limited, partial least squares structural equation modeling (PLS-SEM) shows a higher robustness in comparison to covariance-based SEM (CB-SEM). As such, PLS-SEM was selected as an appropriate technique to test the proposed conceptual framework. The two-step approach was used to test the study’s proposed model. In the first step, the validity and reliability of the measurement model were tested, and later, in the second stage, the proposed relationships were tested.

Results
Descriptive analysis
The characteristics of firms and respondents are provided in Table I. The majority of the MNCs that participated in this study had more than 1,000 employees in their Malaysia branches (58.9 percent) and had been established for more than 15 years (85.8 percent). All the MNCs were foreign-based: the majority of companies came from North America (36.2 percent), followed by Europe (32.6 percent) and Asia (27.6 percent). The majority of the respondents were male (58.2 percent) and had more 10 years’ experience in their particular industry (74.5 percent). Around 71.6 percent of the respondents were SC managers, while 23.4 percent were purchasing managers and 5.0 percent were business managers/directors. Regarding the respondents’ education, 74.5 percent held bachelors’ degrees, while 19.9 percent held masters’ degrees, 3.5 percent held diplomas and 2.1 percent held PhDs.

Measurement model
The convergent validity of constructs was assessed according to the guidelines proposed by Hair et al. (2019). As Table II displays, the composite reliability (CR) values of all variables indicated scores higher than 0.7 with factor loadings above 0.4. The average variance
extracted (AVE) values were found to be more than 0.5. These results demonstrated satisfactory convergent validity (Hair et al., 2019).

We examined discriminant validity by assessing the outer loadings, the Fornell–Larcker criterion (Fornell and Larcker, 1981), and the Heterotrait–Monotrait (HTMT) criteria (Henseler et al., 2015). First, there were no cross-loadings among the measurement items. Second, the square roots of AVE were greater than the relevant inter-construct correlations in the construct correlation matrix, providing evidence for discriminant validity (Table III). Third, as a more conservative measure (Henseler et al., 2015), discriminant validity was examined through the HTMT criteria. The HTMT values were revealed to be less than 0.85 (Table IV), thus confirming the discriminant validity of all given variables (Kline, 2016).

Structural model
The proportion of variance explained was used to determine the accuracy of the model’s predictions. In the present study, the $R^2$ values of suppliers’ social performance, MNCs’ social performance, corporate reputation and financial performance were 0.643, 0.541, 0.305 and 0.346, respectively. Further, predictive relevance was measured by calculating the Stone-Geisser $Q^2$ (cross-validated redundancy) value. The results show that the $Q^2$ values for suppliers’ social performance (0.495), MNCs’ social performance (0.444), MNCs’ corporate reputation (0.273) and MNCs’ financial performance (0.304) were all greater than zero (Chin, 2010), thus confirming the predictive relevance of the endogenous variables in this study.

Based on the bootstrapping results, although supplier development ($\beta = 0.320; p < 0.01$) and supplier collaboration ($\beta = 0.453; p < 0.001$) had a positive effect on suppliers’ social performance, supplier monitoring ($\beta = 0.080; p > 0.05$) and incentives ($\beta = 0.014; p > 0.05$) had no effect. The relationship between suppliers’ social performance and MNCs’ social performance was supported ($\beta = 0.736; p < 0.001$). According to these results (Table V and Figure 1), MNCs’ social performance had a positive effect on both MNCs’ corporate reputation ($\beta = 0.552; p < 0.001$) and MNCs’ financial performance ($\beta = 0.295; p < 0.001$). MNCs’ corporate reputation also had a positive effect on MNCs’ financial performance

<table>
<thead>
<tr>
<th>Variable Categories</th>
<th>Frequently</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Size &lt;1,000 employees</td>
<td>58</td>
<td>41.1</td>
</tr>
<tr>
<td>1,001–3,000 employees</td>
<td>33</td>
<td>23.4</td>
</tr>
<tr>
<td>3,001–5,000 employees</td>
<td>24</td>
<td>17.0</td>
</tr>
<tr>
<td>More than 5,000 employees</td>
<td>26</td>
<td>18.4</td>
</tr>
<tr>
<td>Age of the Company 6–10 years</td>
<td>8</td>
<td>5.7</td>
</tr>
<tr>
<td>11–15 years</td>
<td>12</td>
<td>8.5</td>
</tr>
<tr>
<td>More than 15 years</td>
<td>121</td>
<td>85.8</td>
</tr>
<tr>
<td>Location of Parent Company North America</td>
<td>51</td>
<td>36.2</td>
</tr>
<tr>
<td>Europe</td>
<td>46</td>
<td>32.6</td>
</tr>
<tr>
<td>Asia</td>
<td>39</td>
<td>27.6</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>Gender Male</td>
<td>82</td>
<td>58.2</td>
</tr>
<tr>
<td>Female</td>
<td>59</td>
<td>41.8</td>
</tr>
<tr>
<td>Job Title Supply chain Manager</td>
<td>101</td>
<td>71.6</td>
</tr>
<tr>
<td>Purchasing Manager</td>
<td>33</td>
<td>23.4</td>
</tr>
<tr>
<td>Business Manager/Director</td>
<td>7</td>
<td>5.0</td>
</tr>
<tr>
<td>Experience in this industry Less than 15 years</td>
<td>36</td>
<td>25.5</td>
</tr>
<tr>
<td>More than 15 years</td>
<td>105</td>
<td>74.5</td>
</tr>
<tr>
<td>Education Diploma</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>Bachelor</td>
<td>105</td>
<td>74.5</td>
</tr>
<tr>
<td>Master</td>
<td>28</td>
<td>19.9</td>
</tr>
<tr>
<td>PhD</td>
<td>3</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Table I. Descriptive Analysis
<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Factor loadings</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier Monitoring (SM)</td>
<td>Our firm regularly uses a supplier certification program to certify suppliers’ social sustainability activities</td>
<td>0.923</td>
<td>0.941</td>
<td>0.799</td>
</tr>
<tr>
<td></td>
<td>Our firm regularly reviews suppliers’ environmental performance</td>
<td>0.836</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm regularly reviews suppliers' social performance</td>
<td>0.936</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm regularly reviews suppliers to ensure they comply with the standards and specifications set by us</td>
<td>0.878</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier Development (SD)</td>
<td>Our firm provides technical support to our suppliers for improvement</td>
<td>0.897</td>
<td>0.966</td>
<td>0.849</td>
</tr>
<tr>
<td></td>
<td>Our firm provides training in social sustainability for our suppliers</td>
<td>0.928</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm provides feedback about social sustainability performance to our suppliers</td>
<td>0.901</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm suggests improvement targets to our suppliers</td>
<td>0.941</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm supports our suppliers in improving their capabilities</td>
<td>0.909</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incentives (IC)</td>
<td>Our firm provides financial support to suppliers on social sustainability projects</td>
<td>0.895</td>
<td>0.936</td>
<td>0.786</td>
</tr>
<tr>
<td></td>
<td>There is personnel transfer with our suppliers regarding social sustainability activities</td>
<td>0.906</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm rewards suppliers based on their social sustainability performance</td>
<td>0.899</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm makes long-term contracts with suppliers based on their social sustainability performance</td>
<td>0.845</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier Collaboration (SCO)</td>
<td>Our firm cooperates with suppliers to achieve social sustainability objectives</td>
<td>0.944</td>
<td>0.959</td>
<td>0.853</td>
</tr>
<tr>
<td></td>
<td>Our firm cooperates with suppliers to achieve environmental objectives</td>
<td>0.959</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm coordinates closely with our supplier on social sustainability activities</td>
<td>0.839</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The logistics activities take place in close coordination with us to ensure social sustainability achieved</td>
<td>0.947</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier’s Social Performance (SSP)</td>
<td>Our firm has improved compliance with human rights in the suppliers’ facilities</td>
<td>0.961</td>
<td>0.953</td>
<td>0.835</td>
</tr>
<tr>
<td></td>
<td>Our firm has improved compliance with child labor employment in the suppliers’ facilities</td>
<td>0.947</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm has improved safety and labor conditions in the supplier’s facilities</td>
<td>0.956</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm has reduced environmental impacts of suppliers’ activities</td>
<td>0.779</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNC’s Social Performance (MSP)</td>
<td>Relative to our most relative competitors over the last three years</td>
<td>0.968</td>
<td>0.883</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm has improved in overall stakeholder welfare and betterment</td>
<td>0.921</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm has improved in community health and safety</td>
<td>0.956</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our firm has reduced environmental impacts and risks in general public</td>
<td>0.945</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNC’s Corporate Reputation (MCR)</td>
<td>Our firm has improved protection of claims among public</td>
<td>0.936</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In general, our company has a good reputation</td>
<td>0.973</td>
<td>0.983</td>
<td>0.952</td>
</tr>
<tr>
<td></td>
<td>We are widely acknowledged as a trustworthy company</td>
<td>0.981</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>This organization is known to sell high quality products and services</td>
<td>0.973</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNC’s Financial Performance (MFP)</td>
<td>Relative to our most relative competitors over the last three years</td>
<td>0.984</td>
<td>0.954</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our total assets have been substantially better</td>
<td>0.982</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our sales growth has been substantially better</td>
<td>0.983</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our operating income growth has been substantially better</td>
<td>0.986</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: AVE, average variance extracted; CR, composite reliability

Table II. Convergent validity and reliability assessment
To test the mediation effect of MNCs’ social performance on MNCs’ financial performance through MNCs’ corporate reputation, the bootstrapping indirect effect method was utilized (Preacher and Hayes, 2008). The bootstrapping analysis demonstrated that the indirect effect was significant ($\beta = 0.205; p < 0.001$). As such, all the hypotheses from $H1$ to $H9$ were supported except for $H1$ and $H3$.

**Discussion**

According to our results, supplier monitoring has no significant impact on suppliers’ social performance. This result is not in line with the findings of Zimmer et al. (2016), who found that continuous monitoring was an effective way to embed social responsibility values through suppliers’ activities and to enhance suppliers’ social performance. Some scholars

<table>
<thead>
<tr>
<th>SM</th>
<th>SD</th>
<th>IC</th>
<th>SCO</th>
<th>SSP</th>
<th>MSP</th>
<th>MCR</th>
<th>MFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>0.894</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.738</td>
<td>0.921</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>0.699</td>
<td>0.804</td>
<td>0.887</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCO</td>
<td>0.815</td>
<td>0.755</td>
<td>0.748</td>
<td>0.924</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSP</td>
<td>0.696</td>
<td>0.730</td>
<td>0.674</td>
<td>0.766</td>
<td>0.914</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSP</td>
<td>0.615</td>
<td>0.599</td>
<td>0.550</td>
<td>0.689</td>
<td>0.736</td>
<td>0.940</td>
<td></td>
</tr>
<tr>
<td>MCR</td>
<td>0.441</td>
<td>0.436</td>
<td>0.390</td>
<td>0.435</td>
<td>0.492</td>
<td>0.552</td>
<td>0.976</td>
</tr>
<tr>
<td>MFP</td>
<td>0.423</td>
<td>0.394</td>
<td>0.456</td>
<td>0.451</td>
<td>0.450</td>
<td>0.501</td>
<td>0.535</td>
</tr>
</tbody>
</table>

**Table III.** Fornell and Larcker

<table>
<thead>
<tr>
<th>SM</th>
<th>SD</th>
<th>IC</th>
<th>SCO</th>
<th>SSP</th>
<th>MSP</th>
<th>MCR</th>
<th>MFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>0.781</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.759</td>
<td>0.832</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>IC</td>
<td>0.835</td>
<td>0.792</td>
<td>0.804</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SCO</td>
<td>0.750</td>
<td>0.768</td>
<td>0.730</td>
<td>0.817</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSP</td>
<td>0.657</td>
<td>0.625</td>
<td>0.589</td>
<td>0.727</td>
<td>0.782</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSP</td>
<td>0.466</td>
<td>0.451</td>
<td>0.414</td>
<td>0.453</td>
<td>0.516</td>
<td>0.573</td>
<td></td>
</tr>
<tr>
<td>MCR</td>
<td>0.450</td>
<td>0.407</td>
<td>0.483</td>
<td>0.471</td>
<td>0.474</td>
<td>0.518</td>
<td>0.548</td>
</tr>
</tbody>
</table>

**Table IV.** Heterotrait-Monotrait ratio (HTMT0.85)

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Relationships</th>
<th>Path coefficients</th>
<th>$t$-values</th>
<th>$p$-values</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H1$</td>
<td>SM $\rightarrow$ SSP</td>
<td>0.093</td>
<td>0.754</td>
<td>0.226</td>
<td>Not supported</td>
</tr>
<tr>
<td>$H2$</td>
<td>SD $\rightarrow$ SSP</td>
<td>0.299</td>
<td>2.171</td>
<td>0.015**</td>
<td>Supported</td>
</tr>
<tr>
<td>$H3$</td>
<td>IC $\rightarrow$ SSP</td>
<td>0.050</td>
<td>0.341</td>
<td>0.366</td>
<td>Not supported</td>
</tr>
<tr>
<td>$H4$</td>
<td>SCO $\rightarrow$ SSP</td>
<td>0.427</td>
<td>3.826</td>
<td>0.000***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H5$</td>
<td>SSP $\rightarrow$ MCR</td>
<td>0.736</td>
<td>19.570</td>
<td>0.000***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H6$</td>
<td>MSP $\rightarrow$ MCR</td>
<td>0.552</td>
<td>8.519</td>
<td>0.000***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H7$</td>
<td>MSP $\rightarrow$ MFP</td>
<td>0.295</td>
<td>3.987</td>
<td>0.000***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H8$</td>
<td>MCR $\rightarrow$ MFP</td>
<td>0.371</td>
<td>5.206</td>
<td>0.000***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H9$</td>
<td>MSP $\rightarrow$ MCR $\rightarrow$ MFP</td>
<td>0.205</td>
<td>4.433</td>
<td>0.000***</td>
<td>Supported</td>
</tr>
</tbody>
</table>

**Table V.** Hypothesis testing results

Notes: $t$-values are computed through bootstrapping procedure with 141 cases and 2,000 samples. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (one tail)
believe that monitoring practices only help to improve the reputation of the buying firms by avoiding reputational damage, as they project the firm as a socially responsible member of society (Sanchez et al., 2016; Foerstl et al., 2010). Huq et al. (2016) concluded that third-party audits were only for symbolic compliance, as they found evidence of suppliers’ unacceptable social practices, such as hiding or duplicating records. The monitoring practices had no effect on suppliers’ social performance, as monitoring might only be beneficial to the MNC to ensure that suppliers are adhering to social standards. However, suppliers might choose to do so only during audits or evaluation rather than maintaining a consistent social standard throughout, causing failure to develop sustainable social performance. Furthermore, Normann et al. (2017) stated that governance mechanisms based on codes of conduct and auditing may hurt buyer–supplier relationships, resulting in reduced supplier compliance with social sustainability requirements. Klassen and Vereecke (2012) also highlighted that although monitoring helps in measuring the suppliers’ degree of compliance with standards and codes, it is weakly geared toward implementing these standards and codes.

Our results support the hypothesis that supplier development has a positive influence on suppliers’ social performance. This shows that supplier development in relation to social performance has a similar positive impact as in environmental performance (Lee and Klassen, 2008; Foerstl et al., 2010). This is also consistent with the positive findings reported by Sanchez et al. (2015) and Akamp and Muller (2013), who found that supplier development leads to an improvement in suppliers’ social performance. The support of MNCs improves their suppliers’ social performance, as it provides the opportunity for suppliers to improve their capability in handling social issues by providing training, technology and technical assistance. In the long term, we believe that supplier development practices will nurture a strategic partnership that not only encourages better management of social issues with transparency but also enables mutual understanding and alignment of the evolving social requirements in the SC.

Incentives had no effect on suppliers’ social performance. This means that providing incentives alone is not sufficient to promote suppliers’ performance improvement in terms of social sustainability. This result is not consistent with the findings of Klassen and Vereecke (2012) and Huq et al. (2016), who found that giving incentives was an effective way of promoting social sustainability among suppliers. Suppliers’ lack of knowledge on the requirements of social sustainability is one potential reason for the insignificant relationship in the present study. This suggests that giving suppliers incentives such as financial support without providing the correct guidelines and training on handling social issues is a waste of effort, as the supplier might not be aware of the requirement of social sustainability. Terpend and Krause (2015) found that competitive incentives such as rewarding suppliers based on performance are ineffective in generating improved performance, while cooperative incentives tend to be effective only under conditions of high mutual dependence: in other words, collaboration. Furthermore, Normann et al. (2017) interviewed suppliers and found that the costs of knowing and implementing the requirements of social sustainability were very high for them, and that the incentives offered by buyers, in terms of financial support or long-term contracts, were not adequate. As such, the imbalanced cost-and-benefit equation of being socially responsible is another reason for the insignificant effect of incentives on suppliers’ social performance.

Supplier collaboration also shows a positive relationship with suppliers’ social performance, similar to the results of Akamp and Muller (2013), Sanchez et al. (2016) and Mani et al. (2018). The buying firm’s commitment to improve the supplier’s social performance not only mitigates any SC risk but also, most importantly, increases the performance of suppliers, as collaboration leads to sustainable SC performance (Lee and Roh, 2012; Mani et al., 2018). The exchange of knowledge through collaboration may enhance suppliers’ capability to
meet the requirement of social standards in the industry, especially for those suppliers with limited resources and lack of both knowledge and awareness of social issues. Supplier collaboration brings intangible and valuable resources, such as learning and human resources, which occurs while the supplier and buyer work together to improve social sustainability (Gualandris and Kalchschmidt, 2016). Furthermore, collaboration with suppliers enables suppliers to develop social management capabilities, which in turn reduces the errors and costs of implementation of social practices (Mani et al., 2018).

It is interesting to note that both supplier development and supplier collaboration that requires the direct involvement of the MNC have positive relationships with the supplier’s social performance compared to both supplier monitoring and incentives, which are rather passive modes of involvement from the MNCs. We can conclude that among the two mechanisms in agency theory to deal with suppliers’ social issues, behavior-based contracts are more effective to cope with the risk of defaults in comparison to outcome-based contracts. Sancha et al. (2016) also concluded that assessing suppliers only improves the buying firm’s social performance and does not have any direct impact on the supplier’s social performance, in contrast to collaboration, which improves the supplier’s social performance. A combination of both monitoring and collaboration is required in order to achieve social performance excellence in the SC. Incentives, on the other hand, are a good tool to provide the opportunity for improvement; however, this must be accompanied by collaboration and supplier development activities. Incentives and monitoring as moderators need to be explored further in relation to supplier social sustainability.

Suppliers’ social performance in the present study had a positive relationship with MNCs’ social performance supporting the result from Sancha et al. (2016), which shows a strong direct relationship between suppliers’ social performance and the buying firm’s social performance. Gualandris and Kalchschmidt (2016) also demonstrated that suppliers’ sustainability practices have a positive influence on the firm’s sustainability. A firm that participates in suppliers’ social sustainability not only improves the suppliers’ performance but also improves its own performance (Mani et al., 2018). A firm should ensure the implementation of social standards throughout its SC, as supplier social performance is a reflection of the firm’s social performance as well. It is quite impossible for any firm to project good social performance to its stakeholders if its suppliers’ social performance is failing miserably. Hoejmose et al. (2014) and Yawar and Seuring (2018) argued that management of suppliers is a key criterion, and this enforces the firm to extend its social standards to its suppliers in order to be certified, directly ensuring the existence of the inter-relationship of both suppliers’ and firms’ social performance.

In our research, MNCs’ social performance positively influenced their corporate reputation, and this is consistent with the findings reported by Brammer and Pavelin (2006) and Wang and Berens (2015), showing a strong significant relationship between social performance and reputation. We believe that good social performance helps to build a strong positive reputation for MNCs, and this creates the foundation for trustworthy relationships with stakeholders. In terms of MNCs’ social and financial performance, our results show a positive relationship, extending the results of prior research (Orlitzky et al., 2003; Wang et al., 2016). A firm that has good social performance will avoid disruption in the SC, and this will provide the opportunity to maximize its production outputs, translating to better financial performance. This also provides the firm with a competitive advantage, as it will attract more investors, especially when the firm has good social performance in the eyes of stakeholders.

Although there has been some debate about whether reputation and financial performance have a bidirectional relationship, our objective was to test the influence of reputation on financial performance, and we found a positive relationship. This is consistent with Lee and Roh’s (2012) and Roberts and Dowling’s (2002) findings on the relationship
between corporate reputation and financial performance, regardless of industry type. This is further supported by research of Van den Bogaerd and Aerts (2015) on media reputation and its positive relationship with financial performance in terms of the extent and duration of trade credit received. Furthermore, as in our research on social sustainability and as agreed by Orlitzky et al. (2003), social performance is a critical factor that enables firms to establish a good reputation, which in return allows them to reap the rewards from good financial performance. This means that corporate reputation is one of the reasons why social performance leads to higher financial performance. However, the significant direct relationship between social and financial performance suggests that other reasons also exist, which can be investigated in future studies.

Theoretical and practical contributions
In terms of academic contribution, this research answers recent calls for more empirical research in social sustainability in SC (Hoejmose and Adrien-Kirby, 2012; Quarshie et al., 2016), especially in emerging economies, which has clearly been lacking (Hoejmose et al., 2013; Sancha et al., 2015). The findings of this study extend the literature by determining the socially responsible supplier development practices that have significant effects on suppliers’ social performance. Supplier monitoring, supplier development, incentives and supplier collaboration have been recognized, mostly in qualitative studies, as the practices that buyers can adopt to enhance the suppliers’ social responsibility. However, the lack of empirical work in the literature on the impacts of these four practices on suppliers’ social performance has left the question on effectiveness of these practice unanswered. The results of this study showed that although supplier development and supplier collaboration, which need MNCs’ direct involvement, have significant effects on the social performance of suppliers, supplier monitoring and the provision of incentives, which are passive modes of involvement, have no effect. These findings indicate that behavior-based contracts of agency theory are more effective in enhancing suppliers’ social performance in comparison to outcome-based contracts. The findings also confirm that suppliers’ social performance is a valuable resource that can create competitive advantage and consequently enhance the financial performance of MNCs. The findings extend the literature on the relationship between MNCs’ social and financial performance by introducing MNCs’ corporate reputation as one of the reasons for this relationship.

In terms of practical contributions, our results send a very clear message to MNCs that in order to optimize the practices of social sustainability in the SC, MNCs are required to play an active role in helping their suppliers to establish solid social performance. MNCs must understand that supplier monitoring and providing incentives do not make any significant contributions compared to supplier collaboration and supplier development. This shows the importance of the active role of MNCs in sharing technology and resources and providing training to suppliers, which creates much more value in the long term. However, this does not mean that supplier monitoring and incentives can be ignored; these two activities perhaps can only take place after the MNC has established with the supplier the required standards of social responsibility. However, the moderating roles of supplier monitoring and incentives need further study in future. The significant effect of suppliers’ social performance on the MNCs’ social performance shows the important role of suppliers’ social performance in shaping MNCs’ social performance and consequently their corporate reputation and financial performance.

Limitations and future studies
In the present study, social sustainability in SC was investigated from the MNC perspective. This could be a biased viewpoint, as we did not include the viewpoint of suppliers as the receivers of these initiatives. A supplier perspective would also be useful in either supporting or challenging the relationship of MNCs’ initiatives in social performance and its
overall impact on SC performance. We would suggest that future studies obtain data from both suppliers and MNCs. Based on our findings, supplier monitoring and incentives have no effect on supplier social performance. Future research needs to test the moderating effect of these two factors on the impacts of supplier development and supplier collaboration on social performance. Furthermore, power dependency, trust relationships, organizational distance and the age of the buyer–supplier relationship (Bönte, 2008; Hoejmose et al., 2013) may affect the effectiveness of supplier development practices. Future studies should control for the potential effects of these factors.

Note
1. https://webpower.psychstat.org/models/kurtosis

References


Further reading


Corresponding author
Mohammad Iranmanesh can be contacted at: iranmanesh@usm.my
Mobile application supported urban-township e-grocery distribution

Marcia Mkansi
Department of Operations Management, University of South Africa, Pretoria, South Africa

Sander de Leeuw
Department of Supply Chain Analytics, VU University Amsterdam, Amsterdam, The Netherlands and Nottingham Business School, Nottingham Trent University, Nottingham, UK, and

Olatoye Amosun
Consumatech, Pretoria, South Africa

Abstract

Purpose – The purpose of this paper is to present a mobile application supported township urban e-grocery distribution models that uses a software application (app) to bridge the infrastructural barriers, costs and complexities associated with e-grocery delivery operations in rural township areas.

Design/methodology/approach – Using a qualitative multi-case approach and semi-structured interviews, the study explored distribution practices of eight national emerging e-grocery retail businesses to demonstrate how mobile applications can facilitate South African urban and township e-grocery delivery models.

Findings – The study reveals how the need to scale the use of new mobile application innovations fuels value-added services that power new e-grocery distribution models. Of interest is how the application aggregates demand rapidly, respond to demand within a short lead time and how e-grocers use competitors’ stores as their fulfilment centres. The use of apps reveals a slow transformation of society towards an inclusive model that integrates different types of workers in an informal context.

Practical implications – The mobile application value-added service business model offers a new wave of scaling e-grocery retail to rural and township areas constrained by technological, economic and road infrastructure. The apps transcend e-grocery barriers and enables small businesses with limited resources to leverage e-grocery market opportunities that are unimaginable in townships and rural areas.

Originality/value – The innovative mobile platform-base model offers emerging contextual insight of a pull e-grocery distribution model that demonstrates the supply chain innovations for addressing under-resource and under-developed logistics infrastructure.

Keywords Mobile applications, E-grocery distribution models, Order management, Urban and township delivery

Paper type Research paper

Introduction

E-grocery retail business models have been studied mostly in urban and city environments (Morganti et al., 2014; Durand and Gonzalez-Feliu, 2012; Gevaers et al., 2011; Murphy, 2007). The urban and city focus is due to the perception of complexities and cost associated with supply and distribution of e-groceries in such environments (Ishfaq et al., 2016; Aspray et al., 2013). However, findings from such studies prove difficult to be rolled out easily to townships and rural areas where road and internet infrastructure is still in its infancy (Foster and Briceno-Garmendia, 2010; Murphy, 2007).

Even in urban and city environments the challenges of efficient and effective distribution are abundant. In the context of costs of e-grocery retail, Ishfaq et al. (2016) found a network complexity cost in their study of the realignment of physical distribution channels in omni-channel retail. Yang et al. (2014) unveiled issues of additional expense for
transportation in an attended home-delivery model. Gevaers et al. (2011) state that “not-at-home” deliveries of the last mile imply extra costs. Aspray et al. (2013) reiterate the high cost and complexity of fulfilment for groceries bought online. Asdemir et al. (2009) also emphasise the challenge of balancing utilisation of delivery capacity against time and profit margin in e-grocery retail. Recent studies by Larke et al. (2018) illustrate the complexity in achieving omni-channel retailing in even a mature market. To add to this, Goethals et al. (2012) point towards the additional task of order preparation, delivery activities and investment associated with e-grocery retail as key deterrents for many businesses. To this end, Agatz et al. (2011) introduce a time-slot pricing tool inspired by e-grocery operations. They conclude that high costs in transportation may be related to setting narrow delivery time slots and that there are clear economies of scale in increasing stops. These studies are typically inspired by or set in an urban or city business perspective. However, as Agatz et al. (2011) argue, a regional differentiation of services may lead to significant cost savings. All these studies point towards difficulties in managing e-commerce in grocery retail in urban and city settings and successfully rolling out such distribution models to township and rural areas may, therefore, be even more difficult to achieve.

This study is set in South Africa, where small e-grocery operators are infiltrating the urban, township and rural markets (see Appendix 1 for further details on the grocery retail market in South Africa). Tu et al. (2018) argue that it is pivotal to establish good e-commerce logistics in rural areas to fuel further growth, since studies in China have shown that rural e-commerce logistics may be a bottleneck in e-commerce development. In China, large retailers aim to seize the rural e-commerce market by building their own logistics network. Tu et al. (2018) indicate that Taobao Mall and Tmall established 1,000 county-level service stations and 100,000 village service sites with an investment of $1.5bn. However, the authors also argue that in China companies still have a long way to go before rural e-commerce logistics can be run effectively and efficiently. This prompted the quest of what innovations are needed in the supply chain to address limited resources and under-developed logistics infrastructure.

A comparison of studies on South Africa’s top three e-grocery retailers’ practices (Weber and Badenhorst-Weiss, 2018) against those of the developed world and other developing countries (Hubner et al., 2016; Waitz et al., 2018) reveals very few differences in terms of the distribution models, but rather more variations of contexts underlying the e-grocery retail operations. For example, Weber and Badenhorst-Weiss (2018) reveal three picking options used by a leading e-grocery retailer in the urban areas of South Africa: in-store, centralised distribution centres (DCs) and central warehouse. Hubner et al.’s (2016) holistic strategic planning framework for last mile orders, observed from different published e-grocery studies in the European Union, also reiterates the same picking options. Mkansi et al. (2011) reinforce the same observations regarding the supply and distribution network models (piggyback, hybrid and DC models) used by leading grocery e-retailers in the UK, namely: Tesco, Waitrose, Asda and Ocado. Marchet et al.’s (2018) reiterates in-store as a business logistics model used by food retailers in Italy. The same distribution models are used by other top e-grocery retailers in the developed world such as Germany, France, China and the Netherlands (Mkansi et al., 2018; Lim et al., 2018), and the USA (Li et al., 2018; Waitz et al., 2018; Aspray et al., 2013). A limited context of e-grocery operation models in developing world countries such as India and Pakistan offer similar insights of distribution models use in urban contexts (Bharucha, 2017; Saleem et al., 2018).

All in all, the transition of findings set in urban developed world contexts to townships and rural dwellings is complicated as the latter are perceived to be constrained by lack of a proper digital infrastructure, accurate information and communication technologies, high cost of distribution, expensive data and unstructured road systems, all of which make it hard to deliver (Foster and Briceno-Garmendia, 2010; Murphy, 2007). The aim of the study is
to explore how small and medium e-grocery businesses use innovations to bridge the supply chain challenge of limited resources and under-developed logistics infrastructure in urban, township and rural e-grocery distribution. In order to do so the extant literature is reviewed, and a multiple case-study approach is employed to gain a deeper insight into the urban-township e-grocery distribution models. The study findings show how the use of mobile applications integrates different types of workers in an informal context. To facilitate order processing in townships and rural areas entrenched with issues typical of a context, unemployed youth are deployed to curb obstacles of technological challenged market segments. In addition, apps allow for overcoming issues typical of unstructured roads and street numbers through the use of GPS to capture locations for order delivery. In particular, it reveals a slow transformation of society towards a crowdsourcing-enabled model.

The following section presents a literature review of the urban, township and rural e-grocery context. After that, the third section reviews the research methodology and the fourth section presents results which are discussed in the fifth section. The sixth section concludes the paper.

**Urban, township and rural e-grocery contexts**

Scholars have long acknowledged the interrelationship between distribution network configurations on the one hand and, on the other, the physical geographical development of urban, township and rural dwellings (Osterle et al., 2015; Ploos Van Amstel, 2015; Blanco and Fransoo, 2013). Although emphasised differently, a common theme centres on urban, township and rural design parameters as crucial inputs for distribution and network configuration. For example, Osterle et al. (2015) acknowledge the importance of well-functioning urban distribution systems for distribution of goods to the stores and its economic contributions to the region. Ploos Van Amstel (2015) stresses how transport and technological infrastructure alters distribution models and logistical elements which may confer advantages for those businesses within such contexts. Hughes (2012) emphasises that infrastructural designs (i.e. urban, township and rural designs) and spatial organisation of transport and mediating technological infrastructures play a differential and direct role in enabling distribution of goods and services. Cant (2017) argues that access to infrastructure is a prerequisite for small businesses to thrive and highlights how the lack of infrastructure in the townships of South Africa hinders small businesses. Oduwole (2018) discussed that infrastructural development goes hand-in-hand with entrepreneurship development necessary for accommodating townships peculiarities. As such, the fact that urban, townships and rural areas take different forms of designs (Blanco and Fransoo, 2013) highlights spatial variations that need to be considered in the evaluation of e-grocery distributions models. Such spatial variations and its interrelationships with e-grocery retailers from different contexts, especially those with limited resources and under-developed logistics infrastructure, remains silent in the literature. Yet, understanding spatial differences is crucial in determining how e-grocery distribution models manifest across contexts, specifically the interactions of e-grocery retailers with such environments. Below, an overview of the peculiarities of urban, township and rural contexts is provided and thereafter of the role of mobile innovation, which sets the conditions under which e-grocery models are configured. The South African context of grocery retail in which this research is set is discussed in Appendix 1.

**Urban e-grocery context**

Although distribution networks are, on average, more advanced in urban areas than in township and rural dwellings, distribution networks in developing countries cannot be presumed to be on par with those of developed worlds (Blanco and Fransoo, 2013; Zaide, 2012; Lawrence and Tar, 2010). For example, in developed countries information technology
(i.e. mobile broadband, data and cloud computing) and industrial convergence (i.e. electric grids, transport networks and household appliances), which is necessary for sustainable e-grocery operations, is more advanced than in developing countries (Blanco and Fransoo, 2013). Moreover, the income disparity is minimal in developed countries as opposed to urban areas of developing countries (Blanco and Fransoo, 2013). Such disparities are crucial factors that contribute to the success of e-grocery operation.

In South Africa, urban areas struggle with reliable electricity supply and operate under intermittent load shedding, an interruption of electricity supply to businesses and communities aimed at balancing demand, to prevent the collapse of the power system (plant) which is not present in developed worlds (Baptista, 2018). In fact, load shedding hurts the economy as well as the supply chains of many businesses (England, 2015; Bisseker, 2015). In terms of e-grocery, this extends well beyond unreliable traffic lights that affect on-time delivery and lead to increased road congestion, but also encompass, for example, limited abilities for cold storage of chilled and frozen products and disruptions in processing of payments. Whilst the technological and load shedding issues cannot be assumed to be the single factor differentiating urban distribution in the developed world vs that in South Africa, they do illustrate the importance of understanding contextual e-grocery distribution issues. Urban contexts need a different approach in the supply chain but South Africa has interesting aspects by itself, such as the unique spatial legacy of urban, township and rural contexts from the apartheid era, which makes visible the interface between economical structures and spatial inequality (Philip, 2010).

Township and rural e-grocery context

Townships and rural areas in many developing countries are known to have homogenous characteristics such as income disparities (Blanco and Fransoo, 2013), immature logistics infrastructure, low credit card penetration and poor telecommunications infrastructure (Zaide, 2012; Lawrence and Tar, 2010). Yet, in order to successfully offer e-grocery operations, the infrastructure needs to be embedded within the geographical and economic structures (Murphy, 2007). In fact, the top ten global leading e-grocery retailers thrive due to their advanced telecommunication systems, high number of stores and DCs capabilities dispersed across different markets, and mature logistics systems which are considered to be some of the veins that sustains e-grocery operations (Polacco and Backes, 2018; Lu and Reardon, 2018; Walmart, 2018). Yet, small e-grocery retailers in the townships and rural areas of South Africa contend without the infrastructural and resource muscles observed in the practice of top grocery retailers.

In South Africa, unlike in many other developing countries, townships have inherited designs which had no economic logic and prohibited business activities from the apartheid era. In fact, the majority are still dependent on cities for retail facilities (Thulo, 2015; Philip, 2010). The South African townships are highly characterised by a fragmented logistics network, poverty and a complex spectrum of unstructured street numbers (Shackleton et al., 2018; Schoeman, 2018). Security and crime are rife in townships and the majority of the population relies heavily on cash which places drivers and distributors at high risk of robbery (Agwa-Ejon and Mbohwa, 2015; Blanco and Fransoo, 2013). The inherent apartheid legacy has left most of the population with high economic and income disparities (Oduwole, 2018; Cant, 2017; Thulo, 2015). As such, townships and rural areas consist of poor and rich neighbourhoods (Cant, 2017; Philip, 2010). For example, in Soweto a mixture of rising middle-class and low-income class is observed (Alexander, et al., 2013) whilst Alexandra boosts a huge informal settlement that co-exists next to the most expensive square in Africa, Sandton (Makhubu, 2016). Put simply, the majority of the people in townships and rural areas struggle to make ends meet, rely on social grants (Oduwole, 2018) and data or internet costs are quite high (Calandro et al., 2014; ITU, 2014) making connection to the internet a
luxury outside their bounds. Many townships and rural areas including informal settlements operate without electricity connection (Baptista, 2018), structured phone lines, and have limited water supply, and where available, poor connection and/or supply persists (Hosu et al., 2018). Furthermore, the economic wealth of South Africa is highly centralised to big corporates in cities and urban areas, and tend to exclude participation by small businesses (Philip, 2010). As a consequence, most of the top five grocery e-retailers rarely have a presence in rural areas, and they offer limited presence in townships.

A well-functioning economic and physical infrastructure are necessary to support e-grocery activities, however, these are often lacking in townships and rural areas. The complexities of townships and rural structures in South Africa led Oduwole (2018) to suggest that strategic and structural policy interventions may be the best answer towards bridging the inherited economical gap. However, it is the lack of presence in rural areas and the limited offerings in townships and rural areas of the large retailers that have fuelled mobile innovators to seize the gap in the market. Small grocery e-retailers may play a role in bridging the physical infrastructure gap (and potentially also the economic gap) to consumers by offering a mobile technological intervention that contributes towards poverty alleviation, redressing of inequality and simulate employment.

The role of mobile applications in configuring supply chains
Mobile application technologies have received a great deal of attention in supply chain management, especially in business applications and consumer applications. From a business application perspective, Eng (2006) focussed on mobile applications in enabling location-based service through the use of global positioning system and enabling remote accessibility of company’s database through the combination of radio frequency identifications and short message service database. Shih and Wang (2016) applied a wireless sensor network for cold chain systems. Pan et al. (2013) presents a model for the adoption of mobile supply chain management. Consumer applications studies present, for example, mobile apps for supporting customer integration in the designs of products and manufacturing network (Mourtzis et al., 2016). The increasing application of mobile applications in the supply chain has further advanced wireless food ordering system in restaurants (Mishra et al., 2015; Khairunnisa et al., 2009). Nguyen et al. (2018) acknowledge the role of mobile devices in creating order fulfilment opportunities for customers and retailers.

Another wave of research focussed on the barriers to mobile application diffusion in different segments of the supply chain (Alalwan et al., 2016; Liu et al., 2015; Thi et al., 2016; Lee and Han, 2015). The major concern raised by the latter scholars centres on the initial and operating costs such as data costs necessary for accelerating diffusion (Lee and Han, 2015; Thi et al., 2016). Alalwan et al. (2016) and Liu et al. (2015) point towards data privacy as a major limitation associated with mobile banking and mobile coupon application diffusion, respectively.

Several more studies report on the specific use of mobile tools in the e-grocery supply chain (Cagliano et al., 2015, 2017). Cagliano et al. (2017) developed a system dynamics simulation model to capture and understand the cause and effects of time-dependant relationships enabled by mobile tools. Cagliano et al. (2015) identified reliability and efficiency of the service as crucial drivers for the diffusion of smartphone adoption in the e-grocery supply chain. The findings from the latter scholars offer great insight on how the adoption of mobile tools can enhance e-grocery supply chains. However, not much, if any, is available towards understanding how mobile applications are used to address limited resources and under-developed logistics infrastructures in the distribution of e-groceries, especially in models that extends urban to townships and rural areas.

Given the fact that distribution networks in developing countries are not on par with those of developed worlds, the challenges in e-grocery retail are significant. This is often
exacerbated by the lack of a well-functioning economic and physical infrastructure in townships and rural areas. Given the fact that large grocery e-retailers rarely have a presence in rural areas, or in townships, other solutions are needed that can be adopted in situations with limited resources and under-developed infrastructures. Mobile tools may provide an answer to this and the case-study discussed below will discuss how.

Methodology
A qualitative multiple case-study approach is used in gaining insight into mobile application supported urban-township e-grocery distribution, especially in consideration of the complexity of logistics elements, cost and thin profit-margin challenges that are observed in matured e-grocery markets and urban/city settings. The study received access to 8 case studies from the 13-known pertaining to the emerging population of national urban to township e-grocery operators in South Africa. The suitability of qualitative research in producing rich and in-depth description of the phenomenon is discussed by previous studies (Yin, 2015; Clark and Creswell, 2015). An interview guide was developed based on the elements of logistics with consideration paid to the context of e-grocery operations outlined by Mkansi et al. (2018). An exploration of the eight e-retailers in terms of their logistics elements provided an opportunity to identify diverse and common practices existing between township and urban e-grocery players, in particular their effect on the cost of operation (Ishfaq et al., 2016; Aspray et al., 2013; Asdemir et al., 2009) and profit strategies recognised as a major barrier to entry. At the same time, the method provided an insight into the South African township context. Appendix 2 provides more detail on the sampling strategy.

Findings
Case description
Of the eight-emerging e-grocery operators, four of them are not traditional grocery retailers characterised by stock levels and brick infrastructure such as stores. Two have two DCs where they store and break bulk of the aggregated orders whilst the others only have one DC (see Table I for summaries). Put simply, they manage to use technology to bypass the costs and ownership of some of the logistics elements considered critical in the sustainability and success of leading global e-grocery retailers such as stores and DCs used

<table>
<thead>
<tr>
<th>No. processes</th>
<th>Retailer configured model (Companies: B, C, E and G)</th>
<th>Wholesaler configured model (Companies: D, F and H)</th>
<th>Brand configured model (Company A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Order storage</td>
<td>Competitor's store, i.e. Woolworths, Pick n Pay, Checkers</td>
<td>Distribution centres, kiosks, and bigger spaza shops customers</td>
<td>Distribution centres, and township household garages</td>
</tr>
<tr>
<td>2. Order delivery</td>
<td>Independent drivers, i.e. Uber, Taxify, car owners</td>
<td>Independent drivers, i.e. townships people with cars, and own drivers</td>
<td>Distribution centres, kiosks and bigger spaza shops customers'</td>
</tr>
<tr>
<td>3. Order picking and assembly</td>
<td>Independent personal shoppers, i.e. unemployed youth, students</td>
<td>Independent personal shoppers, i.e. unemployed youth, students</td>
<td>Independent personal shoppers, i.e. unemployed youth, students</td>
</tr>
<tr>
<td>4. Order stock</td>
<td>Competitors stock ambient, chilled, frozen and fresh produce</td>
<td>Competitors stock ambient, and fresh produce that can be stored as ambient, i.e. potatoes</td>
<td>Competitors stock ambient</td>
</tr>
<tr>
<td>5. Order entry and processing</td>
<td>Mobile app, WhatsApp, E-mails</td>
<td>E-grocery mobile app</td>
<td>E-grocery mobile app</td>
</tr>
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</table>

Table I. Summary of case findings

Mobile application
by leading players, i.e. Tesco, Walmart, Carrefour Group and CVS (Mkansi et al., 2018; Pan et al., 2017). When asked about their rationale for the e-grocery app and service, participants offered different motives but commonly emphasised the need for convenience, scalability of their mobile applications, reach to untapped rural and township markets by linking formal and informal markets and the reduction of high unemployment opportunities. Within the rationale for convenience, the participants highlight two unique propositions different from existing large e-grocery retailers. On the one hand, they highlight the customers’ convenience to shop from multiple grocery retailers within a single platform rather than being limited to a single retailers’ platform, and/or having multiple or separate transactions with different retailers. The other convenience is in terms of employment, which creates opportunities for independent shoppers and independent drivers to serve multiple e-grocery retailers at their convenience whilst lifting a heavy weight that comes with permanent employment for the small grocery players. Below we describe the three distribution models. Appendix 3 summarises interview quotes that further illustrate each of the models.

**Mobile application configured e-grocery distribution models**

Although described differently, the eight e-grocery operators’ distribution models are essentially categorised into three: mobile application retailer configured model, mobile application wholesale configured model and mobile application brand manufacture configured model (see Figures 1–3).

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**Figure 1.**
Mobile application retailer configured model

**Figure 2.**
Mobile application wholesale configured model
Mobile application retailer configured model

The mobile application retailer configured model (Figure 1) is the most popular model and used by four small grocery e-retailers. The mobile app streams live e-grocery orders through the app to managers based in a centralised office. The managers extract orders, process and filter them on the basis of the mall’s proximity to the customers’ home. The filtered orders are re-rooted to independent shoppers waiting in malls closest to customers’ location to start picking. The independent shoppers pick from the customers’ preferred grocery retailers such as Pick n Pay, Woolworths, Food Lovers Market or Shoprite and Checkers. As the independent shopper picks and scan orders to the trolley, a tracking feature alerts independent driver of minutes to, or time of, completion and predicts time for groceries to be collected from shoppers who meets the driver at the car park in time for delivery to customers’ homes. At the point of delivery, the customers show the independent driver a code to approve and confirm the accuracy of orders. Put differently, the small e-grocery players indicated they do not have stores or grocery stock but utilise competitors’ bricks and mortar grocery stores and stock placed in malls and other geographical areas nearest to their market segment as fulfilment hubs (see Appendix 3 for quotes).

The orders come from middle-class urban dwellers, office parks, students, single mothers, mothers with small babies and township households. The interesting perspective of mothers participating in online grocery retail is that e-grocery shopping provides much more convenience for women with toddlers. As one executive said:

The insight that we received from mothers is that they do not want to go with their kids to do grocery shopping. So it is better to use our platform to do groceries and we can just deliver.

Within this model, formal and informal partnership exists between the small e-grocery operators and the large grocery retailers. The formal partnership is established under a 5–10 per cent profit share model based on total cost of sales generated by the small grocery e-retailer to the large retailer store, opined as:

We have partnerships with Woolworths, Food Lovers Market and we are in the process of finalising the agreement with Pick n’ Pay as well.... Food Lovers give us a 5-10% commission based on agreed sale volumes.

Amongst those small grocery e-retailers without formal partnership, some appears to have made themselves known to the store managers of the grocery retailers, in which they pick from. However, there is no profit share model on the basis of sales figures generated by the small grocery e-retailers:

We did very much close contact with store managers at Pick and Pay, Woolies and so on. So, before we even started operating there, we introduced ourselves, we got to know the whole management team and how the store works.
For those small grocery e-retailers that bypassed formal partnership and formal introduction, there have been no channel conflicts. Rather, liaison with fast moving consumer goods (FMCG) manufacturers such as Tiger Brands is reported. The FMCG appears to have great interest in the existence of the small grocery retailers as they have become the veins through which unavailability of brands products is communicated. The FMCG’s brand is in competition with retailers’ own brands hence the valued intelligence. The insight on unavailability of brand products appears to have mutual benefits in that whilst FMCG collects information small grocery e-retailers are increasing chances of order accuracy for their customers. Further, small grocery e-retailers earn an affiliated advertising fee for products displayed by FMCGs on their app. The advertising fee complement the 5 per cent service fee and added delivery fee reported by all grocery e-retailers as: “we charge a service fee of about 5% and delivery fees and use the money to pay independent contractors”. The rationale for lack of partnership and formal introduction appears to be perceived fears of prolonged meeting with grocery retailers’ management team and delays to the market (see Appendix 3 for quotes).

Mobile application wholesale configured model
The second popular distribution model is the mobile application wholesale configured model which is utilised by three small grocery e-retailers. Orders are generated by foot agents from a host of B2B and B2C customers. The app aggregates the demand from the foot agent’s mobile interface which is used by the executives to negotiate economies of scale. The bulk purchase is collected from wholesalers by independent drivers. The drivers break the bulk in vans and redistribute to different townships and rural areas. For those small grocery e-retailers with a single DC, if the bulk is too big, drivers deliver to the DC for breaking bulk purposes before redistributing to customers. Where a customer is not available to receive the order, the driver returns it to the kiosk in a specific township location, giving customers an option to collect at their convenience (see Figure 2 and Appendix 3 for quotes).

Orders are generated from household customers (B2C) and business customers (B2B). The B2B customer’s segments include spaza shops, funeral societies, bakeries, chisanyama restaurants, khota bread traders (sipahlo), crèches, office parks and caterers who used products as inputs to their business. The B2C models are house individuals, pensioners, students, mothers and social grant holders for consumption purposes. The B2B groups are key in aggregating weekly demand in the downstream chain as opposed to low order volumes in the B2C segment. Whilst the majority of B2B use the grocery as inputs into their businesses, some of the B2B buy groceries for staff consumption. Together the two market segments assist the e-grocery operators in capturing data, monitoring repeat orders and understanding their loyal and new customers (see Appendix 3 B2B for quote).

The e-grocery operators use customer segments as complementary to the B2B whose customers with high weekly order patterns in townships. The insight from the e-grocery retailers is that the economic status of the B2C township and rural groups means they can only buy in volumes on a fortnightly and monthly basis. The rest of the time is mainly top-up grocery purchases (see Appendix 3 for B2C quote).

Similar to the mobile application retailer configured model, the fulfilment centres of the mobile app wholesale configured e-grocery operators are mainly their competitors (traditional grocery retailers stores such as Pick n Pay, Woolworths, Shoprite Checkers etc., fresh produce markets and wholesalers/discounters like Makro) situated in the malls or geographical areas nearest to their market base segments. Of particular interest was how the mobile application wholesale configured model yield profit in an industry characterised by thin profit margins (Asdemir et al., 2009). The strategies outlined by the e-grocery retail include mark up from economies of scale strategy induced by aggregating demand at the downstream chain (see Appendix 3 for economies of scale quote).
Mobile application configured model

The mobile application configured brand manufacturer model (Figure 3) represents a unique and niche approach only utilised by one e-grocery operator. The model generates demand of specific brands in the base of the pyramid (rural and township markets B2B and B2C markets). Foot agents sign up spazas and customers for specific brands. The mobile app pulls demand data from various townships agents' mobile repositories which are shared with participating brand manufacturers. Packaged order information is communicated through the manufacturer-spaza application/driver mobile application interface, who collects and delivers bulk orders to either a central DC, independent newspaper distributors or household garages in townships. The volume and location of customers dictates the direction of the delivery. The DC and partnering garage household owners break bulk which is picked by independent drivers in townships straight to spazas and other customers.

The executives behind this model are of an opinion that, in store, brands' visibility is impaired by competition. The executives' view corroborates an earlier insight into FMCGs interest in small e-grocery retailers' communication of unavailable products. Big Data residing with the mobile application brand models is found to be the oil that fuels the FMCGs interest and helps them to gather intelligence necessary for analysing the value chain. The executive opined that: “We also have the technology and the data behind us which offer a much better information gathering system than the traditional routine market”. Against such a backdrop, the brand manufacturer configured model offers FMCGs and brand manufacturers a direct link to the base of the pyramid in particular, informal markets where brands have minimal visibility and awareness. The link between formal and informal market bring with it low cost per unit due to the removal of the middle man (i.e. wholesalers and retailers) in the upstream chain. The low cost is what gives the brand model a competitive advantage against other online and offline grocery stores and wholesalers (see Appendix 3 for quote).

Of particular interest is the model’s profit strategy; unlike the other grocery retailers where margins are generated from the downstream chain, the upstream chain sustains the model and carries much of the margins' weight. The rationale put forward is that brand manufacturers pay for the greater penetration of their products and awareness of their brand directly to customers. The major emphasis is on driving the cost down upstream, which influences competitive demand from the downstream chain (see Appendix 3 for quote).

Logistics process management in urban-township e-grocery distribution

The management of logistics elements is considered to be highly complex and to hold the key to successful retailing (Rushton et al., 2014; Reiner et al., 2013). For this reason, there is a need to explore how the emerging grocery operators manage these elements (see Appendix 3 for quotes).

Order entry and processing (communication)

Apart from the mobile application configured models, social media applications such as Facebook and WhatsApp are some of the order processing methods used. Companies A, B, E, F and H are teams of mobile application innovators who pushed their technology (mobile application) to the market through an e-grocery business model. Company D uses a website and is part of a wholesale company that decided to offer e-groceries through the website. Companies’ C and G saw WhatsApp and e-mails as complimentary platforms for management of order entry necessary to complement the website. The chief executive officers (CEOs) started experimenting with order processing on social media platforms and added a complimentary website with the growth of the business. “We used WhatsApp and e-mails for proof of concept and to manage our orders. With that concept given we
built our website with information on how customers order. For the township and rural market, the e-grocery players appear to have mastered the needs of their society such as convenience, time saving, demand patterns, distance to retail facilities and unemployment and their complementary challenges such as digital illiteracy, cost of data, and ailing technological and road infrastructure. The needs and challenges are factored in the design of their mobile application technologies and evident in their clear strategy of how the different levels of e-grocery logistic elements connects and interact within the physical fabric of urban, townships and rural areas. As such, the companies deploy young people to collect and process orders on behalf of the technological challenged townships and rural market.

Order stock (inventory)
Only two of the e-grocery operators offer all categories of grocery stock including chilled and frozen. “We do everything from veggies to meat; meat, frozen goods, we do everything including alcohol and beverages. So we do almost the whole grocery line; we don’t limit our customers”. The majority are only offering ambient products due to the legal requirements and the cold chain management associated with e-groceries. Three companies limit their fresh produce offering to those that can be stored ambient.

Order storage (storage)
There are seven storage approaches used for chilled and frozen products by the e-grocery operators: cooler bags, grocery retailers’ partners refrigerated storage, kiosk, time frame strategy, partnership with spaza customers with high volume orders and courier partner’s DC. Five e-grocery operators have no DCs, stores and refrigerated storage. Amongst those that provide chilled and frozen products, one uses cooler bags from the stores to the customers’ house. However, in transit of groceries from retailers to customers, some grocery operators use cooler packs for chilled and frozen products. The small e-grocery retailer that has a formal partnership with the competitor appears to benefit from safety standards guidance from Woolworths and use of their fridges to keep the cooler bags at a desired temperature. However, one of the e-grocery operators who supplies both urban and townships in use of the mobile application wholesale configured model has a network of kiosks for breaking bulk and returns purposes.

The three e-grocery operators using the wholesale distribution model have different DC models. The one in partnership with a courier company has one DC and uses their courier delivery partner’s DC. The verbatim statement of the executive is:

We have one distribution centre. When the orders are prepared the couriers pick it up and they take it to their distribution centre and they distribute from there. So basically, we use outbound logistics.

The one in partnership with bigger townships customers has two DCs; one in Soweto and Alexandra, respectively. For market penetration, the township operator uses the storage of their biggest company as a strategic storage for breaking bulk and penetration to the market. In Durban, one company entered into partnership with township household owners offering their garage as a storage place for dropping stock and breaking bulk, thus creating micro-employment opportunities.

An interesting insight was that one e-grocery operator plans time frames to manage the in-transit storage of chilled and frozen products (rather than cooler bags and boxes):

We ask the customer when to deliver i.e. if the customer wants his/her order to be delivered at 3pm, we usually buy the groceries in the supermarkets at the shopping mall that is nearest to his/her house nearest to the desired time. That is how we make sure that the ice cream gets there while it is still intact.
Order picking and assembly (unitisation and packaging)
The majority of the companies (seven) utilise the service of independent personal shopper contractors; the other two utilise drivers and their own in-house personal shoppers or do it themselves. The fact that unemployment is high in South Africa and big retailers are far from townships and rural areas give small e-grocery operators certain advantages which townships and rural areas reinforce. Put simply, e-grocery operators’ benefit from high unemployment, spatial inequality, lack of digital infrastructure and the existence of businesses with high percentages of technological challenges (see Table II and quotations below). The emphasis by one of the executives is:

We try to get women and unemployed youth, that is always our key. Then we position ourselves as social entrepreneurs. We do look at getting young guys in and, if not young guys, women.

The small businesses that handle most of their operations outsource on an \textit{ad hoc} basis depending mainly on volume.

Order delivery (transportation)
The majority of the companies (five) use mobile applications to mobilise the service of independent driver contractors including taxi associations, Uber, Taxify and Delivaroo drivers: “We have drivers who are independent contractors including, Uber, and Taxify”.

The other two grocery operators use their own personal bakkies (also known as small pick-up trucks), scooters and bicycles: “We are using medium and small size bakkies such as Bantam size versus a 3ton bakkie”. According to the executive, order volumes influence the mode and size of transport to use.

The two e-grocery operators in partnership with a courier company and an independent newspaper network benefit from the partner’s logistics network assets and capabilities, respectively. The courier delivers throughout South Africa which gives the small e-grocery retailer a greater penetration to the market.

The e-grocery retailer in partnership with taxi association demonstrates a wave of transport alliance that is usually observed in airlines. The difference in this case is that the alliance is between a passenger vehicle and an e-grocery provider. The e-grocery retailers have realised

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<tr>
<th>Order picking and assembly aspect</th>
<th>Company A</th>
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<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
<th>Company G</th>
<th>Company H</th>
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<td>Independent personal shopper contractors</td>
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<td>Unemployed youth</td>
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<td>Drivers</td>
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<td>CEOs DIY or outsource with bigger volumes</td>
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<td>Wholesale picks build orders</td>
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\textbf{Table II.} Order picking and assembly
that taxis are rarely busy during off-peak hours and offered them a profit-sharing proposal that is beneficial for both parties. One small e-grocery retailer argued that taxi drivers provide some sense of security from possible hijacks because nobody will hijack people.

In the absence of structured road and house numbers, which are critical for on time and right place delivery, mobile technology and geographical information systems become the saving grace. An interesting insight was how two of the e-grocery operators use the mobile app to capture coordinates to deal with the issue of unstructured streets and roads in townships for the purpose of deliveries. When the personal shopper takes an order in the township, s/he captures the coordinates which is later used by the driver to ensure deliveries (Table III).

Three of the e-grocery operators in urban areas and townships offer deliveries for free: “We are absorbing the cost of the courier charge but we will be adding a courier charge onto our products in future”. The e-grocery operators’ free delivery is made possible by discounts received from bulk purchases. The other e-grocery retailers charge a percentage for deliveries based on distance and time of delivery (peak or off-peak): “We charge a certain delivery fee which, at the moment, varies based on the time of the day”. The other majority of grocery e-retailers charge a percentage based on the total groceries purchased. The example of percentage charged is: “12% for groceries purchases of R700 to R15, and R60 for purchases in the scale of R3000”. An attended delivery method is popular for all eight e-grocery operators. However, one e-grocery operator offers a pick-up at their nearest kiosk for unavailable customers whilst the others allow customers to recommend their preferred place, especially corporate clients: “If someone is not present first time, we return for the

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<th>Order delivery transportation aspect</th>
<th>Company A</th>
<th>Company B</th>
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<td>Own vans and bikes used by hired drivers</td>
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<td>Independent driver contractors</td>
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<td>Partnership with courier company</td>
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<td>CEO owns vans or outsource</td>
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<td>Wholesaler delivers to DC for bulk orders</td>
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<td>Partnership with taxi associations</td>
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<td>Independent news network</td>
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Table III. Order delivery transportation
second time and, if unavailable, the customer picks up at the nearest kiosk. Other e-grocer retailers offer customers an option for a preferred delivery place within a radius: “The person who lives alone and with no helper or someone to pick-up the groceries tells us where to deliver or we deliver at the time when s/he arrives from work”. In urban areas, a 1-h delivery time slot is in use and the delivery times are aligned to competitors’ store operating times in which they pick groceries:

We use the operating times of the store; the store opens at 8am and closes at 8pm. We are able to deliver within an hour. About 60% of our customers are actually within a 2km radius of that store.

A one-time password system is used for security and ensuring delivery of correct orders. Two of the e-grocery operators use a code system sent to customers’ mobile phones: “At delivery, a customer gives the driver a one-time passcode. That code then tells the driver what must be delivered”. Whilst urban e-grocery operators offer daily deliveries, one of the township operators only delivers three days a week in an effort to aggregate demand necessary for free deliveries. The other township e-grocery operator offers a range of 24–48 h.

**Discussion**

This study aimed to explore how small and medium e-grocery businesses use innovations to bridge the supply chain challenge of limited resources and under-developed logistics infrastructure. The conceptual framework depicted in Figure 4 brings together the major findings of mobile application supported urban-township e-grocery retail (1), associated e-grocery distribution models (2) and logistics processes (3) discussed in the previous section. It portrays a holistic canvass that provides insight into factors fuelling small
e-grocery retail resurgence which is considered a major barrier to entry (Ishfaq et al., 2016; Aspray et al., 2013). The supply chain innovations (4) are divided into three: for addressing under resources, under-logistics infrastructure, and those that fuel retail practices as discussed in depth in the subsequent sections.

Supply chain innovations for addressing resourcing issues

The study revealed a number of supply chain innovation for addressing resourcing issues, which are all integrated through the use of mobile applications across the different parts of the logistics process from order stock, order picking, order entry, order delivery, to order stock. At a basic fulfillment level, small e-grocery players can make use of competitors’ assets to stock and pick e-groceries, activities which are coordinated through the use of mobile applications. This involves the use competitors’ grocery assets, such as stock and infrastructure (stores), to advance access into the e-grocery business industry. Through this strategy, small e-grocers eliminate physical infrastructure (such as stores/DCs), inventory levels and its associated management needs (packing, replenishment and ordering), storage and its maintenance needs (cold storage, security, etc.). Put simply, their distribution strategy allows them to sweat their competitors’ grocery stores assets and wholesales.

Unlike traditional grocery retailers, this strategy allows them to push any retailer brand as requested by customers and thus they have no loyalty to any grocery retailer brand. They are able to offer customers the flexibility to shop from the grocery retailer of choice.

Our findings reveal profit-sharing models with big retailers based on sales percentages. E-grocery revenue model innovation is observed from the partnership between small grocery e-retailers and big grocery retailers, where big grocery retailers offer small e-grocers 5–10 per cent profit share on the basis of sales generated. In this regard, the mobile app serves as a data warehouse that aggregate sales and the necessary profit share between small e-grocery player and the participating grocery retailer. Moreover, the mobile application provides the base for real-time Big Data analytics regarding the consumption patterns and product demand variations of urban vs township and rural customers, information which is necessary to strengthen the e-grocery fulfillment process. Other offline grocery retailers and shopping centres can leverage on the model to increase store and mall sales and reduce waste of fresh produce and other chilled products. Such a strategy is more important in an environment of high fresh and chilled products waste and provides offline grocery retailers the capacity to intervene on food waste and react to uncertain competition.

For order entry, the small e-grocery players use digital platforms such as mobile application to aggregate demand from the downstream chain for economies of scale in the upstream chain. Their mobile application displays a catalogue of groceries, aggregates demand and facilitates communication between personal shoppers, drivers and the management towards achieving seamless retail. These findings extend the literature on the role of mobile applications in supporting supply chains and customer applications (Mishra et al., 2015; Pan et al., 2013). The apps transcend e-grocery barriers and enables small businesses with limited resources to leverage e-grocery market opportunities that are unimaginable in townships and rural areas.

To facilitate greater penetration into the market, the small e-grocery players forged a partnership with townships spazas as holders of stock and mini-DCs. The partnership and activities across the township spazas and household channel members are reinforced by the mobile application, with the interface designed specifically to easily facilitate the roles played by each partner. The partnership with household owners in townships and rural areas offers insight into a strategic extension of downstream chain to include household owners in between retailers and customers. The innovative e-grocer distribution strategy helps small e-grocers to avert the high cost of DCs whilst offering financial benefits in townships.
Lastly, an interesting brand distribution model offers a direct route of groceries and other products to market, especially to the base of the pyramid. The approach serves as an alternative strategy in which brand owners can gain control over retailers, gather relevant data and interact better with their customers. Most importantly, it opens up a direct route to market for start-ups, FMCGs and small farmers subject to consignment conditions imposed by retailers. Furthermore, the brand distribution model amplifies the ubiquitous role of mobile applications in reaching out to the base of the pyramid, especially those that are mainly isolated from the digital revolutions.

**Innovations for under-developed logistics infrastructure**

The findings of this study reveal three innovations used to address under-developed logistics infrastructure. First, the use of GPS coordinates at point of order to capture accurate locations in unstructured townships which is later used for delivery of groceries. The strategy of capturing delivery location coordinates through mobile applications during order processing offers an innovative demand aggregation strategy that simultaneously address issues of unstructured roads and unstructured street numbers necessary for delivery of e-groceries.

Second, a partnership with distributors of products with high daily demand for deliveries, e.g., newspaper and passenger transport during off-peak hours. The joint-distribution of products with high daily demand and high penetration to the geographical market paves the way for better utilisation of truck space and cost reduction associated with delivery of products. Other businesses with high daily demand in urban, city and township areas such as bakeries might find the emerging distribution patterns as a “light bulb” moment for cost reduction and maximum utilisation of truck space. Most importantly, the partnership lights a bulb to a new wave of live traffic monitoring innovations that can help facilitate and coordinate the flow of goods across the supply chain.

Third, the deployment of women and unemployed youth for order entry is specifically used to address the lack of ICT infrastructure, expensive data and the existence of digitally challenged market groups. The mobile applications of the foot agents are loaded with internet data and they capture the orders on behalf of the digitally challenged groups. In particular, it reveals a pull strategy that gives small e-grocery players a bargaining position in the upstream chain and a base for establishing relationships with brands manufacturers. The judicial mix of socio-economic issues with the digital advantages of mobile applications serves as evidence of how township and rural e-grocery players develop and implement innovative business models that seek to uplift the well-being of socially disadvantaged and to redress social problems of inequality and marginalised groups.

**Factors fuelling small e-grocery retail in South Africa**

There are two identified factors that can better explain the resurgence of small e-grocery retailers in townships and rural areas. On the one hand, the existence of technologically challenged informal and formal traders such as stockfela societies, spaza shops, crèches, social grants holders, funeral paler and churches reveals an untapped market that exists in townships and rural areas. Parallel to the digitally challenged groups is the absence of big grocery retailers in rural and townships areas which equally opened a market for small e-grocery players. At best, the target of townships and rural areas reveal the process in which small e-grocery retailers with fewer resources and operating in under-developed logistical infrastructure disrupt the monopolised grocery market in South Africa through the use of mobile applications.

On the other hand, the involvement of students, women and unemployed youth as independent drivers and shoppers reveals a unique context where unemployment, spatial inequality and under-developed infrastructure acts as a stimulus that creates fertile grounds
Conclusion

This study presents supply chain innovations used to address under-resource and under-developed logistics infrastructure in urban-township and rural e-grocery distribution context. Most importantly, it reveals how mobile applications have converged to nourish the existence of small business and e-grocery supply chain whilst addressing some of the social and economic challenges. Our findings reveal how mobile applications in the context of urban, township and rural areas, serve as the rite of passage through which the foundations of e-grocery operations can be realised. The findings, therefore, have implications on the way e-grocery distribution models develop in different contexts and, possibly, how it can develop in other economies such as the BRICS nations with similar contextual patterns.

We introduced three mobile application innovation models: the mobile application retailer configured model, the mobile application wholesale configured model and the mobile application brand/FMCG configured model. The models are weaved with a set of complimentary innovative revenue and business models. The study also identified three categories of innovations that may help e-grocery retailers flourish in rural distribution and urban township areas: innovations to address resource issues, for developing infrastructure and innovations that help e-retailers in small e-grocery retail in developing economies. An interesting insight arising from the study is how the mobile digital platform enabled strategies that allowed emerging operators to exploit competitors’ resources. In this sense, competitors’ grocery stores serve as crucial conduit through which the relations between leading grocery retailers and small e-grocery retailers are articulated. Small grocery e-retailers are becoming complementary partners that extend major grocery retailers’ channels to the online channel. Future research can explore other areas of business where these strategies are possible without ensuing conflicts between channel players.

It further offers a perspective of how technology is deployed in rapidly aggregating real-time demand and supply in developing economies with under-developed logistical infrastructure, whilst empowering informal and formal small and medium e-grocery retailers with limited resources in developing economies. Despite the limitations imposed by townships and rural areas, such as expensive data, unstructured road systems, immature logistics infrastructure and under-developed IT infrastructure, small e-grocers have innovatively devised means of deploying foot agents to aggregate demand on their mobile applications which gives them a strong bargaining position in the upstream chain. The innovative strategy drew interest of malls, competitors and FMCG companies. Future studies can draw contextual effects such as digital illiteracy, unemployment and innovation as possible dependent variables for explaining innovation resurgence and/or adoption drivers and the connection between urban, township and rural supply chains.

In practice, the mobile application configured e-retail model can be easily replicated in both the developed and developing world and the mobile application wholesale and brand models can be replicated in economies with high unemployment and digitally challenged communities for micro-jobs and market penetration. The conditions that underpin the three models offer future research an opportunity to explore potential transferability to other geographical context and product offerings. The involvement of township household owners, and spaza shops in the last mile offers ways in which most redundant buildings can be utilised to e-supply chain. Policy makers can build on the approach for any redundant buildings across the country.
Whilst the study’s findings paint a canvass of alternative e-grocery operations, it is acknowledged, however, that the small sample size of eight e-grocery players and its specific focus on small businesses in South Africa may not always be transferable to other service contexts and geographies. This calls for extension of this study to other geographies and retailers. Nevertheless, such distribution insight emphasises the importance of contextual relevance of township to rural e-grocery operations vis-à-vis urban e-grocery perspectives. Policy makers can use the insight to model necessary support packages that might fuel SMEs’ growth, innovation and inclusion for the benefits of the economy at large.

References


Further reading


**Appendix 1. Grocery retail in South Africa**

In South Africa, the grocery industry is predominantly polarised by the top five major grocery retailers, namely: Shoprite, Pick n Pay, Massmart Holdings, Spar Group and Woolworths (Ntloedibe and Geller, 2017). The five leading grocery retailers have footprints beyond the borders of South Africa with much of their presence evident in the Sub-Saharan Africa, known as the Southern African Development Community (SADC region). Within this top five, only three of the major grocery retailers (Woolworths, Pick n Pay and Spar) are currently offering the online option to a limited market, mostly to the suburban areas of Gauteng and the Western Cape Province (WHL, 2018a, b; Pick n Pay, 2018; Mysuperspar, 2018). Pick n Pay’s online grocery platform offers a 1-h delivery time slot and uses dedicated picking warehouses to satisfy the demand in Gauteng and the Western Cape. The company uses both website and mobile application to process online orders (Pick n Pay, 2018). Woolworths uses a selection of stores and a dedicated “dark store” to fulfil online orders, known as a hybrid model (WHL, 2018b). Spar has a website for specials, and offers a limited online grocery delivery through msuperspar.co.za to certain suburbs of South Africa’s capital city (Pretoria): Monument Park, and Monument Park extensions (Waterkloof Heights, Waterkloof Ridge, Sterrewag and Erasmusrand) Mysuperspar (2018).

More recently, however, a wave of emerging e-grocery operators with no offline presence appears to have changed the landscape of e-grocery retail in South Africa. There are 13 micro-e-grocery players: Spazapp, GrocerEase, Y-shop, Buy Grocery Online, Zulzi, Vuleka, Smartsentials, Onecart, Sisonke Africa, StockUp, Washesa, Wumdrop and Zanel groceries, that are offering e-groceries to urban, township and rural markets. These small e-grocery players, just like many other small businesses, have very little support, if any, in terms of marketing, limited financial resources and DCs, no stores, immature logistics, bargaining powers for economies of scale and warehouses that are typically at the disposal of large e-grocery retailers. However, there is a mismatch when the top ten offline grocery retailers are compared to their online counterparts given that they operate in the same geographical...
locations. Similar to global market developments (cf. Mkansi et al., 2018), the South African e-grocery market is not dominated by the traditional top grocery retailers but rather by the new online grocery retailers. The challenges for these e-grocery retailers are considerable, especially considering the contextual differences (i.e. urban vs township and rural contexts), and the infrastructural muscle between big organisations and small businesses (i.e. stores, DC and logistics capabilities). Pick n Pay and Woolworths use hybrid distribution models (the use of retailers’ own stores and DCs assets) (WHL, 2018a, b; Pick n Pay, 2018). Spar uses a piggyback distribution model which is picking from the existing chain of the stores (Mysuperspar, 2018).

Appendix 2. Sampling
The study received access to eight case studies from the 13-known pertaining to the emerging population of national urban to township e-grocery operators in South Africa. The number of case studies selected is in line with the recommendation of four to ten cases recommended by Eisenhardt (1989). Whilst the maximum number of the township grocery e-retailers’ cases was desired, the efforts were hampered by limited accessibility to the 13 small e-grocery retailers. The fears led to one e-grocery CEO’s withdrawal, which left eight case-study participants. In particular, CEOs of the township e-grocery operators were purposively selected as they are the master minds behind the distribution strategies and, in most cases, they are in charge of the entire operation as observed in the practice of many small and medium enterprises. Put simply, a purposive homogeneous sampling was used to select cases and participants on the basis of their e-grocery retail to townships and urban precinct, positions of the participant and technology innovation-based characteristics different from the traditional and big grocery retailers such as Woolworths, Pick n Pay, Spar and Shoprite Checkers. All case participants in this study, Spazzap (CEO), Grocerease (COO), Y-shop (CEO), Buy Grocery Online (CEO) (buygroceryonline.co.za), Zulzi (CEO), Vuleka (CEO), Smartentials (CEO) and Sisonke Africa (CEO), gave consent for their names to be revealed as samples for awareness of their good practice and existence. However, in reporting of findings, pseudonyms are used to maintain their anonymity when it comes to details of the practices applied. Spazzap has been operating for three years under the stewardship of two senior executives and a team of 15 employees. Smart essentials have been operating for two years under two senior managers, however, extra staff are recruited on an ad hoc basis to reflect demand. Grocerease is under the management of three permanent executives and relies on independent contractors to support different e-grocery logistics elements. It has been under operation for two years. Zulzi have two senior managers, and 50 permanent shoppers, and maintains a consistent relationship with 100 ad hoc independent shoppers. Y-Shop is one year old and operates an e-grocery service under the stewardship of three executives. Sisonke Africa have one CEO and eight employees, and Vuleka is under the management of two senior executives and two permanent employees. Both Sisonke Africa and Vuleka are two years old. Buy Grocery Online is under the management of one executive and have ten permanent employees. It has been delivering e-groceries for less than a year. They all represent contrast in terms of their geographical retail and e-grocery distribution models (Table A1).

Interviews
Semi-structured interviews were held with eight CEOs of the e-grocery operators. The underlying theme of the semi-structured interview was guided by the fundamental elements of logistics germane to e-grocery retail such as order storage (storage and facilities), order entry and processing (communication), order stock (inventory), order delivery (transportation) and order picking and assembly (unitisation and packaging) (Mkansi et al., 2018). The latter logistics elements are considered the central backbone underlying the key success and competitiveness of many industries (Rushton et al., 2014; Hubner et al., 2016). The geographical distance and busy schedule of the eight CEOs favoured a telephone interview strategy whilst a face-to-face interview was held with one of the CEOs who was freely available. The interviews were recorded, with the verbal consent of the participants, on the desktop’s voice recorder system and lasted for the durations of 38 min (for two participants), 41 min (two participants), 33 min (two participants), and 1 h 15 min–1 h 25 min (two of the participants). An outline and purpose of the study was supplied to all participants prior to the interview. Interviews were transcribed and e-mailed to participants to confirm accurate recording and clarification of unclear recording where necessary.
<table>
<thead>
<tr>
<th>E-grocery operator</th>
<th>Geographical coverage</th>
<th>CEO or COO</th>
<th>0–3 years SME</th>
<th>3–5 years SME</th>
<th>Township operators</th>
<th>Urban operator</th>
<th>Innovator teams</th>
<th>0–9 employees (micro)</th>
<th>10–50 employees (small)</th>
<th>50–250 employees (medium)</th>
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<tbody>
<tr>
<td>Spuzapp</td>
<td>South Africa: KZN, Gauteng (Alexandra, Soweto, Tembisa, Joburg, Pretoria), Eastern Cape (Umtata), Namibia, Botswana, Swaziland, and Zimbabwe</td>
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<tr>
<td>GrocerEase</td>
<td>Johannesburg (Sandton)</td>
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<tr>
<td>Y-shop</td>
<td>Joburg North and South, Midrand, Pretoria, mostly country estates, Soweto and Alexandra</td>
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<tr>
<td>Buy Grocery Online</td>
<td>National – South Africa (including Mamelodi and Ga-Rankuwa)</td>
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<tr>
<td>Zulzi</td>
<td>Gauteng (Joburg North, Rosebank, Sandton, Morningside, Greenstone); Western Cape (Cape Town, North Cliff, Croydon, Southern suburbs)</td>
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<tr>
<td>Vuleka</td>
<td>Soweto, Tembisa and Alexandra</td>
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<tr>
<td>Smartsentials</td>
<td>Soweto and Tembisa (Tembisa cancelled because of logistics issues)</td>
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<td>Sisonke Africa</td>
<td>Gauteng province: Mamelodi, Atteridgeville</td>
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Table AI. Sampling profile
**Data analysis**

Data were analysed using Atlas Ti. The first step in Atlas Ti involves open coding where thoughts, ideas, meaning and concepts relevant to the study are identified within the unstructured data and classified into keywords or phrases (micro-codes) given by the participants. This particular approach is advised by Babbie (2013) who emphasises that open coding is used as a starting point and that failure to open up the transcripts compromises the analysis and communication that follows the research. The micro-codes are reapplied whenever a similar description is observed in other transcripts in an effort to reduce redundancy and maintain consistency in accordance with the guidance of Braun and Clarke (2012). All micro-codes were later linked into themes from the literature (Saldana, 2015) which, in this study, are the logistics elements germane to e-grocery retail and serve as a master code function for the study within Atlas Ti. The practice of linking micro-codes from primary data to literature themes (secondary data) is rooted in thematic analysis and extensively discussed by Braun and Clarke (2012). The trustworthiness and transferability of the study involves some of the approach outlined by previous scholars (Yin, 2015; Polit and Beck, 2012) of providing background description of the research context before the interview, outline of methodology to the participants and the preservation of transcripts. The transcripts were also shared with e-grocery operators after the interview session and are outlined in this paper. The audio records and transcripts of the eight e-grocery operators are some of the practice and evidence considered appropriate and relevant for convergence and support of the constructs discussed by Yin (2015) and Rossman and Rallis (2011).

**Appendix 3. Quotes from retailers**

This appendix contains the quotes from retailers that illustrate the concepts in the main text.

**Mobile application retailer configured model**

An interviewee on the mobile application retailer configured model:

We built a mobile App that is available on both the Play store and the Apple store and that seems to be the platform we are using to manage everything, and we sort it all in-house. It takes only three of us and at the moment the idea is to connect customers with their nearby retailers. We provide the service for customers to get their goods from Pick and Pay, Woollies, Dischem and every other retailer on-board. The stores front, effectively come through our App, and customers have a choice where they can place three orders from multiple stores at once. And we have personal shoppers that can shop on behalf of the customers, and then independent driver delivers to customers.

An interviewee on the relevance of informal partnership:

We do not have any formal partnerships right now, but we shop without the concern of this big supermarket. We do not see any need to involve them in our circle for now because it is just going to delay us to the market; it is going to be meeting after meeting and take 2 to 3 years to get sorted. There are lots of distribution points in Johannesburg, so we do not want any extra costs of distribution warehouses. We use existing retail points as our warehouses; that is how we have built our model. In townships, we use the township shopping malls such as Pick n Pay, Shoprite, and Woollies in Soweto. So all the big retailers are already there and that is where we go and buy for our customers I think the advantage for us is more on the consumable companies that advertise on our mobile application and want to partner with us. The biggest challenge for the consumable companies at the moment is that the retailers are actually making all the products that compete with them you know.

**Mobile application wholesale configured model**

An interviewee on the mobile application wholesale configured model:

We have an aggregation platform but we are currently developing version 2 so basically the app aggregates small orders from different spaza shops. Spaza shops are like kiosks in Nigeria. We call them spaza shops, tuck shops, a small mini convenience shop. So, we aggregate their purchases and then we create one bulk purchase. And with that bulk purchase we are able to negotiate discounts.
If we negotiate, let's say 10% discount, we put 4 to 6 percent and give our customers a 4% discount on the goods that they currently ordered at a wholesale level.

B2B: Your business customers are businesses that use food ingredients, that is, groceries as inputs in their business so your bakeries use flour and sugar. Your shisanyama use maize meal, tin food and a whole bunch of things. You have amagwinya (translates to fat cakes), using flour, oil, and sugar daily. Others are fish and chips providers and kotha providers that use food as inputs. A very big customer are caterers who use fresh produce in their cooking for events and crèches that feed kids every day. We have churches and any business or institution. In Dayveton we have picked up undertakers, so he sells policies, but we put together a combo for him for R500. He used to give people R500 cash when they came to claim a policy, now they get R500 combos. There is a nice pack of food and that pack has gone as far as Newcastle... they buy 25kg, 50kg bags of flour in a 1 pallet.

B2C: You then have individuals and households who are buying for home consumption. Their buying quantities are not that high. You have your social grant receipts, whose spend maybe R300 to R400 on groceries, you have middle income households that will spend up to a R1000 on groceries, but they would typically buy at the middle of the month end. They will also buy sometimes whenever they have events at home, for example, a wedding at home, a birthday party, or there is something going on. So those are the two.

Economies of scale strategy: We have gone out and looked for products at the best prices possible. We go to a lot of mass discounters and independent wholesalers who are able to offer prices at up to 20% cheaper than your normal retails and so we buy products there. What that allows us to do is to add a certain markup to that price and that is the price at which we sell. And what happens is we get more and more scale and, effectively we are able to increase that margin to cover the cost of logistics and delivery. Fresh produce is very interesting; we buy it at the Tswhane market or the Joburg market. Every day the price is different and the guys that sell the fresh produce market can give you a discount on the spot. So, you might see a sign that say potatoes (10kg bag), it might be written there R38, but you go and tell the guy you want 20 bags and literally the guy can take R4 off right there. On Wednesdays the prices start to drop because they need to clear it out. And I mean if you are getting R4 off at something that started at R38 that is more than 10%. So it's all about the volume, how much you buy.

Mobile application brand/FMCG configured model

Our business was always around creating a link between the informal and formal market and by that we knew that brands and FMCG companies wanted to get more, let's call it hands on or closer to that small market. We really focused on how to create that bridge between informal and formal markets. At its core, we approach FMCG brands, and look at how we can start almost cutting out a lot of that root to market so that there is a direct link between them and the spaza shop and we do that through technology. The type of technology in our world is mainly smart phone based and over the last year that has proved very resourceful in terms of having smart phone devices in South Africa but also across Africa.

Our relationships is with the brands and not with the buying stock. We are not wholesaler; we do not buy stock, make a markup and sell it. We are very much a marketing tool and for brands. We believe that brands should be the one paying for the bill and not shops that already have our markets. The cheaper we can make it for our spaza shops, the better for us and so we enable that relationship by creating a better route to market. Brands pay up because we have a much more direct route to those smaller stores. That is where the demand comes from and therefore, we get our payment through them rather than through the stores. The informal market and that branding awareness is what the brands pay us to drive.

Logistics process management in urban-township e-grocery distribution

Order entry and processing (communication)

We have developed a mobile application through which the groceries can be ordered. Now, instead of requiring people in townships to download our applications on the phones, we find young people
from the township whom we train and upskill. We deploy them into the township to go and act as agents. Basically, they find customers, tell them about our business and learn about the business and effectively sell products to them. When the customer places their orders, the orders are captured onto the app. We see all of the orders that come in the back office and we can then handle all the fulfilment. So, then we aggregate the orders, go out and buy and we deliver directly to the customer for no additional charge. A challenge is that people in the township are struggling with data and also understanding how to use internet platform. But now, how we go about it is that mostly we meet with people at market and others prefer talking to us on WhatsApp. And then they prefer us making the orders for them and not them using the platform.

Order stock (inventory)
So right now, we do ambient, we do fresh produce that can be stored in ambient. So, potatoes, onions and butternut. We do not do frozen or chilled, not at all. We do not partly because of our supply chain constraints because the moment you start transporting and supplying frozen food, for example, the quality requirements mean that you need to maintain the temperature across the value chain and it needs to be traceable.

Order storage (storage)
Formal guidance: I was talking about the standard as an example, so with the frozen stuff like ice cream we have to keep it at zero degrees. We have some bags used by our shoppers that are kept in the stores’ deep freezers. Whenever there is an order that requires i.e. ice cream, the shoppers put the ice cream into those bags. Woolies have specifications in terms of how they want their frozen product to be delivered.

Kiosk cross docking: We do not store or hold stock for a long period of time. We pick it up and drop it to customers. Storage as a whole is still a no-no. Right now, we break bulk either in the bakkie or at some of our locations; we call them kiosk. We are either breaking it because it needs to go in separate directions or because the quantities they need to flow out are just too small to go in such a big vehicle. So, it needs to go smaller with things like bicycle.

Partners with spaza shop customers: We look for big spaza shops and, at the moment, we have one guy that buys R32000 worth of stock every week. We approach a person like that and say listen, we will deliver the stock to you and then we will even give you buffer stock for you to help us supply to people around you. We sort of put them in a business where they become like a mini DC for us, but also help us to save costs. Instead of going daily to the same person that orders low volumes, they can actually get the stock from a micro DC. He uses the app to order and sends that order to us. We get it electronically and he even makes a deposit into the account. He is pushing more volumes and we are saving. So somehow, we need to give him a discount that also makes sense in terms of absorbing some of his running costs.

Time frame strategy: We work with time frame; we know when to deliver to customer x. We ask the customer when to deliver i.e. if the customer wants his/her order to be delivered at 3pm, we usually buy the groceries in the supermarkets at the shopping mall that is nearest to his/her house nearest to the desired time. That is how we make sure that the ice cream gets there while it is still intact. Once we purchase we get there as soon as possible whilst the goods are still intact.

Partnership with households: We work with independent distributors so instead of having our own network of stores and trucks we use other people’s warehousing and distribute stock through that model. In Durban central we put smaller hubs into different townships areas and that creates the network. We create better hedge market there and so stock comes to our store and we deliver to our smaller micro distributors in the various townships who then deliver within a 20k radius. We break it down into smaller loads that go into our micro distributors that are based within the townships and they depend on size but they mostly double garage size. They are actually double garages because of security access. It is a person that we found that
manages the warehouse and his community around him. So, it just depends on how best to approach each township because you cannot really look across the market generically. Eastern Cape is very different to KwaZulu-Natal (KZN) which is extraordinarily different to Gauteng and you got to take all of those into consideration.

Order picking and assembly (unitisation and packaging)

The executive opined that: It depends on the number of orders; sometimes we have lots of orders where we have to outsource and actually recruit people to help us do the shopping and delivery and sometimes we just do it ourselves internally. We manage, we work hard, we do it ourselves.

Order delivery (transportation)

When we have small deliveries. We use a smaller vehicle and a bigger vehicle for larger deliveries or quantities. In Gauteng, the big vehicle goes and gets everything in bulk and then the smaller deliveries take them around. Last year, and early this year, we used Getz, powered scooter, and tried different modes.

We have a partnership with a third-party courier company and they deliver throughout South Africa. They deliver to the townships, so our target market is from the higher upper class to middle class and even to your lower-class people that have to wake up at 5 o’clock in the morning and only come back at 8 o’clock at night. We try to make life easier for them.

We are using an Uber model on taxis. Taxis peak hours are 6 to 9am and off-peak from 10am to 12pm. We spoke to a taxi association and offered to pay them a full load passenger price if they do 5 deliveries for us and they agreed. The taxi driver collects 5 orders for the value of R50, which is a full local taxi price. Yes, well, nobody will hijack taxi people.

In townships, street names do not exist. We use the coordinates and not the street address. What you have is House 4619, Zone C, but the location is right. The location is what we use to navigate and optimise i.e. if there is five dropped pins in this area we do all five with the same vehicle.

We try to deliver on Mondays, Wednesdays and Fridays. If a customer orders on Monday and Tuesday up to 3pm, they receive orders on Wednesday and for orders made Wednesday and Thursday before 3pm, delivery is done on Friday. Orders received Friday after 3pm, Saturday or Sunday are delivered on Monday. That is how we have done it to give us a long period of time to aggregate.

Corresponding author
Marcia Mkansi can be contacted at: marcia.mkansi@gmail.com

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Supply chain innovations for additive manufacturing

Toni Luomaranta and Miia Martinsuo
Department of Industrial Engineering and Management, Tampere University, Tampere, Finland

Abstract
Purpose – Additive manufacturing (AM) involves the renewal of production systems and also has implications for firms’ supply chains. Innovations related to AM supply chains are, so far, insufficiently understood, but their success will require firms’ awareness of their systemic nature and their firm-specific implications. The purpose of this paper is to explore the supply chain innovations dealing with AM in business-to-business supply chains.

Design/methodology/approach – An exploratory qualitative research design is used. Interviews were conducted in 20 firms, workshops were organized to map AM-related processes and activities, and supply chain innovations were analyzed.

Findings – This study reveals practical changes in supply chains and requirements for AM-related supply chain innovations. While earlier research has centered on technology or firm-specific AM implementations, this study shows that fully leveraging AM will require innovations at the level of the supply chain, including innovations in business processes, technology and structure, as well as supportive changes in the business environment. These innovations occur in different parts of the AM supply chain and are emphasized differently within different firm types.

Research limitations/implications – This research was conducted in one country in the context of the machine building and process industry with a limited data set, which limits the generalizability of the results. The results offer an analytical framework and identify new research avenues for exploring the innovations in partial or complete AM supply chains.

Practical implications – The results offer a framework to assess the current state and future needs in AM-related supply chain innovations. Practical ideas are proposed to enhance AM adoption throughout firms’ supply chains. These results are important to managers because they can help them position their firms and guide the activities and collaborations with other firms in the AM supply chain.

Originality/value – This study draws attention to the supply chain innovations required when firms adopt AM in their processes. The generic supply chain innovation framework is enhanced by adding the business context as a necessary component. Implementation of AM is shown to depend on the context both at the level of the supply chain and the firm’s unique role in the supply chain. The holistic view taken reveals that successful AM technology adoption requires broad involvement from different firms across the supply chain.

Keywords Radical innovation, Additive manufacturing, Manufacturing technology, Supply chain innovation

Paper type Research paper

Introduction
Additive manufacturing (AM) implies the use of digital product designs and a process of joining and adding layers of material (ASTM Standard, 2012) to produce goods. It can challenge traditional removal and molding-centric manufacturing and either revolutionize entire processes (D’Aveni, 2015; Weller et al., 2015) or complement traditional manufacturing (Holmström et al., 2016; Rylands et al., 2016; Sasson and Johnson, 2016). Earlier conceptual studies showed that AM has great potential to enhance operations. For example, with AM, almost any shape can be manufactured without tooling, which allows parts to be made independently at no extra cost. This can potentially simplify supply chains, shorten lead times and reduce inventories, consequently enhancing flexibility and improving customer satisfaction (e.g. Holmström et al., 2010; Weller et al., 2015). The majority of previous research has focused on AM in single large early adopter firms in consumer goods industries, whereas less is known about the possibilities of AM more broadly in supply chains in business-to-business industries and the involvement of small- and medium-sized enterprises (SMEs).
This paper focuses on the supply chain innovations concerning AM in industrial firms’ supply chains. Supply chain innovation represents the possibility for manufacturing firms to enhance their competitiveness by changing their supply chain network, technology, process or a combination of these (Arlbjørn et al., 2011). Implementing AM can have a significant effect on manufacturing firms’ supply chains (Holmström and Partanen, 2014) and potentially requires the re-engineering of business logics (Weller et al., 2015). Each firm may have a very different role in the supply chain, and it is not yet clear which firms should implement AM, how their partners can support AM adoption and what kinds of structures will emerge for AM supply chains (Rogers et al., 2016).

Implementing AM technology not only affects the firm using AM machines for producing goods, it changes the supply chain process and requires involvement in the upstream of the supply chain. AM requires specially processed raw materials (Khajavi et al., 2014), which requires the involvement of raw material manufacturers. Designers need to consider the new production process during the product development and design stages (Martinsuo and Luomaranta, 2018). After AM, parts need post-processing (Khajavi et al., 2014) before product assembly or final use. Although this could be done by the AM machine operator, it could involve another firm, machine shop or similar, that has a large variety of traditional machining equipment (Strong et al., 2018). This implies that AM could influence the downstream supply chain. For example, a machine shop with traditional manufacturing equipment and methods based on paper blueprints now has to convert to very accurate material removal from an almost-finished part based on a digital file. Previous studies have generated a conceptual illustration for the metallic AM supply chain (Holmström et al., 2016) and an empirical illustration of a business-to-consumer metallic AM supply chain from the point of view of a single firm (Rylands et al., 2016), but they do not offer empirical evidence concerning multi-firm supply chains for metallic AM in the context of business-to-business industries of machine building and industrial processes.

The purpose of this study is to explore the supply chain innovations that take place when AM is adopted in the supply chain. Firms need to respond to the changes in the business environment and take part in supply chain innovations in order to successfully complete the implementation of AM. The goal is to create knowledge about AM supply chain innovations and the related activities in the different firms in the AM supply chain. The study focuses on three research questions:

RQ1. What kinds of contextual changes take place in business-to-business AM supply chains?

RQ2. How – through what kinds of activities – do different firms participate in the AM supply chain process?

RQ3. How can firms leverage AM through innovations in their supply chains?

To address these questions, this study focuses on industrial goods manufacturing and, more specifically, on firms with different roles in the AM supply chain.

The paper reviews previous research on AM as an innovation in manufacturing systems, supply chain innovations and related activities and roles of firms involved in them. The exploratory research approach, the interview and workshop data focusing on AM in the machine and process industry and the data analysis approach are then introduced. The findings include mapping of the relevant contextual changes when implementing AM, a categorization of phases in the AM supply chain process and required supply chain innovations. Finally, the contributions are discussed in light of previous literature and a conclusion is provided. This study contributes to the existing knowledge by revealing the contextual changes in the industrial inter-organizational supply chain during the implementation of AM, suggesting context as a necessary component in forthcoming
analyses of supply chain innovations and identifying various means that firms can use to enhance their operational efficiency through the AM supply chain. The results offer evidence that understanding AM through supply chain innovations can help firms connect with other firms in the supply chain and thus leverage AM more effectively. As practical contributions, these results help managers position their firms, guide the activities and collaborations with other firms in the AM supply chain and enhance AM adoption by means of supply chain innovations.

Literature review

Additive manufacturing as an innovation in manufacturing firms

Innovation, in its classical sense, means the introduction of a new good, feature or method of production, the opening of new markets, the acquisition of new material sources or the implementation of a new organization in an industry (Schumpeter, 1934/1983). Innovations can be divided into incremental and radical changes (Freeman and Soete, 1997), and their classification depends on the innovation adopter’s perspective (Johannessen et al., 2001). Innovations can be divided into intra-organizational and inter-organizational (Santosh and Smith, 2008), and they must aim to create new value (new products, services or structures) (Arlbjørn et al., 2011). In this study, we focus on inter-organizational innovations specifically dealing with AM.

AM represents a radical innovation in terms of manufacturing technology (Oettmeier and Hofmann, 2016; Rylands et al., 2016), and in many cases AM technology advancements have been seen as enablers of new benefits in products, batch sizes and waste reduction (Holmström et al., 2010). These and later studies called AM a groundbreaking innovation, where AM technology has pushed the implementation, but regarded it as a complementary innovation for the manufacturing industry or its supply chains (Oettmeier and Hofmann, 2016; Rylands et al., 2016; Steenhuis and Pretorius, 2017; Durach et al., 2017).

There are indications that a single firm cannot achieve the full benefits of AM alone and that AM adoption requires the involvement of multiple stakeholders in the supply chain (Oettmeier and Hofmann, 2017). Supply chain in this study is defined as a network of firms that transfer and process materials and information between them to create value (Heikkilä, 2002). Adopting AM technology might affect the interactions between supply chain firms (Durach et al., 2017) because firms’ roles in the supply chain may change, new firms may enter the field with completely new capabilities and some current supply chain relationships may be substituted by new AM-specific relationships (e.g. AM material suppliers, service providers and designers). Previous research suggests viewing AM as a systemic innovation that requires complementary innovations to achieve the expected large-scale benefits (Martinsuo and Luomaranta, 2018).

Supply chain innovations and required activities

Manufacturing firms often operate in networks of firms that need to collaborate to produce a product or a service, and to innovate (Manceau et al., 2012). The concept of supply chain innovation deals with firms’ innovation efforts to achieve a competitive advantage through and for their supply chain by developing operational and service efficiency and increasing both the firm’s revenue and the supply chain’s joint profits (Bello et al., 2004). Supply chain innovation can be defined as “a change (incremental or radical) within a supply chain network, supply chain technology, or supply chain process (or a combination of these) that can take place in a firm function, within a firm, in an industry or in a supply chain in order to enhance new value creation for the stakeholder” (Arlbjørn et al., 2011, p. 8).

Supply chain innovations take place through a series of activities that help a firm deal with uncertainty in its business environment, respond to its customer demands and enable more efficient supply chain management (Lee et al., 2011). Supply chain innovation can
therefore be used as a tool to enhance supply chain performance through interaction with up- and down-stream supply chain firms (Lee et al., 2014) and creation of collaborative relationships, especially when implementing new technologies that can be beneficial to several firms in the supply chain (Storer et al., 2014).

According to Bello et al. (2004) and Lee et al. (2011), supply chain innovations are operationalized through a set of activities, which can be divided into multiple categories. Two conceptual studies (Bello et al., 2004; Wong and Ngai, 2019) identified similar categories with a sales-oriented focus. Arlbjørn et al. (2011) identified three categories with a focus on operations management: supply chain business processes, supply chain technology and the supply chain network structure. The empirical study of Munksgaard et al. (2014) noted that supply chain innovations can originate from any of these three categories separately or combined. Due to our focus on AM supply chains directly dealing with manufacturing systems, we will build on the supply chain innovation framework of Arlbjørn et al. (2011).

Previous empirical studies have examined supply chain innovation activities in consumer goods manufacturing, specifically hearing instruments and shoe manufacturing (Munksgaard et al., 2014), and car manufacturing and pharmaceuticals (Ageron et al., 2013).

Most of the earlier supply chain innovation studies have focused on analyzing the individual and organizational level of supply chain innovations (Wong and Ngai, 2019), implying a further research possibility concerning the inter-organizational level. Supply chain innovations are also considered as very context dependent and cross-organizational (Ojha et al., 2016), which suggests a research gap, as supply chain innovations have not been covered in business-to-business settings, specifically in the context of AM.

Supply chain innovations for additive manufacturing in different types of firms
Two supply chain types are particularly relevant in the AM industry. The first type concerns AM equipment, proceeds from the machine supplier to the machine owner and user and involves project business. The second type concerns goods manufactured using AM equipment, is product business and extends from material suppliers through AM manufacturers and their design and software partners to their customers and other suppliers (Mellor et al., 2014). In this study, we focus broadly on product-related supply chains.

Supply chain innovations have not been covered purposely for AM, but their indications appear in some previous studies. Many conceptual studies summarize the possible impacts of AM implementation on supply chains (Holmström et al., 2010; Petrick and Simpson, 2013; Steenhuis and Pretorius, 2017; Sasson and Johnson, 2016). The nature of AM (with improved product-level integration) can enable simpler supply chains, shorter lead times and lower inventories, likely resulting in cost reductions (Holmström et al., 2010). Reliance on digital designs can shorten and simplify physical sections of the supply chain (Campbell et al., 2011). For example, an assembled multi-component part can be digitally modeled and manufactured as a complete part with AM. This single-step manufacturing could reduce the physical transportation needs, which would have an impact on inventory and logistics costs (Holmström et al., 2010; Holmström and Partanen, 2014).

Only a few empirical studies have taken supply chain impacts into consideration (Rogers et al., 2016; Rylands et al., 2016; Thomas, 2016; Oettmeier and Hofmann, 2016), they are summarized in Table I, and these have typically emphasized the viewpoint of large firms or a single SME, not a complete supply chain. AM is a rapidly emerging industry where service providers are gaining a foothold (Rogers et al., 2016), and smaller firms need to rely on their networks when they are adopting AM (Martinsuo and Luomaranta, 2018).

Many of the benefits expected of AM assume that some supply chain innovations take place during AM adoption. Manufacturing firms should therefore consider the potential effects of AM on supply chain processes and management both within the firm and in
partner firms (Oettmeier and Hofmann, 2016). For AM to fully deliver its potential, it is argued that such process technology innovations require restructuring of the relationships with suppliers and customers, increasing collaboration (Mellor et al., 2014).

Some production features in the current AM technologies need to be considered to reach the volume-related benefits of AM and may potentially be resolved through supply chain innovations. In AM technologies, manufacturing capacity does not refer to the number of components but rather to the building platform fill rate, meaning the amount of space a component takes up on a building platform where components are then produced. Ultimately, batches of one may not be economically feasible if the component is much smaller than the building platform (Piili et al., 2015). Also, AM currently has a significant need for post-processing (Khajavi et al., 2014) and components need to be machined, heated or polished after manufacturing. Therefore, AM supply chains should also consider operations and firms outside of the bespoke AM processes.

Different types of firms will have their own ways to contribute to AM through supply chain innovations. The empirical studies in Table I have primarily taken the perspective of certain types of firms, such as AM producers (Oettmeier and Hofmann, 2016; Rylands et al., 2016) or service providers (Rogers et al., 2016), whereas one study takes a more systemic view (Thomas, 2016) and another study draws attention to the different firms’ different experiences with AM adoption (Martinsuo and Luomaranta, 2018). So-called supercenters are predicted to arise from large manufacturing firms that implement AM alongside their traditional mass manufacturing technologies to serve internal or external customers (Sasson and Johnson, 2016). Strong et al. (2018) propose that strategically placed AM hubs would feed AM components for post-processing to nearby SMEs that have traditional

<table>
<thead>
<tr>
<th>Sources</th>
<th>Context and method</th>
<th>Findings on supply chain innovation activities</th>
<th>Gap or motivation driving this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oettmeier and Hofmann (2016)</td>
<td>Impact of AM adoption on supply chain management, two case studies (plastic AM from the hearing aid industry), SME firms operating their own AM machine</td>
<td>Processes such as order fulfillment, manufacturing and supply chain management are affected by the adoption of AM</td>
<td>Future research should study the relationships between firms in the AM supply chain</td>
</tr>
<tr>
<td>Rogers et al. (2016)</td>
<td>3D printing services, evaluation of 404 3D printing service providers’ offerings, different service providers (AM machine operators and AM designers)</td>
<td>Different kinds of AM service models are emerging</td>
<td>How will the future supply chain configuration strategies, structures and operations change?</td>
</tr>
<tr>
<td>Rylands et al. (2016)</td>
<td>Value stream changes after the adoption of AM, two case studies (consumer products), metallic AM, two small firms producing filters and wallpapers, sourcing AM manufactured parts</td>
<td>AM changes the value stream so customers can engage in the design process better than before</td>
<td>Supply chains are areas where AM could cause disruption and change</td>
</tr>
<tr>
<td>Thomas (2016)</td>
<td>Comparative single assembly supply chain cost analysis, metallic AM, car steering systems as a whole assembly</td>
<td>AM affects both manufacturing process level and system (supply chain process level)</td>
<td>How will the whole supply chain benefit from AM?</td>
</tr>
<tr>
<td>Martinsuo and Luomaranta (2018)</td>
<td>Adoption of AM in the SME sector, exploratory research, metallic AM, 19 SME firms from supply chains in the machine building and process industry</td>
<td>SMEs rely on their networks when adopting AM</td>
<td>What kind of innovations could complement AM adoption?</td>
</tr>
</tbody>
</table>

Table I. Summary of previous empirical research on AM-related supply chain innovations
manufacturing machines. Adding AM hubs to the traditional manufacturing supply chain could promote both AM adoption and the performance of machinery SMEs by harnessing excess capacity to post-process AM components (Strong et al., 2018).

Research gaps
The literature review and analysis in Table I portray AM as an emerging manufacturing innovation that will require supply chain innovations for better performance. There is a research gap in the area of partial or complete AM supply chains as the different firms collaborate to create value through AM, making this research focus important and complementary to single-firm studies. The second research gap is in the business-to-business context of AM, as its supply chains may be more complex than those in consumer goods manufacturing. As supply chain innovations are context dependent, an AM-focused study will offer novel knowledge in connection with modern manufacturing systems. The third research gap is the context-dependent understanding of AM implementation, and for that, further knowledge is needed about the types of changes occurring in AM supply chains, the types of innovations needed for AM supply chains and the complementarity of different types of innovations.

Research methods
Research design
This research employs an exploratory research design to study supply chain innovations in firms in different positions in AM-related supply chains. This approach was chosen because of the emergent nature of the phenomenon and limited previous research in this domain. The industry context was selected with the intention to access a complex AM supply chain – the machine manufacturing and process industry – where brand-owning manufacturers commonly use subcontractors and external industrial designers, which are very often SMEs. In this supply chain, the AM technology is metal-based AM, since mainly metallic components are used. This context is useful for the study of anticipated and ongoing changes in supply chains and the supply chain innovations needed to fully leverage AM.

Different types of firms involved in machine and process industry supply chains were enlisted through a list of technology industry firms in Finland in a region active in these industries, and by inviting the firms to participate in interviews and an AM supply chain-related workshop series. The initial list contained about 70 firms with different supply chain roles, and they were contacted by e-mail and/or telephone to seek volunteers for participation. Collecting data from different firms was seen as a means to achieve the best possible holistic understanding of supply chain innovations. The firms were selected based on their interest in AM and because they all had experience using AM or were in the adoption phase of AM technology. Altogether, 20 firms were willing to participate in the study, and this was considered suitable for an exploratory study. Alphabetical codes are used to differentiate the firms (A–U), as anonymity was promised to the interviewees during the study. Numerical codes (1–5) are used to cluster and differentiate the firm types involved in the study based on their scope of business, and to enable comparisons.

The firms vary in their supply chain roles, and different roles in potential AM-related supply chains are covered. The firms include some large firms and some medium OEMs/ODMs that can be considered to have a central position in the supply chain because they are the product users of metallic components. Most of the other firms are directly linked with the supply chains of these large/medium brand-owner manufacturing firms. Background information on the included firms is presented in Table II.
<table>
<thead>
<tr>
<th>Firm type</th>
<th>Firm</th>
<th>Approx. No. of personnel</th>
<th>No. of interviewees</th>
<th>Firms displaying additional internal document-based data</th>
<th>Respondents’ position, total years of experience and AM experience in years</th>
<th>Firm experience in AM: years and specific areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Large manufacturing brand-owner firms</td>
<td>R</td>
<td>5,000</td>
<td>1</td>
<td>X</td>
<td>Senior designer, 20+ total, 5 AM</td>
<td>5 years: sources AM parts for prototyping and uses AM tooling in production</td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>45,000</td>
<td>1</td>
<td>X</td>
<td>Vice president of technology, 25+ total, 5 AM</td>
<td>10 years: has an AM machine and an AM department, sells AM products and uses AM parts in products</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>19,000</td>
<td>1</td>
<td>X</td>
<td>Sourcing manager, 25+ total, 7 AM</td>
<td>7 years: uses AM tools in production and AM parts in products</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>12,500</td>
<td>1</td>
<td>X</td>
<td>AM lead designer, 10+ total, 7 AM</td>
<td>7 years: has an AM machine and an AM department, uses AM parts in products and as replacement parts</td>
</tr>
<tr>
<td>2. Medium-sized manufacturing brand-owner firms</td>
<td>A</td>
<td>200</td>
<td>1</td>
<td>X</td>
<td>Manager of production development, 10+ total, 5 AM</td>
<td>5 years: sources AM prototypes for product development</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>50</td>
<td>1</td>
<td>X</td>
<td>Vice president of technology, 15+ total, 5 AM</td>
<td>5 years: sources AM prototypes for product development</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>200</td>
<td>2</td>
<td>X</td>
<td>General manager, 35+ total, 3 AM; Vice president, 10+ total, 3 AM</td>
<td>3 years: sources AM prototypes for product development and uses AM parts in products</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>150</td>
<td>1</td>
<td>X</td>
<td>Manager of R&amp;D, 25+ total, 3 AM</td>
<td>3 years: sources AM prototypes for product development, planning to use AM tools in production and AM parts in products</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>60</td>
<td>2</td>
<td></td>
<td>Vice president of R&amp;D, 20+ total, 3 AM; R&amp;D design engineer, 15+ total, 3 AM</td>
<td>3 years: sources AM prototypes for product development, planning to use AM tools in production and AM parts in products</td>
</tr>
<tr>
<td>3. Small- or medium-sized OEMs and ODMs</td>
<td>B</td>
<td>50</td>
<td>1</td>
<td></td>
<td>General manager, 30+ total, 3 AM</td>
<td>3 years: seeks information on how AM would influence their business, production developed to enable AM when customers ask for it</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>15</td>
<td>2</td>
<td>X</td>
<td>General manager, 30+ total, 4 AM; Lead design engineer, 15+ total, 4 AM</td>
<td>4 years: is post-processing parts that have been manufactured with AM</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>160</td>
<td>1</td>
<td></td>
<td>Production development engineer, 25+ total, 2 AM</td>
<td>1 year: is post-processing parts that have been manufactured with AM and uses AM tools in production</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Firm type</th>
<th>Approx. No. of personnel</th>
<th>No. of interviewees</th>
<th>Firms displaying additional internal document-based data</th>
<th>Respondents' position, total years of experience and AM experience in years</th>
<th>Firm experience in AM: years and specific areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. AM service and machine operators</td>
<td>J</td>
<td>20</td>
<td>1</td>
<td>General manager, 10+ total, 1 AM</td>
<td>1 year: seeks information on how AM would influence its business</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
<td>1</td>
<td>General manager, 25+ total, 4 AM</td>
<td>3 years: has an AM machine, produces AM prototypes, tools and parts for its customers</td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>5</td>
<td>1</td>
<td>Manager of sales &amp; marketing, 10+ total, 6 AM</td>
<td>4 years: has an AM machine, produces AM prototypes, tools and parts for its customers</td>
</tr>
<tr>
<td>5. Engineering and industrial design</td>
<td>C</td>
<td>1</td>
<td>1</td>
<td>Entrepreneur, 25+ total, 6 AM</td>
<td>2 years: designs AM prototypes and parts</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>5</td>
<td>1</td>
<td>Financial manager, 25+ total, 2 AM</td>
<td>1 year: designs AM prototypes</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>280</td>
<td>2</td>
<td>Vice president, 25+ total, 5 AM; Lead design engineer 15+ total, 5 AM</td>
<td>5 years: designs AM prototypes, tests AM parts with its customers</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>70</td>
<td>1</td>
<td>Vice president, 25+ total, 3 AM</td>
<td>3 years: designs AM prototypes</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>1</td>
<td>1</td>
<td>Entrepreneur, 20+ total, 5 AM</td>
<td>2 years: designs AM prototypes, AM tools, and AM parts. Sells AM products</td>
</tr>
</tbody>
</table>

Notes: X = firm displayed additional internal document-based data
Primary data were collected through 3 workshops and 25 semi-structured interviews in 20 firms (Table II). Interview duration ranged from 40 to 108 min. Of these 20 firms, 13 also displayed internal documents (in-depth firm and strategy presentations), and this additional information was documented as approximately one to two pages of written notes per firm. Secondary data were collected from the target firms’ websites to get background information about the firms and from two workshops to validate the results. The workshop contents and data included:

- WS1 – AM value and supply chains: primary data, 18 participants, 2 pages of notes and 4 posters.
- WS2 – future scenarios: primary and secondary data, 14 participants and 7 pages of notes.
- WS3 – future scenarios: primary and secondary data, 12 participants and 6 pages of notes.
- WS4 – new AM markets: secondary data, five participants, one page of notes and three posters.
- WS5 – new business possibilities: secondary data, five participants and two pages of notes.

The interviews took place after the first three workshops. The contact persons from target firms were asked to identify a person from the managerial level with the best knowledge about AM in their firm. The interviewees were managers and directors from engineering, design, business development, sourcing or general management (CEOs). At the beginning of each interview, the interviewees were asked whether there was another person in their firm who had better or different knowledge about AM. When another person was identified, a second interview was conducted. One additional interview was also conducted with an AM machine supplier. That interview is used as a secondary source to validate the results, together with the secondary data from the workshops.

An interview outline was formed with the help of the preliminary analysis from the first three workshops. The interview outline included questions concerning the background and position of the respondent; the firm’s experience and plans for implementing AM; identified challenges in implementing AM; possible industry-specific needs for AM; opportunities to add value for the business and its customers by using AM; and production and supply chain changes required by AM. This paper concentrates on opportunities to add value for the business and its customers by using AM; and production and supply chain changes required by AM. The recorded interviews were transcribed for further analysis. After the preliminary analysis, two more workshops were organized with industry experts and firm representatives to present the preliminary results, to validate them and to check whether anything was missing.

Data analysis
The analysis of the first three workshops took place first. Handwritten notes from the researchers were compared and rewritten analytically so each observation was retained. Posters from the first workshop represented the AM actor network and supply chain process. All four posters were compared and combined to identify a complete AM supply chain process. This is presented in Figure 1 in the results section. Notes from the internal documents of the firms targeted for interviews were used in the further analysis of the AM supply chain process and to analyze the firms’ strategic focus on that process. Each interview response was then coded in terms of whether and how the firm (i.e. a firm with a certain supply chain network role) was involved in the different phases of the supply chain process. We then cross-tabulated these results with an analysis of the internal documents, revealing the involvement of each firm in the different phases of the supply chain process. This is presented in the results in Table IV. As secondary data, the firms’ websites were explored and used where possible, particularly to improve the validity of the results.
The subsequent more detailed analysis of interview data started by exploring the data and marking four themes to structure the analysis: (a) How does the market change when AM is a feasible alternative? (b) How does the business environment change when AM is a feasible alternative? (c) Important issues in AM subcontracting, and (d) important issues for AM supply chain structure formation. Each theme’s citations were inductively coded with more detail to condense the interviewees’ experiences and retain the terms that the interviewees used. These findings were then pattern coded and structured thematically under two main topics: contextual changes in the supply chains preceding or after the implementation of AM (Themes a and b), and required supply chain innovations (Themes c and d). Pattern coding the expected changes in AM supply chains and in the business environment resulted in five categories, presented in Table III, which includes the dominant changes in AM supply chains repeated in the interviews, explanations for these, and interviewee quotes. Changes that were expressed by only a single interviewee were excluded from the table. Since business environment changes are an important component of supply chain innovations (Lee et al., 2011), this was considered an important intermediate phase in the analysis of supply chain innovations, for revealing the innovation context.

For the interview analysis, the needed supply chain innovations were grouped into innovations in supply chain business processes, technologies and network structures, based on the thematic framework proposed in Arlbjørn et al. (2011), due to its appropriateness for operations management-oriented innovations and, thus, for the core focus of this study. We then mapped how each of these supply chain innovation types appeared across the different types of firms. These results were validated with the results from Workshops 2 and 3. The results are presented in Table V, which shows the categories of supply chain innovations, needed activities, example quotations, and the number of different firm types in which the innovation was expected.

After discovering the needed supply chain innovations from interviewees with the support of workshops, another analysis was performed to reveal the relations between firm types, supply chain process positioning and supply chain innovation needs. This was done by identifying patterns from Table IV and analyzing the reasons behind these patterns. In the findings section, we first introduce the contextual changes experienced in AM supply chains, then map the supply chain process and different firms’ roles in it and then categorize the supply chain innovations and experiences of them across different firms.

Findings
Overview of contextual changes in AM supply chains
Based on the previous literature, the introduction of AM in the manufacturing industry was expected to cause changes in the business environment, with implications for firms’ supply chains. Interviewees were asked to describe what kinds of changes had already occurred and what future changes they expected in the context for AM-related innovations. The interviewees from large firms had the most insight into how AM has changed their business environment. All four interviewees stated that their new product development cycles have shortened. Three of the four large firms had already replaced some traditionally manufactured components in their products with AM components. Interviewees from two large firms said the reason their firms’ own AM machines is that AM manufactured components are cheaper to produce. According to them, integrating multiple components into one – which was previously impossible – has made the parts and the parts production more effective. The same digital models are used throughout the manufacturing process, and the firms are planning to replicate this for other critical components, regardless of the actual manufacturing technology.

An interviewee from one large firm said that due to the tightening regulations concerning their end product, the manufacturing time for one product has shortened and the
batch size has decreased. Therefore, they have given up on molds for manufacturing certain components and have started to produce them using AM. The interviewee further explained that: “About ten years ago, we had one product variant in the production for years, but nowadays we need to adjust our product every year or every two years. There is no sense anymore to order expensive molds, as the batch sizes have gotten so small it is cheaper to manufacture these small series additively. This has actually been one answer to manage the ever-tightening regulations affecting the product development in our industry” (Large manufacturing firm). This has also led to a challenge for their former logistics providers, who were not able to make small deliveries on short notice, and in some cases, some of the firm’s employees had to pick the components themselves.

Even though some changes have occurred, most respondents indicated that traditional manufacturing still dominates, and operating AM technology is primarily the concern of specialized AM firms. According to one interviewee, “There are so many new areas in metal printing that it currently is not and most expectedly will not be the business of every firm” (Engineering and industrial design firm).

For this study, anticipating possible future changes was considered important, as changes may have implications for supply chain innovations. Table III summarizes the

<table>
<thead>
<tr>
<th>Change in AM supply chains and the business environment</th>
<th>Explanation</th>
<th>Example quotations</th>
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<tbody>
<tr>
<td>Digitalization of the entire design-to-manufacturing chain</td>
<td>Using the same digital model from the designer in every phase of the supply chain process</td>
<td>“The whole supply chain must start using digital plans and the key issue is to agree on roles. It must start from designing so that manufacturing can start leveraging digitalization.” (Firm B)</td>
</tr>
<tr>
<td>Digitalization increasing the need for trusted business partners</td>
<td>Digital files and data transmission may be more vulnerable than working based on paper plans</td>
<td>“Trust and security are emphasized in digital services.” (Firm N)</td>
</tr>
<tr>
<td>AM features complement traditional manufacturing</td>
<td>Changes due to “economies of one”: orders only on demand, no need for big batches to gain a cost advantage from the economies of scale</td>
<td>“The supply chain is going to be faster when you don’t need to order big batches because of the price.” (Firm D)</td>
</tr>
<tr>
<td>Changes in operations management</td>
<td>Some steps will be left out from the manufacturing process, and the flexibility of batch sizes challenges traditional production management</td>
<td>“AM decreases the need for machining but increases the value of the machining needed.” (Firm T)</td>
</tr>
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<td></td>
<td></td>
<td>“Of course AM will cause significant changes. Manufacturing steps are left out, quite a lot of them, I presume. And, indeed, the whole environment of the enterprise resource planning changes.” (Firm A)</td>
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<td></td>
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<td>“This will change operations management because every part can be different – it brings flexibility – but on the other hand, it can be quite slow compared to machining. There will be possibilities for new product development, testing, and ramp-up that no one has utilized yet.” (Firm G)</td>
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<td></td>
<td></td>
<td>“[...] if integration within one engine reduces the need for 855 parts to 12 parts, then it has a strong impact on supply chains and logistics.” (Firm L)</td>
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</table>
changes that some interviewees had already noticed in their firms’ business environment and the changes expected in supply chains due to AM, grouped into five categories, further described below.

Digitalization of the entire design-to-manufacturing chain is a change that was experienced in all types of firms. It is an ongoing change enabled by recent technological developments, and an opportunity to streamline supply chains. The interviewees expressed that full digitalization increases the need for trusted business partners to be addressed in the supply chain definition and in partner selection. Also, firms that operate with traditional manufacturing technology rely heavily on their partner firms, for example, to offer research and development and post-processing capacity or services. Some of these firms act as subcontractors for other firms, and research and development for their products is initiated and/or even implemented by their customers. Two SME interviewees (B and F) said that they had to renew their production software to be able to continue the work with their customers who required post-processing for their AM parts.

According to the interviewees, AM is a flexible manufacturing method that complements traditional manufacturing. AM allows production based on “economies of one,” which enables firms to manufacture orders only on demand. Consequently, the need for big batches to gain a cost advantage from economies of scale decreases. This opens up possibilities for entirely new operational models. Interviewees suggested that the small batch orientation will also lead to changes in operations management because some steps will be left out of the manufacturing process and the production type will change. This again creates an opportunity to develop operational activities and new innovations.

Changes in logistics mean there is a possibility for reduced or simpler logistics due to integrated parts. Lighter parts may also reduce costs if logistics costs are calculated based on weight. One interviewee predicted that the use of metal parts casting would decrease when AM replaces it, which means the number of suppliers may also decrease due to AM. Despite reduced logistics, the interviewees mentioned that the need to post-process components still requires transportation, since AM service providers currently do not have advanced post-processing capabilities. Therefore, it would be useful to locate post-processing firms within close proximity of AM service providers. AM service providers considered this to be important because part of their value promise is speed of production. With delivery times of one or two days, they cannot wait for transport for a very long time.

The AM supply chain process in the machine and process industry

The supply chain process includes the business operations across time and place, the beginning and the end, and the inputs and outputs of a supply chain (Mentzer et al., 2001). Classically, supply chain processes include manufacturing raw materials, designing the product, manufacturing the product, warehousing the product, and at last, distributing the product to customers.

To understand the nature of AM in the machine building and process industry and its specific nature, we mapped the core AM-related supply chain process. Figure 1 illustrates this process and its key activities as discovered through empirical data in the machine manufacturing and process industry, compared to a generic supply chain. This study suggests that supply chain innovations can occur in any phase of the supply chain process and across the phases.

After distribution, components go to be assembled in customer or OEM premises because, in the context of the machine and process industry, AM parts are mostly used as components for larger assemblies or products (such as spare parts used within a piece of equipment), instead of as final AM products after manufacturing (such as hearing instruments).

Because a supply chain is comprised at the highest level of two root processes: the production planning and inventory control process, and the distribution and logistics process (Beamon, 1998), it differs from traditional manufacturing processes at the root
process level of production planning and inventory control. AM needs much more design work than traditional manufacturing due to the complexity of AM technology. On the other hand, AM has the potential to reduce or even entirely remove post-production warehousing processes. AM also needs one extra step in the raw material manufacturing phase as well as in the post-production and quality assurance phases.

**Roles of the different firms in the AM supply chain processes**

The interviewees were asked to describe (and offer secondary data on) what kinds of activities their firms are involved in with regard to AM generally and the AM supply chain specifically. The roles of the studied firms in the supply chain process were mapped and are summarized in Table IV. This map reveals that every process phase of the AM supply chain is covered through the firms involved in this study. All but two (B and J) of the firms are currently working with AM, and their positions in the AM supply chain process are marked with x. The two firms not yet involved in an AM supply chain clearly indicated where they would be positioned in AM processes, and these are marked as o. At this point, distribution and logistics are excluded from the analysis because all of the firms is taking part have outsourced them to external logistics firms.

Table IV shows that large product brand owners (Type 1), small and medium OEMs/ODMs (Type 3) and AM machine operators (Type 4) have distinct supply chain process roles based on their activities, whereas medium-sized brand owners and industrial designers show some similarities. Two of the four large firms (U and T) are active almost throughout the AM supply chain process, and they have implemented their own AM machines for in-house applications. The other large firm (U) also produces AM-specific metallic powder for internal use and external sales. In the smaller firms, AM machines are implemented by only two AM service providers, which have also invested in knowledge of AM design. As machine operators, this was seen as crucial by the interviewees from these two firms. Two of the four OEMs/ODMs that operate mainly with traditional manufacturing technology are actively taking part in the post-processing of AM components, meaning that they had to develop their capabilities for very accurate

**Sources:** (a) Adapted from Beamon (1998) and New and Payne (1995); (b) based on the interviews and workshops in this study
machining operations to almost net-shaped parts (close to the dimension of the ready-to-be-used parts). Otherwise, the majority of the firms concentrate on their own product design and on assembling the products, but many of the AM phases have been outsourced to smaller firms specializing in AM.

Required supply chain innovations and activities to leverage AM

In order to leverage AM in their firms, interviewees expected that various innovations were required, and these are presented in Table V. The most frequently expressed needs deal with new practices in product development, investments in digital systems in the supply chain, and a partnership approach in the supply chain, expressed by over half of the respondents. Each of the other topics was discussed by fewer respondents.

Requirements for supply chain innovations during AM adoption depend on the strategies of certain leader firms that decide to invest in either machinery or AM manufactured goods. The interview data suggest that it is not clear who should own the AM machines. Currently, two large firms have implemented their own AM machines, but these are solely for internal use. Two service providers are the only smaller firms that had implemented industrial-scale AM so their capacity would be accessible to others as well, but they will need a strong and cooperative supply chain for AM to become competitive. The interviewees anticipated that new firms may be emerging in AM-oriented supply chains. Also, possibilities for other firms to implement AM machines may open up as the technology improves.

Based on the interviews, supply chain business process innovations deal with product development, order fulfillment, demand management, customer/supplier relationship management and service capacity. Innovations in product development processes are expected because of the faster iteration cycles with real components instead of mock-ups or weak quality prototypes. The capacity fill rate of the building platform plays a crucial role in terms of costs. Optimizing the fill rate is, therefore, a goal for firms that have implemented AM, and it will require innovation activities in order fulfillment, demand management and

<table>
<thead>
<tr>
<th>Firm type</th>
<th>AM raw material manufacturing</th>
<th>Product design</th>
<th>Design for AM</th>
<th>AM production</th>
<th>Post-processing</th>
<th>Quality assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Large manufacturing brand-owner firms</td>
<td>R</td>
<td>X</td>
<td>X</td>
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<td>2. Medium-sized manufacturing brand-owner firms</td>
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<td>M</td>
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<td>3. Small- or medium-sized OEMs and ODMs</td>
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<td>F</td>
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<td>4. AM service and machine operators</td>
<td>N</td>
<td>X</td>
<td>X</td>
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<td></td>
<td>Q</td>
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<td>5. Engineering and industrial design</td>
<td>C</td>
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**Notes:** x = current role in the AM supply chain process; o = expected/planned role in the AM supply chain process, not yet implemented

Table IV. Roles of interview target firms in the AM supply chain process
service capacity. In current practice, one AM machine operates with only one material, since material changes are currently very expensive due to the required cleaning process of the machine. Therefore, interviewees suggested that at least in the beginning there should be a handful of machines with different material set-ups that firms could load with different materials, and an agreed-upon way to share the production resources.

Supply chain technology innovations were expected in terms of investing in digital systems that promote digitalization in the entire design-to-manufacturing chain and changes in manufacturing methods and open up the possibility to effectively streamline the design-to-manufacturing chain and enhance transparency. The change in manufacturing methods means that with AM technology, supply chain management has new tools to make manufacturing processes more flexible. One important question to solve is how to integrate AM in the supply chain of a product that consists mostly of traditionally manufactured components with only a few AM components.

Supply chain structure innovations and, more precisely, innovations with suppliers and customers, deal with models of cooperation, specialization and co-location of expertise; the emergence of new actors and job profiles; and alternative initiators of innovations. According to the interviews, a suitable operations model in the supply chain structure is cooperation, which requires finding the right partnerships. AM technology is new and complex, and cooperation between the customer and the supplier is needed to maximize R&D innovations. Some interviewees thought specialization would be the best operating model for cooperation, whereas others indicated that expertise centers should be formed for AM. Expertise centers were described as multiple specialized firms within the same building – or at least in very close proximity – where partnership is close and several firms can work as one firm. An interviewee in one of the AM service provider firms revealed that they have already started to implement this kind of model by acquiring premises large enough for multiple firms and negotiating with promising partner firms. More actors and new job descriptions are expected to emerge in the supply chains in each scenario. New actors could emerge in the field of total AM supply chain management that would optimize all steps in the value chain and handle quality assurance. According to one interviewee, this would be the best way of managing expertise centers.

Regarding who should be the leader of AM implementation and network innovators, one interviewee in a medium-sized OEM firm said they would like to source AM parts or services traditionally from the subcontractor with the lowest bid. Interviewees in other OEMs saw collaboration or cooperation as a better model, although they mentioned that they would expect their subcontractors to be the initiators in providing new technology capacity to them. Subcontractors, on the other hand, are waiting for their customers to ask them to provide AM capabilities or, ideally, to start to co-develop AM with them. Two of the large firms that had implemented their own AM machines had also defined AM as an important new technology in their strategy. Their interviewees stated that the implementation of AM began when they discovered some of their important components were easier or faster to manufacture with AM. Now their strategic aim is to educate their designers so AM will not only be a special manufacturing method for special parts but could also be used for more general purposes. This is expected to be a wise way to generate product design innovations. Interviewees in two other large firms said their subcontractors implemented AM based on their requests, and then the required capabilities were co-developed. They also stated that intellectual property rights were the most important thing in selecting subcontractors for co-development.

We further analyzed participating firms’ experiences concerning supply chain innovations to identify potential patterns of innovations according to firm type. Table V implies that different types of firms experience different kinds of innovation needs. Table V shows four distinctive clusters of participation, which provide evidence about the supply chain innovation within the specific context of a supply chain process phase.
<table>
<thead>
<tr>
<th>Element of supply chain innovation</th>
<th>Description: domains where innovation activities are expected</th>
<th>Specific innovation example</th>
<th>Example quotations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovations in supply chain business processes</td>
<td>Product development</td>
<td>Possibility to manufacture working prototype components for testing a complex product or assembly</td>
<td>“Design schedules have become so short nowadays. After our designer has designed the component, it needs to be integrated into the product to be tested within three weeks. We don’t have any other possibility but to have the components additively manufactured so that they are real working components, not just weak prototypes.” (Firm U)</td>
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<td>1</td>
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<td></td>
<td>Order fulfillment</td>
<td>A new real-time pricing system based on delivery times, with online quotations for customers</td>
<td>“We had to come up with a new pricing system with online quotations to ensure that our building platform is always filled to the acceptable rate and that the customers have fast delivery times if needed, because that is what we promise.” (Firm Q)</td>
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<td>Demand management</td>
<td>A new tool to estimate and forecast both the demand and manufacturing time</td>
<td>“Our main goal has been to maximize the machine utilization rate. We have gathered a lot of know-how to excel in forecasting the manufacturing schedule, to handle incoming orders by promising the right delivery times.” (Firm N)</td>
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<td></td>
<td>Customer/supplier relationship management</td>
<td>A new tool for quality management and quality documentation requested</td>
<td>“We demanded that our AM supplier had to develop new systems to</td>
<td>3</td>
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<tbody>
<tr>
<td>Service capacity</td>
<td>Overall innovation needed to create a new front-end supply chain business process for AM services to fulfill customers' expectations (delivery time, multiple batch sizes, quality assurance and reasonable costs)</td>
<td>by the customer, developed together with the customer, AM producer and supplier</td>
<td>guarantee the quality of AM parts. Eventually we developed new systems for quality management with our supplier, and they took care of the documentation and access to all the material data from their feedstock supplier.” (Firm U)</td>
</tr>
<tr>
<td>Innovations in supply chain technology</td>
<td>Investments in digital systems in the entire design-to-manufacturing chain</td>
<td>Using the same digital model throughout different manufacturing phases and technologies making development and production more efficient and of better quality</td>
<td>“Good service capacity is expected from our AM suppliers, meaning that we must know when we get the part, how the quality is assured, and how much it costs, since these differ from the traditional sourcing.” (Firm A)</td>
</tr>
<tr>
<td>Change in manufacturing methods creates opportunities for new tools for the supply chain and operations management</td>
<td>New supply chain and operations management tools to take advantage of AM benefits and integrate the AM</td>
<td></td>
<td>“We have developed our systems so that our designers make the design model in a certain way and we have integrated systems to use the same model in each phase from R&amp;D to product assembly. We can now use the same model in digital simulations, printing the part, post-processing it, and measuring the part to inspect the quality […]” (Firm U)</td>
</tr>
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<td></td>
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<td>“Because of the tough competition, the design cycles and new product cycles are so short that it does not</td>
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<tr>
<td>Supply chain structure: innovation with suppliers/customers</td>
<td>Partnership, cooperation</td>
<td>Open and cooperative relationships between the different companies in the supply chain, i.e. suppliers are expected to raise new ideas for production to the customer</td>
<td>“We definitely take up ideas from our subcontractors, and we constantly try to improve co-operation with our subcontractors. Cooperation with subcontractors is what makes us successful, and we can trust that our subcontractors also develop their competences to have the latest methodological expertise in AM.” (Firm K)</td>
</tr>
<tr>
<td>Specialization</td>
<td>Seeking and adding new companies to the supply chain and share production resources of the different firms</td>
<td>“None of our established suppliers have started to provide us the possibility of AM, so we had to seek those smaller companies specialized in AM. It seems that this is the case of how we need to operate. Of course there are many new methods in AM, so one company cannot handle them all.” (Firm M)</td>
<td>1</td>
</tr>
<tr>
<td>Expertise centers: clusters of specialized firms in the same or a close location</td>
<td>Innovative way of relocating companies near to each other for more efficient supply chain structure</td>
<td>“Although the digitalization level of firms is growing and AM operators can basically be anywhere in the</td>
<td>1</td>
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<td></td>
<td>New supply chain roles and job descriptions</td>
<td>A new role for design chain management that carries the original idea and requirements through different phases of design, manufacturing with different technologies, and quality management</td>
<td>world, post-processing is very important for the manufacturing industry. It requires a geographically relatively tight ecosystem to benefit, for example, from the relative speed of the AM method.” (Firm N) “New professions are emerging as we speak. Part of it is formed from old quality assurance or material management, and in this whole manufacturing process there will be, for example, design management professions related to the design chain that have to carry the idea through to the end with certain criteria. And there’s a lot of designer stuff to think about through different stages. Now we try to take care of those responsibilities, but it is complicated because we are just a small company and our customers are big companies.” (Firm N)</td>
</tr>
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The number of the firms (within the five firm types) where innovation was expected

| 1 | 2 | 3 | 4 | 5 |
First, product development process innovations are expected widely in different firms (Firm Types 1, 2, 4 and 5, that is, in all firm types except small/medium OEMs/ODMs). Product development innovations concern mostly the early parts of the supply chain, from material development to product design. Here, the collaboration between traditional product designers and designers with advanced AM design skills is crucial because in many cases traditional product designers do not know what is possible with AM and, on the other hand, AM designers do not have the product-specific knowledge to implement AM ideas.

Second, AM service providers (Firm Type 4) are experiencing innovations throughout supply chain business processes. These innovations mainly include the latter part of the supply chain, from manufacturing to delivery. This pattern may stem from the emerging nature of business and business models for AM service provision.

Third, innovations in supply chain technologies are expected evenly throughout the supply chain positions. Supply chain technology innovations are linked with process and structure innovations, as they can be seen to support each other. Product development innovations will benefit from the increased accuracy of digital designs. Order fulfillment and service capacity will benefit from the increased use of digital systems and new operations management tools.

Fourth, interviewees in the smaller firms (and in medium firms to some degree) particularly emphasized supply chain structure innovations, while large firms did not. This pattern may reflect the advantage that large firms have in term of capabilities and possibilities to invest in the whole AM supply chain process. Small and medium firms are restricted in terms of their capital and capabilities, which leads to the need for partnerships or cooperation with firms as complementary capability sources.

Discussion

This paper inspected AM in industrial goods manufacturing and its inter-organizational supply chains holistically, and supply chain innovations when firms are implementing AM into their processes. This innovation process should not be seen as only a linear process where one aspect of AM has a direct effect on the supply chain, creating opportunities for supply chain innovations. Innovation can also happen the other way around, where supply chain innovations have an effect on the adoption, implementation or utilization of AM.

The first research question inquired:

RQ1. What kinds of contextual changes take place in business-to-business AM supply chains?

While earlier empirical research on AM supply chains has primarily taken a consumer goods-centric, intra-organizational and single-firm perspective (e.g. Oettmeier and Hofmann, 2016; Rogers et al., 2016; Rylands et al., 2016), this study covered the AM supply chain broadly, particularly in machine manufacturing and process industries. Five major contextual changes were identified, as reported in Table III. The general finding that AM complements rather than replaces traditional manufacturing lends support to Rylands et al.’s (2016) ideas. As a contrast to previous research that portrays AM as a means to simplify the supply chain and improve its efficiency (e.g. Holmström et al., 2010), our findings highlight the complexity of the supply chain transformation associated with AM, drawing attention to the new kinds of firms (i.e. partners), material flows and digital information flows within the supply chain.

The most frequently expressed change concerned the digitalization of the entire design-to-manufacturing chain, which links directly with the firms involved and with changes in the material flow, and also confirms the centrality of the digital transformation pointed out in earlier AM-related research (Campbell et al., 2011). However, this digitalization trend and its implications have not been analyzed sufficiently in previous supply chain research or in AM
specifically. Although digitalization is not solely an AM-specific change, AM and other digital manufacturing technologies are driving industries in a more digitalized direction. On the other hand, fully leveraging digital manufacturing technologies will require adopting a holistic view of the digitalized supply chain. This may have far wider effects than just for manufacturing processes. For example, product designers with different roles in the supply chain can benefit from the possibility of co-designing products in real time using suitable design software. Digitalization also has the possibility to enhance the response time in customer relationships.

The second research question asked:

**RQ2.** How – through what types of activities – do different firms participate in the AM supply chain process?

Its response required mapping the AM supply chain process (Figure 1) and different firms’ involvement in it (Table IV). The findings revealed that different types of firms have different roles across the supply chain process. The findings contribute to research that acknowledges the supply chain implications of AM (Rogers *et al.*, 2016; Rylands *et al.*, 2016; Thomas, 2016; Oettmeier and Hofmann, 2016) by showing evidence that AM is not an isolated innovation within one firm and gaining its benefits requires and enables the involvement of different types of firms in the supply chain. In particular, SMEs with traditional manufacturing equipment are actively seeking to be part of the AM supply chain in the post-processing phase, which reflects Strong *et al.*’s (2018) prediction that post-producing is a way for machinery SMEs to join the AM supply chain.

The description of the AM supply chain process includes the phases and activities needed in the AM supply chain context of this study (goods manufacturing, metallic AM) and provides a starting point for studies in other fields. Respective supply chains in different contexts may need some additional phases.

For RQ3 the interviewees’ experiences of required AM supply chain innovations were mapped. We identified a total of 11 required innovation expectations (Table V) that were divided into three categories, based on the framework of Arlbjørn *et al.* (2011). The findings suggest that manufacturing technology innovations such as AM cannot be seen as isolated innovations that could be leveraged merely as a technology adoption task. Instead, they need to be viewed as a systemic innovation requiring complementary innovations to realize their benefits at full scale (Chesbrough and Teece, 2002; Martinsuo and Luomaranta, 2018). Martinsuo and Luomaranta (2018) raised the question about what kinds of innovations could be complementary for AM adoption stemming from the systemic innovation nature of AM, and Thomas (2016) asked how the whole supply chain would benefit from AM. This study provides evidence that supply chain innovations complement AM technology and, thereby, support the technology’s adoption. Supply chain innovations are also a means for the entire supply chain to benefit from AM and to help firms leverage AM effectively.

Based on a further analysis, four different patterns were identified concerning the depth and focus of the firms’ perceived innovation requirements for leveraging AM. The broad expectation across the supply chain regarding the possibility of enhanced product development is consistent with a previous study that pointed out the need to develop product design activities to promote AM adoption (Martinsuo and Luomaranta, 2018). Another broad requirement spanning the supply chain addresses the need to invest in digital systems and supply chain operations management tools, which Campbell *et al.* (2011) predicted. The digitalization of production and supply chains affects entire industries, not just single firms. AM service providers’ specific expectations regarding innovations in business processes reflect the emergent phase of AM service business models, thereby lending support to findings in Rogers *et al.* (2016).

Implementing an AM machine and processes is demanding both financially and operationally. It requires new expertise within a firm, as well as supply chain innovations
that emphasize cooperation, coordination and specialization. A collaborative approach has been emphasized in this study as a means to benefit from AM-driven changes, especially in the SME context, confirming Oettmeier and Hofmann’s (2017) predictions. A consortium of smaller firms co-locating, forming expertise centers and having a strong network with each other could promote the increased speed through AM production. This finding is in contrast with Sasson and Johnson (2016), who predicted that large firms would evolve into AM supercenters. While larger firms may indeed evolve according to this prediction in the future, SMEs in particular require complementary capabilities from their broader networks.

The perspective of an entire supply chain in AM-related innovations reveals that firms in different supply chain positions will have different ways to support AM adoption and leverage the novel technology in their networks.

The thematic framework of Arlbjørn et al. (2011) was used in the analysis to map supply chain innovations, and it was found useful for AM supply chains. However, the interviewees often linked their needs and the implementation of supply chain innovations to changes in the AM supply chain and the broader business environment. Also, the business-to-business context appeared as more complex in its supply chain operations than ordinary consumer goods manufacturing. Changes in the supply chain context and the business environment generally can, therefore, be seen as key factors in supply chain innovations. Therefore, the results of this exploratory study offer evidence to elaborate the framework of Arlbjørn et al. (2011) by adding the context of supply chain innovations as a new analytical dimension. This could enhance the further usefulness of the framework by providing a broader contextual view of supply chain innovations, which has already been recognized as important by Ojha et al. (2016).

Conclusion
Contributions
Since AM technologies are being considered in various industries, firms need information about how they can promote and speed up AM adoption and succeed with the new technologies. The results of this study provide a process model of the AM supply chain, offering evidence of the activities and firms involved in producing goods through metallic AM. The specific involvement of different types of firms in the AM supply chain process was described, indicating that AM adoption takes place very differently for different supply chain firms. Since AM machines are purchased and implemented only by certain firms, the implications of AM implementation are spread throughout the supply chain and require an understanding of multiple perspectives to become effective for all supply chain firms.

Firms experience various practical changes in their supply chains when considering and implementing AM. These changes can also be drivers for AM, for example, the digitalization of the whole design-to-manufacturing chain. Successful AM adoption requires complementary supply chain innovations in business processes, technology and structure. They also need awareness and sensitivity to the specific context in which AM supply chain innovations are implemented, and we have proposed adding the innovation context to the framework of supply chain innovations.

The findings provided evidence on using the framework of supply chain innovations to acquire a holistic view of the possible effects of AM and revealed the effects of AM on supply chains and inter-organizational relationships. Supply chain innovations can complement AM technology innovations during AM adoption and offer practical mechanisms for the entire supply chain to benefit from AM, which can help firms leverage AM more effectively.

Practical implications
Engaging the supply chain more broadly in AM-related discussions will help the different firms justify their investment decisions, negotiate their network position, and access other
firms as sources of complementary capabilities. The results serve as an inspiration for practitioners to view the implementation and leveraging of AM from a wider perspective through the framework of supply chain innovations. Practitioners can use the ideas to map the relevant changes stemming from AM, generate supply chain innovations, improve their supply chains, and, consequently, enhance AM adoption.

Different companies in the supply chain have specific expectations of AM. Some expectations, such as those concerning a certain service capacity, can be solved by creating a new front-end supply chain business process for AM services that would inform customers and other partners about the implications and requirements of AM (e.g., delivery time, quality assurance and cost). Furthermore, because the implementation of AM may influence the strategic location of manufacturing facilities and capability needs in a society, the results are useful for designing new training programs for SMEs or within larger firms, and when funding institutions screen the business plans of newly founded AM firms.

Limitations and avenues for further research

The exploratory research design enabled a broad exploration of the phenomenon but not in-depth observations or analysis of a specific case. All firms were from the machine and process industry, and the AM technology was metallic AM, which limits the findings to this context. In some firms, only one person was interviewed and additional documentation or website data were not available for triangulation purposes, which may limit the reliability of the data. However, efforts were made to identify knowledgeable key informants, use secondary data where possible, and test the main results in collaborative workshops to confirm the key findings. Not all relevant supply chain innovations were covered in this study, and further research is needed to delve deeper into other AM-related innovation scenarios in the future. Furthermore, the firms did not necessarily represent the same supply chains, so conclusions concerning a single supply chain cannot be made.

In the future, a single supply chain and its AM investment should be investigated to confirm this study’s predictions and develop them further. Since cooperation between firms was considered important in this study, it would be beneficial to study to what degree large firms’ support of their respective supply chains explains the successful adoption of AM throughout the supply chain.

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About the authors
Toni Luomaranta, MSc (Tech), is a doctoral researcher in the doctoral program of Business and Technology Management at Tampere University. His research is focused on supply chain changes and responsible manufacturing technology innovations, particularly concerning additive manufacturing. Toni Luomaranta is the corresponding author and can be contacted at: toni.luomaranta@tuni.fi

Miia Martinsuo, DSc (Tech), is Professor of Industrial Management at Tampere University. Her field of research and teaching is project and service business. Professor Martinsuo has over 15 years of academic experience in project and service business, and 9 years of industrial experience particularly in organization and process development in the metal and engineering industry. Her research interests include: project-based organizing; steering and selecting product development project portfolios; managing manufacturing and process innovations; industrial service operations and innovations; and organizational transformation toward service business.

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Value of supply chain resilience: roles of culture, flexibility, and integration

Chunsheng Li
School of Business, Macau University of Science and Technology, Taipa, China

Christina W.Y. Wong
Institute of Textiles and Clothing, Hong Kong Polytechnic University, Kowloon, Hong Kong

Ching-Chiao Yang
Department of Shipping and Transportation Management, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan

Kuo-Chung Shang
Department of Transportation Science, National Taiwan Ocean University, Keelung, Taiwan, and

Taih-cherng Lin
Department of Shipping and Transportation Management, National Taiwan Ocean University, Keelung, Taiwan

Abstract
Purpose – Building supply chain (SC) resilience is crucial for business continuity given the ever-changing environmental conditions. Based on the resource orchestration and organizational culture theories, the purpose of this paper is to investigate the business value of SC resilience with the consideration of the roles of internal integration (II) and external integration (EI), risk management culture (RMC) and SC flexibility (SCF).

Design/methodology/approach – This study investigates how RMC, SCF and intra and interorganizational integration affect the performance of SC resilience. It collects primary and secondary data from 194 manufacturing firms listed in the Taiwan Stock Exchange and Taipei Exchange.

Findings – Results validate the authors’ hypothesis that RMC, SCF and II improve the financial performance of firms through SC resilience efforts.

Research limitations/implications – This study uses firms from Taiwan manufacturing industry, which might introduce country and industry bias.

Practical implications – This study helps managers improve the financial performance of their SC resilience efforts by developing RMC, SCF, II and EI across functions and partner firms.

Originality/value – This study contributes to the literature by empirically testing the relationship between SC resilience and financial performance, and how the relationship is moderated by RMC, SCF, II and EI based on the theories of organizational culture and resource orchestration.

Keywords Supply chain resilience, Organizational culture, Flexibility, Financial performance, Integration, Resource orchestration

Paper type Research paper

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Introduction

Establishing risk management is crucial for the development of supply chain (SC) resilience given the ever-changing and uncertain business environment. SC resilience refers to the capacity to cope with and respond to unpredictable changes (Ambulkar et al., 2015; Kochan and Nowicki, 2018; Ponomarov and Holcomb, 2009). It enables SC operations to recover from disruptions by maintaining continuity of operations at the desired level of connectedness and control over structure and function.

The extant literature is confined to the conceptualization of SC resilience (e.g. Hosseini et al., 2019; Kochan and Nowicki, 2018) and investigation of its operational performance impact (e.g. Chowdhury et al., 2019; Liu and Lee, 2018). Research on the effect of SC resilience on financial performance is still in its infancy. SC resilience and financial performance are positively and significantly correlated (Yu et al., 2019). However, many scholars propose that the implementation of SC resilience is a buffer for the maintenance of excessive capacity, thereby causing a doubt to the relationship; for example, hiring additional people increases the wage cost, having back-ups leads to capital consumption and occupation (e.g. Bairamzadeh et al., 2015; Ghaderi et al., 2018).

Further investigation on the financial impact is needed to respond to managers’ concerns on the cost of SC resilience (Hohenstein et al., 2015). Thus, we raise the first research question:

**RQ1.** Does SC resilience positively and significantly affect firms’ financial performance?

Prior studies have identified various approaches that were used to mitigate SC disruptions. Such approaches range from organizational attributes, such as operational slack, diversification and vertical relatedness in risk mitigation and response (e.g. Braunscheidel and Suresh, 2009; Kovach et al., 2015), to human resources management by increasing job satisfaction, decreasing turnover (e.g. Jiang et al., 2009; Kumar et al., 2018) and providing information about the value of organizational efforts in developing SC resilience. The business benefits of cross-functional integration have been conceptualized (Enz and Lambert, 2015), and the effects of culture and flexibility on the performance impact of asymmetry on SC management have been investigated (Dubey et al., 2019; Kurniawan et al., 2017; Wiengarten et al., 2019). As such, culture, flexibility and integration are crucial to SC resilience. However, the literature provides limited empirical information about culture, flexibility and integration that would help (or challenge) firms enhance SC resilience-induced financial performance. Thus, we raise the second research question:

**RQ2.** How does culture, flexibility or integration affect the relationship between SC resilience and financial performance?

The theories of organizational culture (Denison and Spreitzer, 1991; McDermott and Stock, 1999) and resource orchestration (Sirmon et al., 2007, 2011) are integrated to investigate the SC resilience-induced financial performance and the roles of culture, flexibility and integration in this relationship. Organizational culture refers to a collection of values, beliefs and assumptions that are shared and reflected in organizational goals and practices (Khazanchi et al., 2007). Culture is what makes the members of a certain organization stand out from others (Hofstede, 1980). Organization culture, which is developed by sharing values and ideas, is positively related to firm performance (McDermott and Stock, 1999). Denison and Spreitzer (1991) suggest that organizational culture has two different value orientations, emphasizing independent willingness to focus on change or stability. One orientation refers to control-oriented activities, reflecting order, control and stability. The presence of risks leads to unstable environmental condition and imposes difficulties in decision making. Risk management creates value by reducing the damage of potential problems and maintaining an uncertain environment (Revilla and Saenz, 2017). Another type of value orientation refers to flexibility-oriented activities, which reflect the spontaneity and adaptability of organizational culture. The roles of organizational flexibility, such as procurement/sourcing, manufacturing and distribution/logistics flexibility, help reduce environmental uncertainty and increase mutual understanding (Obayi et al., 2017;
Organizational culture can play a vital role in affecting firm performance to cope with SC disruptions due to orientation differences (Denison and Spreitzer, 1991).

Resource orchestration theory is regarded as the extension of the resource-based theory because it explicitly provides effective structuring, bundling and leveraging of firm’s resources to create value for competitive advantages (Sirmon et al., 2007, 2011). This theory advocates that utilizing and leveraging organizational resources are equally important as owning resources, and possessing resources does not guarantee better performance. SC strategy across functions is critical to increasing managers’ awareness of the activities for proceeding resource orchestration (Sirmon et al., 2011). Resource orchestration enables the accumulation of organizational resources (Sirmon et al., 2007, 2011). Internal integration (II) and external integration (EI) can be used to sustain competitive advantage (Sirmon et al., 2011). II enables the deployment and coordination of internal resources across functions. It helps firms structure and leverage internal resources effectively to perform, track and monitor management efforts across functions (Riley et al., 2016; Wong et al., 2015). EI allows firms to obtain valuable information and resources from suppliers and customers and manage the SC activities by orchestrating resources and competencies across the supply and customer bases (Wong et al., 2015).

Organizational culture theory and resource orchestration theory have similarities and key differences. Both theories advocate the need for continuous efforts to efficiently and effectively carry out activities and thus create a stable organizational environment (Michailova and Hutchings, 2006; Sirmon et al., 2011). The differences between these theories are about “how” firms can obtain stability. Organization culture theory suggests that firm commitment and openness with key partners enrich knowledge base and enlarge accessibility to resources (Michailova and Hutchings, 2006; Randall et al., 2014). In addition, resource orchestration theory focuses on resource integration and encourages operational cooperation to compete in the dynamic marketplace (Sirmon et al., 2011). These theories are integrated in the present study for their complementarity. Organizational culture theory specifically encourages participation, empowerment and teamwork to create a common value on how to arrange and fully utilize firms’ resources. It complements resource orchestration theory, which advocates the efficient allocation of firm resources to retain productivity, by establishing a flexible and adaptable organizational culture that copes with uncertainties.

The present study contributes to the operation and SC resilience literature in several ways. First, it proves the business value of SC resilience, thereby addressing the concerns of researchers and managers on the costly adoption of SC resilience. Second, it takes the resource orchestration and organizational culture perspectives to empirically investigate the roles of SC flexibility (SCF), risk management culture (RMC), II and EI in the relationships of SC resilience and financial performance. Third, it helps managers determine how to improve the financial performance of their SC resilience efforts by developing culture, flexibility and integration across functions and partner firms.

Theoretical background and hypothesis development

Research framework
The current study uses organizational culture and resource orchestration theories to investigate how culture, flexibility and integration affect the performance of SC resilience. According to the organizational culture theory, RMC and SCF can be developed as a culture that enables control-oriented and flexibility-oriented activities (Denison and Spreitzer, 1991). On the one hand, RMC is considered as a part of control-oriented activities that involve such practices as collaborative and business continuity planning, information sharing and employee training to build resilience in internal operations (Das and Lashkari, 2015). On the other hand, SCF is referred to as the activities of SC partners to adjust tactics and operation scope to a certain degree (Gligor et al., 2013). SCF is considered as flexibility-oriented activities that require efforts of firms to maintain the capacity to cope with disruptions (Erol et al., 2010).
Integration, on the other hand, is concerned with the exchange of knowledge and information to coordinate and streamline resources across the SC (Lee and Whang, 2004). Firms manage their resource portfolio that resides within firms and across partner firms to develop resource-based competitive advantages. In line with the theory of resource orchestration (Sirmon et al., 2011), bundling and leveraging resources across internal and external (e.g. suppliers, customers) functions through integration effectively enable resource orchestration. Integration can be considered as an operational capability to support the orchestration of resource across functions and firms (Wade and Hulland, 2004). II and EI represent two core organizational dynamic capabilities of a firm that facilitates the use of resources. II is the extent to which the internal functions are working collaboratively and in synchrony to support organizational strategies and practices (Morash et al., 1996). EI is considered as the extent to which a firm can integrate with its major customers and suppliers to coordinate interorganizational activities (Morash et al., 1996).

Japanese automotive manufacturer Toyota can be used to illustrate the success in adopting SC resilience, as well as RMC, flexibility and integration. Toyota’s production was stopped due to a fire incident at its Aisin Seiki plant in 1997 and earthquakes in 2007 and 2011 (Kubota, 2016). After 2011, Toyota has been building SC resilience (e.g. by sourcing each component from multiple suppliers and building a supply database) and a dynamic RMC (e.g. by reserving resource and keeping track of the impact of disruptions); it also increases SCF (e.g. using standardized parts that can be outsourced globally) together with II and EI (e.g. tightly integrating SC systems and integrating disaggregated production process) to handle the disruptions (Kubota, 2016; McCarthy-Byrne and Mentzer, 2011). Toyota suffered many disruptions since then, including the three-day suspension due to its two assembly factories near Tianjin port during the explosion in 2015 (Shirouzu, 2015), seven-day halt due to an explosion at a steel supplier in February 2016 and shutdown of 26 assembly lines due to the Kumamoto earthquakes in April 2016 (Kubota, 2016). Although these disruptions adversely affect Toyota’s SC, its SC resilience together with its RMC, SCF and integration built after 2011 help reduce its downtime. Toyota’s profitability from 2013 to 2017 becomes about thrice as high as its profitability from 2010 to 2012 (Morningstar, 2017).

Figure 1 depicts the framework of this study driven by the real-life cases and guided by organizational culture theory and resource orchestration theory.

**SC resilience–financial performance relationship**

Firm services or products are disrupted by unanticipated and unplanned events, such as workforce strikes, extreme weather and truck breakdowns (Kochan and Nowicki, 2018). Under such conditions, SC resilience comes into use to minimize the impact of SC disruptions and maintain business continuity (Ambulkar et al., 2015; Li et al., 2017). According to resource
orchestration theory, resource utilization, and not resource possession, is what leads to improved performance (Sirmon et al., 2011). SC resilience enables firms to cope with disruptions, maintain supply to customers, keep a positive trade relationship and optimize resource allocation (Roehrich et al., 2014). From an organizational culture perspective, firms need to maintain the relationship among functions to provide a quick response and flexibility in operations when SC disruptions emerge (Denison and Mishra, 1995; Denison and Spreitzer, 1991).

Firms can minimize shortage risks through maintaining connectedness among their functions and partners to ensure stock availability and handle disruptions due to SC resilience (Ambulkar et al., 2015; Golgeci and Ponomarov, 2013; Ponomarov and Holcomb, 2009), thereby enhancing firm profitability and reputation (Roehrich et al., 2014). Moreover, delivery competence, which ensures reliable services, is improved via adoption of SC resilience practices like dynamic pricing (Liu and Lee, 2018). As suggested in prior studies (e.g. Christopher and Peck, 2004), SC resilience can keep a low inventory level through minimal batch sizes and short lead time (Azevedo et al., 2013). Hence, the firm's financial liquidity and asset turnover can be improved. IKEA, a Swedish-founded company that designs and sells furniture, successfully delivers small batches to its market to avoid unsold inventory or deadstock in its warehouse (TradeGecko, 2018), thereby increasing its assets turnover and therefore financial performance. Thus:

H1. Firm's SC resilience is positively related to financial performance.

Roles of RMC and SCF on the relationship between SC resilience and financial performance

Organization culture focuses on activities for the purpose of control and flexibility, termed as RMC and SCF, respectively, based on the organizational culture theory. RMC plays an important role in the relationship between SC resilience and financial performance. RMC practices, such as training personnel about resilient policies and developing RMC, allow personnel to recognize the nature of risks in their SCs, while developing internal efficiency and coordination to cope with disruptions and to attain business stability and continuity (Christopher and Peck, 2004; Denison and Spreitzer, 1991). According to Ambulkar et al. (2015), firms are aware of the occurrence of disruptions and learn from past disruption experiences. A high level of RMC is required to enhance the impact of SC resilience on a firm's productivity and profit. Such organizational capacity enables firms to serve customers well and operate efficiently with minimal downtime (Obayi et al., 2017; Ponomarov and Holcomb, 2009). Firms can cope with the disruptions in a short time. Hence, disruptions on meeting customer needs can be mitigated (Fattahi et al., 2017). The capability to handle unpredictable disruptions is critical for an organization to reduce loss from the disruptions and manage the mismatches of supply and demand (Cardoso et al., 2015; Roehrich et al., 2014). RMC helps firms with risk awareness and avoidance, which has an essential influence on the business value of SC resilience. Thus, we propose the following hypothesis:

H2. A high level of RMC enhances the relationship between SC resilience and financial performance.

SCF enables firms to adapt to the changing market needs and manage risks by allocating resources across SCs (Obayi et al., 2017). Along with SCF, SC resilience could be seen as a mitigation tactic. SCF helps firms respond quickly to the supply and demand changes through maintaining resources and forming strategic partners; the product development time can be shortened, and the firm can offer products more frequently (Braunscheidel and Suresh, 2009). SCF facilitates interactive and effective teamwork among internal functions and across firms after disruptions to develop new markets and obtain most of the benefits, such as innovation, additional resources acquisition, business growth and improved
financial performance (Denison and Spreitzer, 1991). With SC resilience and SCF, firms can adapt their operations according to the customers’ preferences and satisfy the changing demand (Cardoso et al., 2015). Karl Mayer, a leading knitting machinery manufacturer, keeps production in-house as much as possible and relies on digitization to increase overall flexibility (D'Souza, 2017). Its multi-axial warp knitting machines are continuously updated to satisfy knitting factories’ requirement on the resilient production lines that can produce multiple fabric patterns (Davis, 2018). All these practices make Karl Mayer a great success in customer satisfaction and loyalty. The rate of customer switching is reduced, and the firm acquires new customers and generates profit (Davis, 2018). Thus, we propose the following hypothesis:

\[ H3. \text{A high level of SCF enhances the relationship between SC resilience and financial performance.} \]

Roles of integration on the relationship between SC resilience and financial performance

The ability to manage resources is important for a firm to complement existing operational weaknesses and recover from declining performance (Sirmon et al., 2007, 2011). Bundling and leveraging resources across internal and external functions through integration effectively ensure resource management. According to Hill et al. (1992), managers need to build special channels to facilitate the information flow, make joint decisions and build trust among different departments or firms through integration.

Based on resource orchestration theory, a firm could own a lot of resources, but its performance depends on the ability of structuring and utilizing its resources. Successful operational collaboration could result in effective resource integration and orchestration (Sirmon et al., 2011). II enables process efficiency through cooperation and coordination across internal functions (Morash et al., 1996; Wong et al., 2011). It also coordinates production scheduling, demand planning and customer and material management (Riley et al., 2016), thereby enabling a firm’s implementation of SC resilience. EI extends II across boundaries of firms by involving suppliers and customers’ integration and strategic business processes alignment (Demeter et al., 2016; Morash et al., 1996). EI helps firms obtain requirements from customers and supply information from suppliers, thereby coordinating tasks with upstream and downstream SC partners (Wong et al., 2011). Such integration enables firms to respond to marketplace changes (Vanpoucke et al., 2017). II and EI help reduce the bullwhip effect (Vanpoucke et al., 2017). The communication and shared information among functions and partner firms reduce redundancy and wastage and improve customer service and delivery performance. Together with integration, SC resilience ensures the improvement of partner-related processes and routines with real-time collaboration to respond to the disruptions in the SC (Liu and Lee, 2018). Thus, we propose the following hypotheses:

\[ H4. \text{A high level of II enhances the relationship between SC resilience and financial performance.} \]

\[ H5. \text{A high level of EI enhances the relationship between SC resilience and financial performance.} \]

Research methodology

Questionnaire design

In this study, we collect data through a mass survey in combination with objective firm performance data. First, we carried out an extensive literature review to ensure the reliability and validity of our measurements, and we extracted our measure items adopted in the prior studies, as presented in Table II. Four items of SC resilience were adapted from...
Golgeci and Ponomarov (2013) and Ponomarov and Holcomb (2009). Four items of EI and three items of II were based on Rodrigues et al. (2004) and Stank et al. (2001). Three measures of RMC were selected from Christopher and Peck (2004). Four items of SCF were adapted from Gligor et al. (2013) and Juttner and Maklan (2011). The measurement scales of this study, which come from the original literature, are in English. We designed our questionnaire in English and asked knowledgeable professors in this field to review the file and improve its reliability. We followed the translation and back-translation method to ensure the linguistic equivalence of our measurements (Ketterer et al., 2010).

A pilot test was then conducted on a group of 30 manufacturing managers from Taiwan to ensure the readability of the questionnaire. The pilot test aimed to assess if the respondents correctly understood each question, and slight modifications were made according to the result.

Data collection
We chose Taiwan’s manufacturing industry to be our empirical setting. It has been considered as one of the important production bases to supply electronic hardware products for global sourcing, such as chip, notebook and liquid crystal display (IDB, 2013). It is a global center of the production of flat panel displays and integrated circuits foundries, and it has a large market share in the production of golf heads, shoes and high-tech products. The output of the Taiwanese manufacturing industry reaches US$413bn, which accounts for approximately 88 percent of the industrial sector’s total output in Taiwan. Hence, the industry contributes to 30 percent of the country’s GDP.

We collected a sample from the manufacturing firms listed in the Taiwan Stock Exchange (TWSE) and Taipei Exchange (TPEx) (i.e. over-the-counter market) in May 2014. A total of 1,180 firms were listed in our sample – 649 firms were listed in TWSE and 531 firms in TPEx. To improve the response rate, we prepared a cover letter containing the work’s purpose and significance and mailed it together with our questionnaire and a return envelope, which had been prepaid and preaddressed. We contacted the respondents by telephone before sending the questionnaire out. A total of 142 responses were received in the first round. We reminded the nonrespondents through phone call, and sent the follow-up mailing to the remaining 1,038 nonrespondents. We received another 94 responses in the second round. From the two rounds, we received 236 questionnaires in total. Hence, the response rate is 20.0 percent. After screening, 33 questionnaires were disqualified because of incomplete responses. Therefore, 203 responses were used for our analysis. The respondents’ demographic characteristics were summarized in Table I.

Following Kovach et al. (2015), return on assets (ROA) was used to measure financial performance, representing the efficiency and profitability of the assets utilization. We collected the firms’ objective financial data of the fiscal year 2015 from the databases of TWSE and TPEx in April 2016.

We targeted top managers (see their job titles in Table I) as respondents in the mass survey because they are knowledgeable enough to provide the relevant information about the organizations (Montabon et al., 2018). In addition, the combination of primary data from a mass survey and secondary data from the database is recommended by recent researchers to minimize the associated biases (e.g. common method and respondent bias) and enhance the relevance of the study findings (Flynn et al., 2018; Montabon et al., 2018).

Bias issues
We adopted the extrapolation method suggested by Armstrong and Overton (1977) to compare the early respondents and late ones across the measures by commencing a t-test analysis. The results showed that no statistical difference existed among the measures ($p < 0.001$). Hence, nonresponse bias is not an issue in this study.
Perceptual inputs and objective data were collected as multiple-source data to address the common method variance issue. The perceptual measures of independent variable were self-reported, whereas the objective measures of dependent variables were collected from the sample firms’ annual reports. We followed Podsakoff et al. (2003) to check if any common

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Number of respondents</th>
<th>Percentage of respondents</th>
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<tbody>
<tr>
<td><strong>Job title</strong></td>
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<tr>
<td>Vice president or above</td>
<td>62</td>
<td>30.5</td>
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<tr>
<td>General manager</td>
<td>47</td>
<td>23.2</td>
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<td>Manager</td>
<td>61</td>
<td>30.0</td>
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<td>Director</td>
<td>15</td>
<td>7.4</td>
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<tr>
<td>Other</td>
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<td>8.9</td>
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<td><strong>Tenure in current company (years)</strong></td>
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<td>1–3</td>
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<td>4–9</td>
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<td>16–20</td>
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<td>21 and above</td>
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<td><strong>Age of firm (years)</strong></td>
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<td>1–10</td>
<td>6</td>
<td>3.0</td>
</tr>
<tr>
<td>11–15</td>
<td>28</td>
<td>13.8</td>
</tr>
<tr>
<td>16–20</td>
<td>33</td>
<td>16.2</td>
</tr>
<tr>
<td>21 and above</td>
<td>136</td>
<td>67.0</td>
</tr>
<tr>
<td><strong>Type of industry</strong></td>
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<td></td>
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<tr>
<td>Electronic</td>
<td>45</td>
<td>22.2</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>21</td>
<td>10.3</td>
</tr>
<tr>
<td>Information and communication</td>
<td>20</td>
<td>9.9</td>
</tr>
<tr>
<td>Machinery</td>
<td>20</td>
<td>9.9</td>
</tr>
<tr>
<td>Computers and consumer electronics</td>
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<td>7.4</td>
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<tr>
<td>Garments and textile</td>
<td>12</td>
<td>5.9</td>
</tr>
<tr>
<td>Iron and steel</td>
<td>12</td>
<td>5.9</td>
</tr>
<tr>
<td>Auto and parts</td>
<td>9</td>
<td>4.4</td>
</tr>
<tr>
<td>Metal</td>
<td>9</td>
<td>4.4</td>
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<tr>
<td>Construction materials</td>
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<td>3.9</td>
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<tr>
<td>Chemical</td>
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<td>3.4</td>
</tr>
<tr>
<td>Plastic and rubber</td>
<td>7</td>
<td>3.4</td>
</tr>
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<td>Food</td>
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<td>2.5</td>
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<td>Others</td>
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<td>6.4</td>
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<tr>
<td><strong>Number of employees</strong></td>
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<tr>
<td>&lt; 100</td>
<td>20</td>
<td>9.9</td>
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<td>101–200</td>
<td>38</td>
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<td>201–400</td>
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<td>401–600</td>
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<tr>
<td>601–1,000</td>
<td>32</td>
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</tr>
<tr>
<td>&gt; 1,001</td>
<td>50</td>
<td>24.6</td>
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<tr>
<td><strong>Annual revenue of firm (billion NT$)</strong></td>
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<tr>
<td>&lt; 1.0</td>
<td>32</td>
<td>15.8</td>
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<tr>
<td>1.1–2.0</td>
<td>47</td>
<td>23.1</td>
</tr>
<tr>
<td>2.1–3.0</td>
<td>30</td>
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<td>3.1–5.0</td>
<td>27</td>
<td>13.3</td>
</tr>
<tr>
<td>5.1–10.0</td>
<td>22</td>
<td>10.8</td>
</tr>
<tr>
<td>&gt; 10.1</td>
<td>45</td>
<td>22.2</td>
</tr>
</tbody>
</table>

**Note:** One US dollar equals approximately 32.5 New Taiwanese (NT) dollars

| Value of supply chain resilience     |                       |                           |
|--------------------------------------|                       |                           |

Table I: Demographic data of respondents
method variance issue exists through the following procedural and statistics methods. First, respondents were guaranteed that their identity would be anonymous and confidential when we report the results to encourage the respondents to answer honestly. Second, the percentage of the respondents who held a senior position is 61.4 percent, and those who had tenure for more than seven years is 69.5 percent. The respondents are assumed knowledgeable about the operations and management of their firms. Third, Harman’s one-factor test was conducted to ensure that no single factor exists, which led to the majority of covariance. Seven factors from the measurement items were extracted because their eigenvalue was greater than 1, and the proportion of these extracted factors in all the variances was 73.32 percent. The first factor accounted for 26.11 percent. No issue of common method variance existed in this study because no one factor accounted for a large proportion of the variance.

Assessing model assumptions, validation and reliability

We controlled for outliers that potentially influence the results through trimming the objective financial data at the 1 percent level in each tail (Hendricks and Singhal, 2005). Nine firms were excluded, and 194 firms’ data were applied for further analysis. Table III shows the mean, standard deviations and correlations of the variables. The correlations among SC resilience and the four moderators are significant at the level of \( p < 0.001 \), ranging between 0.38 and 0.45. Thus, the criterion validity is acceptable (Nunnally and Bernstein, 1994). The variables were mean-centered to further mitigate the effects of multicollinearity, outliers and non-normality (Jaccard and Turrisi, 2003). The variance inflation factor values (VIFs) were calculated to test the potential multicollinearity (Hair et al., 1998). The value of VIF is smaller than the expected cut-off value of 3.3 (Peng and Lai, 2012). Hence, multicollinearity is not a concern in this study. We adopted Shapiro–Wilk test to check the normality of the data (Dagostino et al., 1990) and Levene test for variance homogeneity (Tabachnick, 2013). The insignificant results (\( p > 0.05 \)) support the assumption of normality and variance homogeneity for our analysis.

Table II shows the composite reliability and Cronbach’s \( \alpha \) to measure the reliability and internal consistency of the scales and constructs. The results show that composite reliability and Cronbach’s \( \alpha \) of all constructs are greater than expected threshold of 0.7, from which the reliability can be ensured sufficiently (Nunnally and Bernstein, 1994). Anderson and Gerbing (1988) suggest the use of confirmatory factor analysis (CFA) to measure the factor structures’ psychometric properties. We adopted the estimation of the maximum likelihood with the covariance. Table II summarizes CFA results and shows that the values of the comparative fit index (CFI), the incremental fit index (IFI) and the Tucker–Lewis index (TLI) are greater than the expected cut-off value of 0.9, whereas the values of the root mean square residual are below the expected threshold of 0.05. Therefore, all the constructs present a good fit with the data obtained (Hu and Bentler, 1999).

We assessed convergent validity through the factor loadings’ statistics, significance and average variance extracted (AVE) (Anderson and Gerbing, 1988; Hair et al., 1998). The results in Table II show that the loadings are between 0.51 and 0.91, and all indicators are significantly loaded to their respective constructs (\( p < 0.001 \)), which proves the presence of convergent validity. Additionally, the values of AVE of the constructs are greater than the threshold value of 0.5, which provides further evidence of convergent validity.

We assessed the extent to which one construct is different from others to measure the discriminant validity. A series of tests on \( \chi^2 \) difference between nested CFA models were tested for every pair of constructs. We found significant \( \chi^2 \) differences (\( p < 0.001 \)) between the constrained and unconstrained models, suggesting the discriminant validity (Bagozzi et al., 1991). Table IV shows the results. Additionally, the square root of each construct’s AVE in Table III is greater than the correlations among other pairs, which provides further evidence for the variables’ discriminant validity (Table IV).
Hypothesis testing and results

For the control variables, we included firm age, annual revenue, industry type and firm size in terms of employee number, as these influence organizational ability in resilience and experience in handling with disruptions. We established a structural equation model based on the construct of SC resilience and ROA to test H1. The first row of panel A in Table V shows the goodness of fit ($\chi^2 = 189.88$, df = 27, IFI = 0.96, TLI = 0.94, CFI = 0.96, RMSEA = 0.07). Table V shows a positive and significant relationship between SC resilience and ROA ($\beta = 0.13$, $p < 0.05$). Thus, H1 was supported.
We then adopted a multi-group analysis to test H2–H5. A two-group model was created for each moderating factor by dividing the sample into low and high levels based on the mean of the composite score (Wong et al., 2011). Table V summarizes the results, including the $\chi^2$ statistics, goodness of fit, path coefficients and significance. The parameters of the structural model varied freely between low and high groups in the baseline models. The parameters of all the paths were constrained to be the same in both groups in the constrained models, whereas the parameters of the paths from SC resilience to business performance were constrained in the constrained paths. The differences between baseline and constrained models in $\chi^2$ statistics and their significance indicate variance of the models between the low and high moderating groups. The $\chi^2$ differences between baseline models and constrained paths suggest the moderation effects.

Table V shows that the $\chi^2$ differences between the baseline and the constrained models ($\Delta \chi^2 = 15.77$, $\Delta df = 8$, $p < 0.05$) and the $\chi^2$ differences between the baseline model and the constrained path ($\Delta \chi^2 = 11.28$, $\Delta df = 1$, $p < 0.01$) are significant under low and high levels of RMC. The results further suggested that the impact of SC resilience on ROA is significantly enhanced under low ($\beta = 0.12$, $p < 0.05$) and high ($\beta = 0.19$, $p < 0.05$) levels of RMC. Therefore, H2 was supported.

### Table III.
Mean, standard deviations (SD) and correlations of the variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>SCR</th>
<th>II</th>
<th>EI</th>
<th>RMC</th>
<th>SCF</th>
<th>ROA</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR</td>
<td>3.81</td>
<td>0.65</td>
<td>0.76</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>4.04</td>
<td>0.76</td>
<td>0.38***</td>
<td>0.50***</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EI</td>
<td>3.48</td>
<td>0.82</td>
<td>0.39***</td>
<td>0.58***</td>
<td>0.60***</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMC</td>
<td>3.50</td>
<td>0.80</td>
<td>0.43***</td>
<td>0.62***</td>
<td>0.55***</td>
<td>0.65***</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>SCF</td>
<td>3.83</td>
<td>0.72</td>
<td>0.45***</td>
<td>0.62***</td>
<td>0.55***</td>
<td>0.65***</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>ROA</td>
<td>3.73</td>
<td>6.94</td>
<td>0.12</td>
<td>−0.02</td>
<td>0.05</td>
<td>−0.01</td>
<td>0.097</td>
<td>−</td>
</tr>
</tbody>
</table>

**Notes:** Square root of AVE is on the diagonal. SCR, supply chain resilience; II, internal integration; EI, external integration; RMC, risk management culture; SCF, supply chain flexibility. ***$p < 0.001$

### Table IV.
Discriminant validity analysis results

<table>
<thead>
<tr>
<th>Construct pairs</th>
<th>Unconstrained</th>
<th>Constrained</th>
<th>$\Delta \chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply chain resilience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal integration</td>
<td>39.85</td>
<td>13</td>
<td>110.02</td>
</tr>
<tr>
<td>External integration</td>
<td>50.37</td>
<td>19</td>
<td>116.48</td>
</tr>
<tr>
<td>Risk management culture</td>
<td>24.07</td>
<td>13</td>
<td>91.10</td>
</tr>
<tr>
<td>Supply chain flexibility</td>
<td>29.36</td>
<td>19</td>
<td>80.22</td>
</tr>
<tr>
<td><strong>Internal integration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External integration</td>
<td>61.91</td>
<td>13</td>
<td>115.15</td>
</tr>
<tr>
<td>Risk management culture</td>
<td>69.27</td>
<td>8</td>
<td>88.81</td>
</tr>
<tr>
<td>Supply chain flexibility</td>
<td>68.68</td>
<td>13</td>
<td>114.37</td>
</tr>
<tr>
<td><strong>External integration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk management culture</td>
<td>42.26</td>
<td>13</td>
<td>78.02</td>
</tr>
<tr>
<td>Supply chain flexibility</td>
<td>54.75</td>
<td>19</td>
<td>87.82</td>
</tr>
<tr>
<td><strong>Risk management culture</strong></td>
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<tr>
<td>Supply chain flexibility</td>
<td>46.07</td>
<td>13</td>
<td>63.36</td>
</tr>
</tbody>
</table>

**Note:** ***$p < 0.001$
Panel A: hypotheses testing (DV: ROA)

<table>
<thead>
<tr>
<th>Value of supply chain resilience</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>IFI</th>
<th>TLI</th>
<th>CFI</th>
<th>RMSEA</th>
<th>( \Delta \chi^2 )</th>
<th>( \Delta df )</th>
<th>( p )</th>
<th>( \beta ) (Low/High)</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC resilience ( \rightarrow ) ROA (H1)</td>
<td>189.88</td>
<td>27</td>
<td>0.96</td>
<td>0.94</td>
<td>0.96</td>
<td>0.07</td>
<td>0.13*</td>
<td>Support H1</td>
<td></td>
<td></td>
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<tr>
<td>Multi-group analysis (DV: ROA)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMC (H2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Baseline model</td>
<td>231.36</td>
<td>54</td>
<td>0.98</td>
<td>0.92</td>
<td>0.93</td>
<td>0.05</td>
<td>15.77</td>
<td>8</td>
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<td>0.12*</td>
<td>0.19*</td>
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<tr>
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<td>0.92</td>
<td>0.06</td>
<td>11.28</td>
<td>1</td>
<td>&lt; 0.01</td>
<td>0.15*</td>
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<td>0.91</td>
<td>0.94</td>
<td>0.06</td>
<td>11.28</td>
<td>1</td>
<td>&lt; 0.01</td>
<td>0.15*</td>
<td>Support H1</td>
</tr>
<tr>
<td>Multi-group analysis (DV: ROA)</td>
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<tr>
<td>RMC (H2)</td>
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<tr>
<td>Baseline model</td>
<td>231.88</td>
<td>54</td>
<td>0.98</td>
<td>0.94</td>
<td>0.97</td>
<td>0.07</td>
<td>26.23</td>
<td>8</td>
<td>&lt; 0.001</td>
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<td>Support H3</td>
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<td>0.95</td>
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<td>0.95</td>
<td>0.07</td>
<td>26.23</td>
<td>8</td>
<td>&lt; 0.001</td>
<td>0.15*</td>
<td>Support H3</td>
</tr>
<tr>
<td>Constrained path( a )</td>
<td>239.96</td>
<td>55</td>
<td>0.96</td>
<td>0.93</td>
<td>0.96</td>
<td>0.07</td>
<td>26.23</td>
<td>8</td>
<td>&lt; 0.001</td>
<td>0.15*</td>
<td>Support H3</td>
</tr>
<tr>
<td>SCF (H3)</td>
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</tr>
<tr>
<td>Baseline model</td>
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<td>0.94</td>
<td>0.95</td>
<td>0.95</td>
<td>0.06</td>
<td>17.88</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.12*</td>
<td>0.20*</td>
</tr>
<tr>
<td>Constrained model</td>
<td>235.54</td>
<td>62</td>
<td>0.95</td>
<td>0.95</td>
<td>0.96</td>
<td>0.06</td>
<td>17.88</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.12*</td>
<td>0.20*</td>
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<tr>
<td>Constrained path( a )</td>
<td>222.57</td>
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<td>0.97</td>
<td>0.96</td>
<td>0.97</td>
<td>0.06</td>
<td>17.88</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.12*</td>
<td>0.20*</td>
</tr>
<tr>
<td>II (H4)</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Baseline model</td>
<td>244.25</td>
<td>54</td>
<td>0.89</td>
<td>0.90</td>
<td>0.91</td>
<td>0.06</td>
<td>12.12</td>
<td>8</td>
<td>0.15</td>
<td>0.13*</td>
<td>0.16*</td>
</tr>
<tr>
<td>Constrained model</td>
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<td>62</td>
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<td>0.91</td>
<td>0.91</td>
<td>0.06</td>
<td>12.12</td>
<td>8</td>
<td>0.15</td>
<td>0.13*</td>
<td>0.16*</td>
</tr>
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<td>Constrained path( a )</td>
<td>248.42</td>
<td>55</td>
<td>0.91</td>
<td>0.90</td>
<td>0.91</td>
<td>0.06</td>
<td>12.12</td>
<td>8</td>
<td>0.15</td>
<td>0.13*</td>
<td>0.16*</td>
</tr>
<tr>
<td>EI (H5)</td>
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</tr>
<tr>
<td>Baseline model</td>
<td>244.25</td>
<td>54</td>
<td>0.89</td>
<td>0.90</td>
<td>0.91</td>
<td>0.06</td>
<td>12.12</td>
<td>8</td>
<td>0.15</td>
<td>0.13*</td>
<td>0.16*</td>
</tr>
<tr>
<td>Constrained model</td>
<td>256.37</td>
<td>62</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
<td>0.06</td>
<td>12.12</td>
<td>8</td>
<td>0.15</td>
<td>0.13*</td>
<td>0.16*</td>
</tr>
<tr>
<td>Constrained path( a )</td>
<td>248.42</td>
<td>55</td>
<td>0.91</td>
<td>0.90</td>
<td>0.91</td>
<td>0.06</td>
<td>12.12</td>
<td>8</td>
<td>0.15</td>
<td>0.13*</td>
<td>0.16*</td>
</tr>
</tbody>
</table>

Panel B: robustness analysis (DV: ROE)

<table>
<thead>
<tr>
<th>Value of supply chain resilience</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>IFI</th>
<th>TLI</th>
<th>CFI</th>
<th>RMSEA</th>
<th>( \Delta \chi^2 )</th>
<th>( \Delta df )</th>
<th>( p )</th>
<th>( \beta ) (Low/High)</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC resilience ( \rightarrow ) ROE (H1)</td>
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<td>27</td>
<td>0.94</td>
<td>0.93</td>
<td>0.94</td>
<td>0.09</td>
<td>0.12****</td>
<td>Support H1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Multi-group analysis (DV: ROE)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>RMC (H2)</td>
<td></td>
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<td>54</td>
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<td>0.90</td>
<td>0.93</td>
<td>0.08</td>
<td>17.61</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.11*</td>
<td>0.16*</td>
</tr>
<tr>
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<td>0.93</td>
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<td>0.91</td>
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<td>0.93</td>
<td>0.07</td>
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<td>1</td>
<td>&lt; 0.05</td>
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(continued)
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<th>TLI</th>
<th>CFI</th>
<th>RMSEA</th>
<th>$\Delta\chi^2$</th>
<th>$\Delta$df</th>
<th>$p$</th>
<th>$\beta$ (Low/High)</th>
<th>Hypotheses</th>
</tr>
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<tbody>
<tr>
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<td>54</td>
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<td>0.94</td>
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<td>0.93</td>
<td>0.07</td>
<td>23.69</td>
<td>1</td>
<td>&lt; 0.001</td>
<td>0.10*</td>
<td>Support H5</td>
</tr>
<tr>
<td><strong>Constrained model</strong></td>
<td>233.76</td>
<td>62</td>
<td>0.93</td>
<td>0.91</td>
<td>0.93</td>
<td>0.07</td>
<td>16.46</td>
<td>8</td>
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<td>0.17*</td>
<td>Support H4</td>
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<td>Constrained path$^b$</td>
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<td>0.92</td>
<td>0.94</td>
<td>0.07</td>
<td>3.87</td>
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<td>&lt; 0.05</td>
<td>0.05**</td>
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</tr>
<tr>
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<td>221.73</td>
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<td>0.95</td>
<td>0.93</td>
<td>0.95</td>
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<td>8</td>
<td>&lt; 0.001</td>
<td>0.23***</td>
<td>Support H2</td>
</tr>
<tr>
<td>Constrained model</td>
<td>242.21</td>
<td>62</td>
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<td>0.07</td>
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<td>&lt; 0.05</td>
<td>0.30**</td>
<td>Support H3</td>
</tr>
<tr>
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<td>231.82</td>
<td>55</td>
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<td>0.91</td>
<td>0.94</td>
<td>0.07</td>
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<td>&lt; 0.01</td>
<td>0.16***</td>
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</tr>
<tr>
<td><strong>Baseline model</strong></td>
<td>216.15</td>
<td>54</td>
<td>0.97</td>
<td>0.94</td>
<td>0.97</td>
<td>0.06</td>
<td>0.20*</td>
<td>0.06</td>
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<tr>
<td>Constrained model</td>
<td>228.43</td>
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<td>0.93</td>
<td>0.96</td>
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<td>0.23***</td>
<td>Support H2</td>
</tr>
<tr>
<td><strong>Constrained model</strong></td>
<td>249.13</td>
<td>62</td>
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<td>0.93</td>
<td>0.93</td>
<td>0.06</td>
<td>28.81</td>
<td>8</td>
<td>&lt; 0.001</td>
<td>0.10*</td>
<td>Support H5</td>
</tr>
<tr>
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<td>0.93</td>
<td>0.07</td>
<td>23.69</td>
<td>1</td>
<td>&lt; 0.001</td>
<td>0.10*</td>
<td>Support H5</td>
</tr>
<tr>
<td><strong>Baseline model</strong></td>
<td>233.76</td>
<td>62</td>
<td>0.93</td>
<td>0.91</td>
<td>0.93</td>
<td>0.07</td>
<td>16.46</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.17*</td>
<td>Support H4</td>
</tr>
<tr>
<td>Constrained model</td>
<td>221.17</td>
<td>55</td>
<td>0.94</td>
<td>0.92</td>
<td>0.94</td>
<td>0.07</td>
<td>3.87</td>
<td>1</td>
<td>&lt; 0.05</td>
<td>0.05**</td>
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</table>

**Panel C: robustness analysis (DV: Net Profit)**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>$\chi^2$</th>
<th>df</th>
<th>IFI</th>
<th>TLI</th>
<th>CFI</th>
<th>RMSEA</th>
<th>$\Delta\chi^2$</th>
<th>$\Delta$df</th>
<th>$p$</th>
<th>$\beta$ (Low/High)</th>
<th>Hypotheses</th>
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<tr>
<td><strong>EI (H5)</strong></td>
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<td>0.94</td>
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<td>29.82</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.29***</td>
<td>Reject H5</td>
</tr>
<tr>
<td>Constrained model</td>
<td>224.78</td>
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<td>0.94</td>
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<td>0.94</td>
<td>0.05</td>
<td>4.46</td>
<td>1</td>
<td>&lt; 0.05</td>
<td>0.27***</td>
<td></td>
</tr>
<tr>
<td><strong>EI (H5)</strong></td>
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<td>54</td>
<td>0.91</td>
<td>0.94</td>
<td>0.94</td>
<td>0.05</td>
<td>29.82</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.29***</td>
<td>Reject H5</td>
</tr>
<tr>
<td>Constrained model</td>
<td>224.78</td>
<td>55</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>0.05</td>
<td>4.46</td>
<td>1</td>
<td>&lt; 0.05</td>
<td>0.27***</td>
<td></td>
</tr>
<tr>
<td><strong>Baseline model</strong></td>
<td>221.73</td>
<td>54</td>
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<td>0.93</td>
<td>0.95</td>
<td>0.07</td>
<td>26.58</td>
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<td>&lt; 0.001</td>
<td>0.23***</td>
<td>Support H2</td>
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<td>242.21</td>
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<td>0.07</td>
<td>17.05</td>
<td>8</td>
<td>&lt; 0.05</td>
<td>0.30**</td>
<td>Support H3</td>
</tr>
<tr>
<td>Constrained path$^c$</td>
<td>231.82</td>
<td>55</td>
<td>0.94</td>
<td>0.91</td>
<td>0.94</td>
<td>0.07</td>
<td>6.66</td>
<td>1</td>
<td>&lt; 0.01</td>
<td>0.16**</td>
<td></td>
</tr>
<tr>
<td><strong>Baseline model</strong></td>
<td>216.15</td>
<td>54</td>
<td>0.97</td>
<td>0.94</td>
<td>0.97</td>
<td>0.06</td>
<td>0.20*</td>
<td>0.06</td>
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<tr>
<td>Constrained model</td>
<td>228.43</td>
<td>55</td>
<td>0.96</td>
<td>0.93</td>
<td>0.96</td>
<td>0.08</td>
<td>12.28</td>
<td>1</td>
<td>&lt; 0.001</td>
<td>0.23***</td>
<td>Support H2</td>
</tr>
</tbody>
</table>

**Notes:**
- Constrained the path “SC resilience → ROA”;
- Constrained the path “SC resilience → ROE”;
- Constrained the path “SC resilience → Net Profit”.
- $*p < 0.05$;
- $**p < 0.01$;
- $***p < 0.001$;
- $****p < 0.1$.
Similarly, both \( \chi^2 \) differences are significant under different levels of SCF (\( \Delta \chi^2 = 26.23, \Delta df = 8, p < 0.001; \Delta \chi^2 = 8.07, \Delta df = 1, p < 0.01 \)) and II (\( \Delta \chi^2 = 17.88, \Delta df = 8, p < 0.05; \Delta \chi^2 = 4.91, \Delta df = 1, p < 0.05 \)). Table V shows positive and significant results for the relationship between SC resilience and ROA when SCF is low (\( \beta = 0.18, p < 0.05 \)) or high (\( \beta = 0.15, p < 0.05 \)) and II is low (\( \beta = 0.12, p < 0.05 \)) or high (\( \beta = 0.20, p < 0.05 \)). Hence, \( H3 \) and \( H4 \) were supported.

Investigating the moderating role of EI in the relationship between SC resilience and ROA, we found significant \( \chi^2 \) differences (\( \Delta \chi^2 = 4.17, \Delta df = 1, p < 0.05 \)) between the baseline and the constrained path, but we found insignificant \( \chi^2 \) differences (\( \Delta \chi^2 = 12.12, \Delta df = 8, p > 0.05 \)) between the baseline model and the constrained models. Hence, \( H5 \) was rejected.

Robustness analysis and endogeneity tests

We chose two additional indicators of financial performance to verify the robustness of the study findings, namely, return on equity (ROE) and net profit to reconduct the hypotheses testing. ROE accounts for a financial perspective from a shareholder point, presenting profit generation of the stockholders’ equity. Net profit measures how much revenues are left after excluding all expenses, appearing at the bottom of a firm’s income statement. Firm managers, creditors, and investors refer to these indicators for the judgment of the firm’s financial position (Jegers, 1991). Panels B and C of Table V show the results. The moderating effect of EI (\( H5 \)) was supported with ROE as the dependent variable. All other hypotheses testing results were consistent with panel A of Table V.

Three dependent variables can be affected by other factors that are not observed in this study, raising our attention on the issue of endogeneity. We addressed this concern by introducing a two-stage least squares (2SLS) method, as suggested by Larcker and Rusticus (2010) and Wooldridge (2009). In this study, we apply a reversed scale of risk/disruption management teams’ hierarchy levels in their firms as the instrumental variable. First, an instrumental variable should be correlated with the independent variable (Wooldridge, 2009). The low hierarchy level of the risk/disruption management team represents a significant place in the firm, and the team can allocate more resources to handle disruptions (Porter, 1962), indicating the firm’s higher level of SC resilience. Second, how the hierarchy level of the risk/disruption management team would affect financial performance is unclear, suggesting the instrumental variable’s exogeneity (Wooldridge, 2009). Same as main test, firm age, annual revenue, employee number and industry type were included as control variables.

Hansen’s J-test was first conducted to measure the instrument’s appropriateness following Larcker and Rusticus (2010). This test aims to investigate the association between the instrument and dependent variables from over-identifying restrictions. The insignificant results (\( p > 0.05 \)) show the validity of the instrument. We then assessed the strength of the instrument. The instrument is positive and significant (\( p < 0.05 \)) in the first-stage model of 2SLS, suggesting that we did not suffer from the weak instrument (Wooldridge, 2009).

The second-stage model was then adopted to address the concern on the endogeneity due to unobservable omitted variables. The positive and significant (\( p < 0.05 \)) impact of predicted values of SC resilience from the first stage on financial performance is consistent with the results \( H1 \). Thus, we conclude that the results were robust and this study did not suffer from potential biases caused by endogeneity (Larcker and Rusticus, 2010; Wooldridge, 2009). Table VI shows the results of the endogeneity tests.

Discussion and implications

Discussion and theoretical implications

This study contributes to the SC resilience literature that calls for investigation on the financial impact of SC resilience (Hohenstein et al., 2015). SC resilience is recognized as a
buffer for excessive capacity maintenance that increases expenses (Ghaderi et al., 2018). However, the present study empirically confirmed that SC resilience positively affects the firm’s financial performance, suggesting the business value of SC resilience for handling SC disruptions. The result supports our expectation and is consistent with prior research (e.g. Yu et al., 2019). The present study advances the SC resilience literature by focusing on objective measures of financial performance, instead of several subjective items listed in the questionnaire (e.g. Li et al., 2017; Yu et al., 2019), which may result in common method variance (Podsakoff et al., 2003).

The present study contributes to the theories of organizational culture and resource orchestration. The common view of organizational culture and resource orchestration theories suggests that organizations strive for reducing the influences of SC disruptions. However, beyond this common ground, organizational culture provides a theoretical foundation for RMC and SCF, which are regarded as a control- and flexibility-oriented organizational activities, whereas resource orchestration theory provides a foundation for integration. Complementing one another, these two theories are integrated to explain the relationship between SC resilience and financial performance, and how the roles of RMC, SCF and integration affect the relationship.

Handling disruptions is one of the most important elements of SC resilience. Considerable logically interrelated practices or approaches support one another and help firms build resilience (Dabhikar et al., 2016). RMC, SCF and integration are the strategies or the capabilities that help firms cope with disruptions and obtain good performance based on the literature and the above-mentioned theories. However, their roles in the relationship between SC resilience and business performance are still unknown. The present study contributes knowledge to the literature by providing insights into the moderating roles of the culture, flexibility and integration in the performance impact of SC resilience. It serves as a reference for future research to explore the impact of other activities and environmental conditions in the relationship.

This study proves the positive and significant effects of RMC, SCF and II on the relationship between SC resilience and financial performance. As a control-oriented activity, RMC has a significant effect on the SC resilience–financial performance as conjectured based on organizational culture theory (Denison and Spreitzer, 1991). The results suggest that having control-oriented activities is sufficient in helping firms to cope with the changing environmental condition, which is largely out of the firm’s control. The significant moderating effect suggests that RMC as a cultural element offers firms with control of

<table>
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<th>SC resilience</th>
<th>ROA</th>
<th>ROE</th>
<th>Net profit</th>
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<td>0.152* (0.356)</td>
<td>0.169* (0.552)</td>
<td>0.260* (0.173)</td>
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<tr>
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</tr>
<tr>
<td>Firm age</td>
<td>0.038 (0.065)</td>
<td>−0.047 (0.086)</td>
<td>−0.069 (0.086)</td>
<td>0.010 (0.085)</td>
</tr>
<tr>
<td>Annual revenue</td>
<td>0.111 (0.083)</td>
<td>0.007 (0.102)</td>
<td>−0.021 (0.102)</td>
<td>−0.024 (0.100)</td>
</tr>
<tr>
<td>Number of employees</td>
<td>0.055 (0.075)</td>
<td>−0.078 (0.102)</td>
<td>−0.028 (0.102)</td>
<td>0.011 (0.101)</td>
</tr>
<tr>
<td>Type of industry</td>
<td>0.138 (0.065)</td>
<td>0.048 (0.087)</td>
<td>0.058 (0.087)</td>
<td>0.062 (0.086)</td>
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<tr>
<td>Instrumental variable</td>
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<tr>
<td>Intercept</td>
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<td>0.000 (0.070)</td>
<td>0.000 (0.070)</td>
<td>0.000 (0.069)</td>
</tr>
<tr>
<td>$R^2$</td>
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<td>0.026</td>
<td>0.023</td>
<td>0.050</td>
</tr>
<tr>
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<td>0.020</td>
<td>0.017</td>
<td>0.031</td>
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<tr>
<td>Hansen’s J-test</td>
<td>−0.121 (1.651)</td>
<td>−0.108 (2.777)</td>
<td>−0.053 (0.852)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard errors in parentheses; $\Delta R^2$ refers to $R^2$ change comparing with models that include control variables only (not shown in the table). *$p < 0.05$
changes in its business environment. SCF and II significantly affect the relationship between SC resilience and financial performance, which suggests the value of SCF and II for firms’ financial performance when the firms maintain teamwork in the internal organization and build strategic partnership across SCs.

With respect to the role of EI, the results did not show support for the value of SC resilience on financial performance. A plausible explanation can be related to our sample group. Table I shows that many medium and large companies are listed in Taiwan. The large firm size and complexity of external partners of the firms may make EI insufficient to positively affect the relationship between SC resilience and financial performance. SCs are complex due to the tiers of SC partners (e.g. suppliers and customers) from different countries and industries, thereby increasing the difficulty of EI (Shao et al., 2018). Considerable efforts on administration, coordination and control over their actions are required to implement EI in large firms. Hence, the moderation of EI in the relationship between SC resilience and financial performance is insignificant. Firms’ specific efforts on the adoption of certain strategies help them outperform their competitors but do not guarantee an improved financial performance based on resource orchestration theory (Sirmon et al., 2011). In line with the theory, firms could find operational value in the process of EI implementation, considering as capability building activities, even in the absence of effects on the financial benefits of SC resilience.

Managerial implications
Managers currently face increasing disruptions in the SC management. In response, they increase the organizational capability to cope with disruptions to avoid the negative effect. Although some scholars find that firms can improve their operational performance and gain profit due to SC resilience (Chowdhury et al., 2019; Wieland and Wallenburg, 2013), managers still believe that adopting SC resilience is costly. From the results of this study, managers are equipped with empirical evidence of the positive effect of SC resilience on financial performance. The finding motivates managers to invest in SC resilience to protect the firms against negative impacts from SC disruptions. Although the adoption of SC resilience-related practices is a cost, considerable financial results can be achieved through the allocated resources and efforts on building resilient SCs.

Based on the findings, three out of four moderators (i.e. RMC, SCF and II) enhance the financial performance outcomes of SC resilience, whereas EI does not affect the relationship. Managers can now tell how to adopt strategies and get financial performance with SC resilience and why the efforts on the implementation of certain strategies and building SC resilience do not always cause desirable performance outcomes. Excessive practices adopted in a firm may lead to negative business performance impact, as severe disruptions (e.g. earthquakes and floods) do not happen frequently. Managers should adopt management practices with the consideration of the environmental conditions (e.g. political environments, industry characteristics, firm scale and market share) and disruption types that they learn to cope with. Most of Taiwanese firms are export oriented (Chen et al., 2015). They invest in factories in less-developed countries and operate internationally to gain market opportunities. This mode of operations introduces risks of managing their SC with cultural differences, which makes it difficult to develop RMC, SCF and II. The positive and significant effects of RMC, SCF and II on the SC resilience-performance relationship indicate the importance of work closely across functions, share the same culture in risk management and retain flexibility in SC. Due to the international operations nature of the sample firms, the study findings provide references for managers in other places as well.

Limitations and future research agenda
Several limitations of this study should be noted. First, our measurements for SC resilience capture firms’ capabilities, such as adaptability and responsiveness to SC disruptions.
Managers still lack knowledge about the practices they can adopt to improve their capabilities (Ambulkar et al., 2015). Thus, identifying specific organizational practices that constitute to SC resilience to handle disruptions is important. The practices of SC resilience and its measurement scales will provide useful references for firms to conduct an evaluation of their efforts on SC resilience and detect improvement areas. Second, we only conducted a survey to get primary data for measurements of SC resilience and the moderators (i.e. RMC, SCF, II and EI). Future studies are suggested to adopt a multimethod research design, including field studies and interviews, to obtain additional information from firms. Third, our sample was chosen from the manufacturing industry located in Taiwan. Other studies can choose different industries and/or different places to carry on further studies on the same relationships as well as validate and generalize our study findings. Last, as the limitation of the survey method, we did not collect data from a long term. Hence, further studies should focus on the impact of SC resilience and the role of culture, flexibility and integration on financial performance in the long run.

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Corresponding author
Christina W.Y. Wong can be contacted at: tcchris@polyu.edu.hk

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Supply chain integration in omni-channel retailing: a human resource management perspective

Shaohua Song, Xianliang Shi and Guang Song
School of Economics and Management, Beijing Jiaotong University, Beijing, China

Abstract
Purpose – The purpose of this paper is to apply the dynamic capability view to identify relationships between human capital (HC), supply chain integration (SCI) and firm's performance. It also examines the moderating effect of product variety (PV) on these relationships in the context of omni-channel retailing (OCR).

Design/methodology/approach – An empirical study was conducted based on survey research. In total, 230 retailers in China’s market adopting omni-channel strategy were surveyed to examine the hypotheses proposed in our conceptual model using statistical techniques.

Findings – This study reveals that HC has a positive impact on SCI, and the impact of employees’ capital is greater on the success of SCI than that of managers' capital. Moreover, the results confirm that SCI facilitates the achievement of superior performance. Organization integration contributes the most to performance improvement in OCR. Additionally, this study identifies the positive moderating effect of PV on the relationship between HC and SCI, while the moderating effect is insignificant to the influence of SCI on performance.

Research limitations/implications – We obtained valuable insights for both academicians and practitioners. On the one hand, this could be an early attempt as an interdisciplinary study to empirically analyze supply chain management in OCR from human resource perspective. It reveals the importance of human resource management (HRM) and the contribution of SCI to OC retailers. Therefore, this study fills current research gaps. On the other hand, this study provides several practical insights to top management: the importance of improving an individual’s competency to sustain a retailer’s dynamic capability; and the importance of strengthening the organization’s integration to better achieve effective SCI in OCR. Additionally, this study proposes future research based on its limitations.

Originality/value – SCI is investigated in the context of OCR from the HRM perspective. Moreover, this study reveals the importance of HRM and discusses the moderator’s effect in OCR.

Keywords Human capital, Supply chain integration, Omni-channel

Paper type Research paper

Introduction
Omni-channel retailing (OCR) is viewed as an enabler to facilitate retailers to increase customer loyalty, enhance customer satisfaction and improve economic performances (Melacini et al., 2018). However, the channel alignment is a complex task because each channel presents different features, for example, the offline channel is characterized by less order quantity and product self-pick-up, whereas the online channel presents larger order quantity and home delivery (Verhoef et al., 2015; Chopra, 2016). The distinct characteristics of two channels indicate that the transition from multi-channel to omni-channel (OC) requires the joint efforts of every operation process in an entire supply chain (Murfield et al., 2017). Therefore, supply chain integration (SCI) is the key to achieving successful OCR. Furthermore, offline retailers have relatively simple requirements for employees that mainly focus on strong practicality (Kim and Kim, 2012). However, OC retailers require multi-skilled talents that understand information technology and participate more in the supply chain design to achieve precision marketing for customer’s demand (Lee, 2017; Verhoef et al., 2015). Therefore, individual capability is an enabler for SCI in the context of OCR.

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In the literature, SCI in OCR has been discussed only by a few researchers who developed propositions based on exploratory studies. Such studies concluded that retailers could integrate the supply chain from information integration (II), process integration (PI) and organization integration (OI) (Cao, 2014; Hübner, Holzapfel and Kuhn, 2016), and stated that the firm’s performance can be improved when an integration strategy is adopted (Um et al., 2017; Rajaguru and Matanda, 2019). Furthermore, a number of studies linking supply chain management (SCM) and human resource management (HRM) claimed human capital (HC) is a dominant driver of SCI (e.g. Wang et al., 2016; Ding et al., 2015). Particularly, latest research on SCM in OCR has proposed that the most critical driver to influence the success of SCI to OC retailers is people’s capability (Song et al., 2019).

Despite SCM and individual competency in OCR being researched in the recent literature, there are still research gaps. First, the link between HC and SCI in OCR has received little attention in the literature; consequently, the effect of HRM on SCI is unknown. Second, most current studies discussing supply chain issues in OCR were qualitative, while many propositions have not been examined quantitatively. Although SCI has been widely studied in the manufacturing field, SCI in OCR presents significant variance to manufacturers. For example, the internal integration of OC retailers not only involves the cooperation among functions of each channel, but also mentions the alignment between channels that are often operated as individual business unit in practice. Third, prior studies of SCI from the OCR context mainly discussed the direct effects of various factors on channel integration, while the influence of contextual factors was ignored. To fill these research gaps, we conduct an interdisciplinary study on SCM in the context of OCR aiming to empirically identify the relationships between HC, SCI and firm’s performance and examine the moderating effects of product variety (PV).

In this study, the dynamic capability view (DCV) is applied for the following reasons. First, DCV explains how firms achieve success in a rapidly changing environment (Teece et al., 1997; Barrales-Molina et al., 2015). Retailers must improve their adaptability to cater to significant changes in both demand and technological development. Therefore, DCV is a proper theory corresponding to the characteristics of the retail market. Second, DCV emphasizes sustainable competitive advantage relying on the renewal of firm competencies (Teece et al., 1997; Gutierrez-Gutierrez et al., 2018). A competent HR enables sustainable growth because a well-trained workforce enhances the capability of organizational learning. Therefore, DCV is a suitable theory to explain the evolvement of individual competencies. Third, many studies (e.g. Feng et al., 2017; Rajaguru and Matanda, 2019) have viewed SCI as a firm’s dynamic capability because it facilitates firms to acquire external knowledge and develop strategic routines for supply chain members. Therefore, DCV is appropriate for studying SCI.

We contribute to the literature in several aspects. First, this paper might be the first attempt as an interdisciplinary study to empirically explore the mechanism of SCI in the context of OCR from HRM perspective. Second, this study proposes a theoretical framework to evaluate HC from skill, attitude and interpersonal relationships. Third, this study not only identifies the direct relationships between HC, SCI and performance, but also analyzes the effects of moderators on these relationships.

The remainder of this study is organized as follows. Section 2 presents a literature review of relevant topics. Section 3 explains the hypothesized conceptual model. Section 4 explains the research methodology, and Section 5 presents the results of the empirical analysis. Section 6 discusses the main findings, and Section 7 presents the conclusion, limitations and future research lines.

**Literature review**

**HC in OCR**

Several researchers have claimed that the success of SCM practices in OCR relies on individual capability. For example, Gonzalez-Loureiro et al. (2014) suggested that the HC
could be considered a strategic priority in channel integration because people's capabilities leverage firms' sustainable growth in OCR. Moreover, Song et al. (2019) argued that OC retailers need to reallocate HRs to improve their employees' efficiency and promote organizational integration. Although the significance of HC in OCR field is gaining increasing recognition, prior studies mainly contributed to the qualitative analysis, while quantitative research on this issue remains scarce and the effect of people's competency on SCI in OCR is still unexplored.

In the field of HRM, HC can be defined as the sum of the skills, experience, commitment and abilities of personnel within and across organizations (Flothmann, Hoberg and Wieland, 2018). As a complex concept, HC can be assessed from several perspectives. For examples, Huo et al. (2015) explored the impact of HRM on SCM based on the analysis of employees' skills, incentives and their participation. Huo et al. (2016) also applied personnel commitment and skill level as representative factors of HC to study their roles in SCM. Moreover, Shou et al. (2018) considered people's intellectual capital and relationship as HRM antecedents to identify the effects on SCM. Although various factors of HC have been studied and some of them present homogeneous meaning in the literature of SCM, there is still not an agreed-upon classification of HC. In this study, we classify HC into the following three dimensions: skill, attitude and interpersonal relationship.

To provide further detail, the skill of HC refers to the depth and breadth of professional skills, knowledge and experiences related to job performance (Huo et al., 2016); the attitude of HC involves the trust, commitment and enthusiasm of the people (Fu et al., 2013) and measures the extent of the personnel's job participation and devotion; and the interpersonal relationship presents the individual's relational capability as a critical resource supporting SCI because it facilitates teamwork culture in joint problem solving (Wang et al., 2016). Furthermore, HRM literature has stated that customers of HR are managers and employees (Foss et al., 2015), and the previously mentioned studies that linked SCM and HRM also considered management level and ordinary employees independently. Therefore, we measure HC from the perspectives of managers and employees separately to consider the roles of the various actors of OC retailers on SCI.

HC in SCI
In the current literature, some studies analyzed the direct impact of HC on SCI and presented mixed findings. A few revealed fully positive effects of individual capabilities on SCI. For example, Wang et al. (2016) examined the effects of manufacturers' HR capabilities and IT resources on a firms' internal integration capabilities and their further influence on supplier integration. They found that employee capabilities had positive effects on both internal and external integration. Nevertheless, some studies have shown that HC may not always play a positive role in SCI. For example, Huo et al. (2015) considered HC to comprise employee skill and participation, and identified some partial positive relationships between HC and SCI.

The inconsistencies of the findings can be explained as the varying contexts pose different needs for and outcomes of integration (Chang et al., 2016; Turkulainen et al., 2017). Therefore, some studies have considered the moderators when studying the relationship between HC and SCI. For example, Prajogo and Oke (2016) examined the role of external environmental factors on the relationships between HC and business performance and stated that dynamic environments positively moderate those relationships, whereas competitive environments weakened it. Mandal (2018) not only investigated the influence of HC on healthcare agility and supply chain performance, the author also studied the moderating role of IT capability and empirically confirmed all of the hypothesized relationships.

Despite several past contributions about the relationships between HC and SCI, there are huge gaps that should be filled. On the one hand, no study has quantitatively addressed the effects of HC on SCI from the context of OCR. On the other hand, the discussion about
moderators in the relationship between HC and SCI remains inadequate, particularly in the context of OCR. Therefore, this research conducts an interdisciplinary study linking HRM and SCM and explores the moderating effect of the firm nature to provide deeper understanding from the context of OCR.

SCI and performance

Over the past two decades, the relationship between SCI and performance has been widely discussed in literature. Several researchers (e.g. Shou et al., 2017; Delić et al., 2019) claimed that SCI is beneficial to both financial efficiency and operational effectiveness. For example, Kim and Chai (2016) investigated the relationship between business uncertainty and SCI, assessing the moderating effect of manufacturing approaches using data from US manufacturing firms. Their results showed that SCI was positively related to both financial and operational performance. Moreover, Yu et al. (2018) used a sample of food companies to investigate and confirm that II was positively related to both reactive and proactive flexibilities and that it improved the firm's operational performance.

Other studies revealed how SCI could impair a firm's performance under certain conditions because integration requires intensive resources, additional conflicts can be created because of the different orientations among functions and entities (Bernon et al., 2016). Moreover, a higher level of SCI could result in redundant resources and opportunistic behaviors (Ertimur and Venkatesh, 2010; Lui et al., 2006). For example, Zhao et al. (2015) examined the relationships among internal integration, supplier integration, customer integration and firm performance (FP); they revealed that too little or too much SCI could impair financial performance. Additionally, some studies claimed that the SCI–performance relationship contingent on a company’s competitive priorities. For instance, Wiengarten et al. (2019) revealed that SCI in terms of customer and supplier integration does not always improve FP and the marginal competitive advantage and subsequent financial benefits gained from integration might decrease due to competition.

Whereas many studies exist about the relationship between SCI and performance, there are still significant gaps. Most extant literature has placed the focus on the manufacturing sector, whereas the retailing industry has been considerably overlooked. Second, many studies of content-based SCI have discussed single dimensions, such as the foundation role of II on the SCI, rather than considering all potential dimensions (e.g. II, PI, OI) together. Therefore, this research considers all widely discussed integration dimensions to study SCI from the context of OCR.

Conceptual model

This research aims to identify the relationships between HC, SCI and FP in the context of OCR. On the basis of DCV and the characteristics of OCR, the conceptual model is illustrated in Figure 1, and the rationales of the hypothesized model are explained below.

Management level plays a strategic role in SCM under the background of OCR. Managers in OCR not only make the decisions and create dynamic capabilities but also coordinate to ensure that the integrative strategy can be conducted in routine operations through the efforts on information, process and OI. First, the establishment of integrated information system and information sharing mechanism require managers to make overall planning and top-level designs while their sense of responsibility, cross-field knowledge and problem-solving ability are considerably important in OCR (Hübner, Wollenburg and Hozapfel, 2016; Song et al., 2019). Moreover, managers’ relationships with others help to share information among departments and with external partners, and facilitate to develop rules and norms in partner communication (Shou et al., 2018). Second, given that PI involves many links in the supply chain, the capability of managers is
considerably important. High-skilled and experienced managers could redesign the workflow from a strategic perspective and encourage workforces to improve collaboration (Wang et al., 2016). Third, managers’ multi-skills and excellent character, such as being honest and trustworthy, could greatly influence the working atmosphere and team spirit as well as help build a learning-oriented culture (Gonzalez and Melo, 2017). Moreover, a motivated and trustworthy workforce facilitates interaction and strategic collaboration across functions (Huo et al., 2016), and a manager’s relationship with people is not only essential in developing cross-functional or organizational teams but also crucial for influencing other attitudes and understanding organizational changes (Chen et al., 2018). Therefore, we developed the following hypotheses:

\[ H1a. \] With OCR, managers’ capital (MC) is positively related to II.

\[ H1b. \] With OCR, MC is positively related to PI.

\[ H1c. \] With OCR, MC is positively related to OI.

According to DCV, employees’ competencies ensure that the workforce is capable of understanding the firm’s strategy and performing rational behavior in the changing retail environment (Gutierrez-Gutierrez et al., 2018). Therefore, employees’ capital (EC) is a key factor to providing distinct competencies when retailers integrate the supply chain (Jin et al., 2010). First, an experienced workforce is more likely to provide accurate technical know-how and will have better access to knowledge embedded in networks and relationships (Shou et al., 2018). Therefore, well-trained employees can build and use integrated information systems to achieve real-time information sharing while accurately completing a series of processes, leading to effective information and Pls (Lin, 2017). Second, high levels of knowledge and skills facilitate employees to understand the philosophy and principles of the retailers and to adapt to environmental changes (Hohenstein et al., 2014). Moreover, employees’ well-established interpersonal relationships facilitate teamwork culture in joint problem solving, regarding the individual’s relational capability as a critical resource supporting SCI (Wang et al., 2016). Third, under the OC strategy, cooperative and high-involvement employees are more helpful for retailers to achieve organizational amalgamate and reorganization, moving toward interactive and mass-communication (Huo et al., 2016; Melacini et al., 2018), because well-established interpersonal relationships are foundation to coordinate all
functions and have long-term, stable cooperation with suppliers (Farndale et al., 2010). Therefore, we developed the following hypotheses:

$H2a$. With OCR, EC is positively related to II.

$H2b$. With OCR, EC is positively related to PI.

$H2c$. With OCR, EC is positively related to OI.

In OCR, a unique and integrated information system across all channels should be well established as a key element in improving overall value via the sharing of real-time information among channels (Chopra, 2016; Zhou and Wan, 2017). On the one hand, by considering an OCR strategy, where data are integrated across all channels and customers can seamlessly move from one channel to another, it can not only help retailers to develop appropriate logistics methods certainly according to different product types (e.g. low- and high-inventory turnovers products), but also improve the level of inventory management through real-time data sharing, using stores merely as showrooms (Bhatnagar and Syam, 2014). On the other hand, II with supply chain partners can help to reduce bullwhip effect and improve supply chain flexibility, which in turn leads to successful performance outcomes (Savastano et al., 2019). Furthermore, DCV regards information as valuable, rare, inimitable and non-substitutable resources. It is crucial to develop dynamic learning by creating a mechanism to integrate information and knowledge within the supply chain to improve a firm’s competitive advantages (Govindan et al., 2016). Therefore, we developed the following hypothesis:

$H3$. With OCR, retailer’s II is positively related to firm’s performance.

Under the OC strategy, a successful factor for retailers is the ability to integrate business processes between two channels (Hübner, Holzapfel and Kuhn, 2016). First, focusing on the PI between online and traditional channels, retailers can use existing facilities to handle both online and traditional sales to minimize logistics costs and respond rapidly to their customers, such as “Click & Collect,” using traditional stores as pick-up points (Melacini et al., 2018). Second, retailers have an effective and integrated inventory management, which is significant in terms of both timing and quantities of order-fulfilment (Li et al., 2015). Moreover, retailers can offer customers rapid delivery and cover wide area, which can bring convenience to customers, help to increase customer loyalty and produce benefits for the retailer in the long run (Cao et al., 2016). Furthermore, based on the DCV, retailers improve customer consumption experience and cultivate customer loyalty by PI activities, which have been defined as dynamic capabilities to strengthen their competitiveness. Therefore, we developed the following hypothesis:

$H4$. In OCR, retailer’s PI is positively related to firm’s performance.

Some researches claimed that transitioning to OCR requires a superior organization and integration in inter-organizational practices (e.g. Bernon et al., 2016; Rai, Verlinde, Macharis, Schoutteet and Vanhaverbeke, 2019). OI is viewed as a facilitator of high-efficiency SCM operations because it involves multiple collaborative working relationships across all organizational levels and regular communication between partners (Zhang et al., 2015; Alfalla-Luque et al., 2015). On the one hand, significant revisions for retailers could occur at the organizational level because OC retailers can facilitate OI and maintain long-term competitive advantages via the shifting of corporate culture, restructuring the organization and redesigning the HRM mechanism (Cao, 2014). On the other hand, the success of OI allows retailers to develop and manage relationships with customers and their supply chain partners and to coordinate with cross-functional cooperation, thereby enabling retailers to integrate their supply chains more easily and effectively (Cao et al., 2015). Based on DCV,
retailers can obtain organizational capability, which impacts their capacity for creating
tvalue by affecting the transformation of inputs into outputs (Qi et al., 2017). Therefore, we
developed the following hypothesis:

\[ H_5. \text{With OCR, retailer's OI is positively related to firm's performance.} \]

From a marketer’s perspective, retailers with a wider PV would capture a larger market
share because of the greater probability of meeting customer needs (Um et al., 2017).
Particularly, when traditional retailers move toward OC approach, they are able to further
fulfill customer expectations due to the wide product assortments that are virtually
limitless online (Hubner, Holzapfel and Kuhn, 2016). However, research of SCM tends to
indicate opposite attitudes about the effects of PV on FP, including longer lead times and
higher inventory levels caused by increased supply chain complexity (Syam and
Bhatnagar, 2015; Wan and Sanders, 2017). To mitigate the negative impact of PV,
improvement of individual capabilities is required because the qualified workforce is
capable of handling the management complexity (Um et al., 2017). Moreover, SCI can
maintain a competitive advantage in a high PV because many operational challenges
could be improved through information transparency and coordination with supply
chain partners (Wan and Sanders, 2017). Therefore, this study considers PV measured by
the number of stock-keeping units (SKU) as a variable to examine the moderating effect
on the relationships between HC, SCI and performance, the following hypotheses
are presented:

\[ H_6. \text{With OCR, retailer's PV positively moderates the relationship between HC and SCI.} \]

\[ H_7. \text{With OCR, retailer's PV negatively moderates the relationship between SCI and performance.} \]

**Methodology**

**Research process**

This study conducts an empirical analysis based on survey research and sampling of
retailers in Chinese markets. The detailed research process used in developing and
assessing the conceptual model was based on a four-step procedure. First, a data pre-test
was conducted to examine the reliability of the collected data. Second, an exploratory study
was carried out to identify the factor groups based on common characteristics of identified
measured items. Third, a confirmatory study was employed to test the validity of the
hypothesized factor construct. Last, hierarchical regression was used to examine the
hypotheses and the effects of moderator.

**Measures and questionnaire design**

In this study, a comprehensive review of the studies across the fields of HRM, SCI and OCR
was conducted to identify potential measures for the conceptual constructs, and the
academic contributions in the special issues of the *International Journal of Physical
Distribution & Logistics Management* and the *Journal of Retailing* are particularly studied.
Consequently, 37 measured items were adopted, and the supported references are listed in
Table AI.

According to the conceptual model and the adopted measures, the questionnaire is
divided into three parts. In the first part, we measured the levels of both MC and employees'
capital in OC retailers from skills, attitude and interpersonal relationship. In the second part,
the three integration dimensions of SCI are evaluated from internal and external sides,
which indicated the integration level between retailers’ two channels and between retailers
and their suppliers. Finally, the improvements of retailers’ performance including
operational and financial aspects are investigated. A popular approach used in several studies on SCI includes the five-point Likert scale to measure the items, with “1” indicating “strongly disagree” and “5” indicating “strongly agree.”

Sampling and data collection

As the largest developing country and e-commerce market, China presents tremendous value and potential in the retailing sector. In 2018, the overall revenue of the Chinese retailing reached RMB38.1T, made up 76.2 percent of China’s economic growth (NBS, 2018). Although the retailing market is unbalanced in mainland China and based on geographic location, the channel integration presents substantial development due to the increasing innovation ability of leading retailers and the encouragement of government in recent years (MOFCOM, 2018). In particular, some traditional market leaders not only explore the online channel as a complement of offline channel but also offer buy-online-pickup-in-store and buy-in-store-ship-direct services to attract consumers in developed cities (QZIRI, 2019). Therefore, studying China’s sample is of great significance in OCR.

In this study, we sent questionnaires to traditional firms that explored the online channel and registered in the China General Chamber of Commerce (CGCC). The questionnaire was designed by an internet-based application and sent to retailers as a website link embedded in the invitation letter that was e-mailed by CGCC. Before running the survey, we carried out pilot tests with interviews of three researchers and three practitioners in OCR, and the necessary modifications were conducted based on their feedbacks to ensure the acceptability and understandability. An individual who is a decision maker of firm strategy was asked to answer the questionnaire anonymously to ensure that the comprehensive and accurate information could be collected from knowledgeable informants. Furthermore, four weeks divided into two equal periods were given for each respondent. Respondents were requested to finish the questionnaire during the first period, and they would receive a reminder when the first period finished. Finally, we sent 700 questionnaires at the end of the collection period.

In the questionnaire, every question was mandatory and required an answer. Therefore, although almost 30 percent of the respondents rejected the survey on the grounds that they had not adopted OC strategy for the time being, 230 of them were usable and acceptable after a comprehensive verification of the returned answers, translating to a response rate of 32.8 percent, presenting a more satisfied result compared with other relevant studies wherein the return rate is often lower than 20 percent (e.g. Flynn et al., 2010; Huo et al., 2017).

The profiles of the respondents and their firms’ characteristics are summarized in Table I. Although this study did not consider the impact of firm age, size and ownership on the implementation of SCI under OCR, applying descriptive statistics on the characteristics of respondent retailers can make the results more universal.

The traditional validation methods were applied to test the validity of the data set. Non-response bias was tested based on the differences of measured items between early and late responses. By comparing the late responses (86 in total) obtained after a reminder with the early responses (144) on measured items and demographic variables, the results of t-tests indicate no significant differences, suggesting that non-response bias is not a concern. Furthermore, a two-pronged approach was applied to test common method bias. First, six factors with eigenvalues higher than 1.0 were extracted based on exploratory factor analysis. The results showed that the constructs are conceptually and practically correlated. Second, the single-factor model was examined through confirmatory factor analysis, and the fit indices ($\chi^2/df = 8.257$, RMSEA = 0.153, NFI = 0.761, CFI = 0.772) presented an unacceptable level. Therefore, common method bias is not an issue.
Results

Preliminary study

Considering that the measured items are mainly identified from previous studies and have not been systematically tested under the background of OCR, this study conducted factor analysis to examine the reliability and validity of the constructs. To ensure the suitability of the collected data for entire factor analysis, a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett’s test were conducted. The overall result of the KMO test was 0.875, and the Bartlett’s test for sphericity showed a satisfactory result. Therefore, both measures indicated that the data set was suitable for factor analysis.

Exploratory study

Exploratory factor analysis was first applied to extract crucial factors using SPSS 24.0. The result presented 37 variables that were loaded into six factors (see Table II), accounting for approximately 74.9 percent of the total variance. The $\alpha$ value of each factor group was higher than the suggested threshold of 0.6 (Skipper and Hanna, 2009), indicating all measured variables could be represented by the six factors named in the conceptual model.

Confirmatory study

Confirmatory factor analysis was then employed to assess the unidimensionality, reliability and validity. The results shown in Table III indicate that the model is purely acceptable because the overall fit is adequate based on the main fit indices (i.e. $\chi^2/df=1.817$, 

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>%</th>
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<tbody>
<tr>
<td><strong>Respondent’s position</strong></td>
<td></td>
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<tr>
<td>General manager</td>
<td>57</td>
</tr>
<tr>
<td>Vice president/director of SCM</td>
<td>43</td>
</tr>
<tr>
<td><strong>Firm age (number of years in China’s market)</strong></td>
<td></td>
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<tr>
<td>&lt; 5</td>
<td>21</td>
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<tr>
<td>5–10</td>
<td>22</td>
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<td>11–15</td>
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<td>16–20</td>
<td>15</td>
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<tr>
<td>&gt; 20</td>
<td>27</td>
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<tr>
<td><strong>Firm size (annual sales in millions of RMB)</strong></td>
<td></td>
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<tr>
<td>&lt; 50</td>
<td>17</td>
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<tr>
<td>50–100</td>
<td>14</td>
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<tr>
<td>100–200</td>
<td>9</td>
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<tr>
<td>200–2,000</td>
<td>25</td>
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<tr>
<td>&gt; 2,000</td>
<td>35</td>
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<tr>
<td><strong>Ownership of the firm</strong></td>
<td></td>
</tr>
<tr>
<td>State owned</td>
<td>40</td>
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<tr>
<td>Local private</td>
<td>50</td>
</tr>
<tr>
<td>Foreign</td>
<td>6</td>
</tr>
<tr>
<td>Joint venture</td>
<td>4</td>
</tr>
<tr>
<td><strong>Number of SKU</strong></td>
<td></td>
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<tr>
<td>&lt; 500</td>
<td>52</td>
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<tr>
<td>500–1,000</td>
<td>14</td>
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<tr>
<td>1,000–5,000</td>
<td>12</td>
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<tr>
<td>5,000–10,000</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 10,000</td>
<td>18</td>
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</table>

Table I. Profile of respondents and their firms
Moreover, the results revealed that the $t$-value of all items exceeded the critical ratio at a 0.05 level of significance and that the $R^2$ value of each variable was greater than 0.4. This is sufficient evidence of convergent validity. The test of discriminant validity was examined by comparing the average variance extracted (AVE) with the squared correlation between constructs (Koufteros, 1999). The results indicate that all squared correlations were significantly lower than their individual AVE values (see Table IV).

### Hypotheses testing and results

A hierarchical regression was applied to test the proposed hypotheses. To avoid the threat of multi-collinearity, variance inflation factors were computed at each step of the hierarchical regression model. All variance inflation factors values were less than 10.000, revealing that the data set was suitable for regression analysis.
### Table III. Parameter estimates of the confirmatory factor analysis

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item</th>
<th>Standardized factor loading</th>
<th>t-value</th>
<th>R^2</th>
</tr>
</thead>
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<tr>
<td>Factor 1: MC</td>
<td>MC1</td>
<td>0.881</td>
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<td>0.628</td>
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<tr>
<td></td>
<td>MC2</td>
<td>0.870</td>
<td>18.389</td>
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</tr>
<tr>
<td></td>
<td>MC3</td>
<td>0.848</td>
<td>17.474</td>
<td>0.744</td>
</tr>
<tr>
<td></td>
<td>MC4</td>
<td>0.849</td>
<td>17.525</td>
<td>0.794</td>
</tr>
<tr>
<td></td>
<td>MC5</td>
<td>0.691</td>
<td>12.353</td>
<td>0.650</td>
</tr>
<tr>
<td></td>
<td>MC6</td>
<td>0.780</td>
<td>14.983</td>
<td>0.685</td>
</tr>
<tr>
<td>Factor 2: EC</td>
<td>EC1</td>
<td>0.815</td>
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<td>0.487</td>
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<tr>
<td></td>
<td>EC2</td>
<td>0.761</td>
<td>12.975</td>
<td>0.412</td>
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<tr>
<td></td>
<td>EC3</td>
<td>0.789</td>
<td>13.643</td>
<td>0.423</td>
</tr>
<tr>
<td></td>
<td>EC4</td>
<td>0.809</td>
<td>14.143</td>
<td>0.781</td>
</tr>
<tr>
<td></td>
<td>EC5</td>
<td>0.821</td>
<td>14.426</td>
<td>0.746</td>
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<td></td>
<td>EC6</td>
<td>0.785</td>
<td>13.782</td>
<td>0.802</td>
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<tr>
<td>Factor 3: II</td>
<td>II1</td>
<td>0.773</td>
<td>–</td>
<td>0.797</td>
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<tr>
<td></td>
<td>II2</td>
<td>0.711</td>
<td>7.504</td>
<td>0.860</td>
</tr>
<tr>
<td></td>
<td>II3</td>
<td>0.711</td>
<td>8.506</td>
<td>0.710</td>
</tr>
<tr>
<td></td>
<td>II4</td>
<td>0.770</td>
<td>8.154</td>
<td>0.739</td>
</tr>
<tr>
<td></td>
<td>II5</td>
<td>0.755</td>
<td>10.482</td>
<td>0.460</td>
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<tr>
<td></td>
<td>II6</td>
<td>0.778</td>
<td>7.853</td>
<td>0.604</td>
</tr>
<tr>
<td>Factor 4: PI</td>
<td>PI1</td>
<td>0.772</td>
<td>–</td>
<td>0.596</td>
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<tr>
<td></td>
<td>PI2</td>
<td>0.777</td>
<td>13.999</td>
<td>0.606</td>
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<td></td>
<td>PI3</td>
<td>0.678</td>
<td>10.947</td>
<td>0.429</td>
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<tr>
<td></td>
<td>PI4</td>
<td>0.809</td>
<td>14.789</td>
<td>0.449</td>
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<td></td>
<td>PI5</td>
<td>0.842</td>
<td>14.447</td>
<td>0.505</td>
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<td></td>
<td>PI6</td>
<td>0.927</td>
<td>16.52</td>
<td>0.373</td>
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<td></td>
<td>PI7</td>
<td>0.893</td>
<td>15.611</td>
<td>0.453</td>
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<tr>
<td>Factor 5: OI</td>
<td>OI1</td>
<td>0.895</td>
<td>–</td>
<td>0.632</td>
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<tr>
<td></td>
<td>OI2</td>
<td>0.864</td>
<td>18.744</td>
<td>0.674</td>
</tr>
<tr>
<td></td>
<td>OI3</td>
<td>0.883</td>
<td>19.63</td>
<td>0.655</td>
</tr>
<tr>
<td></td>
<td>OI4</td>
<td>0.650</td>
<td>11.465</td>
<td>0.622</td>
</tr>
<tr>
<td></td>
<td>OI5</td>
<td>0.642</td>
<td>11.247</td>
<td>0.579</td>
</tr>
<tr>
<td></td>
<td>OI6</td>
<td>0.698</td>
<td>12.758</td>
<td>0.665</td>
</tr>
<tr>
<td>Factor 6: FP</td>
<td>FP1</td>
<td>0.828</td>
<td>–</td>
<td>0.608</td>
</tr>
<tr>
<td></td>
<td>FP2</td>
<td>0.806</td>
<td>21.446</td>
<td>0.478</td>
</tr>
<tr>
<td></td>
<td>FP3</td>
<td>0.891</td>
<td>17.128</td>
<td>0.721</td>
</tr>
<tr>
<td></td>
<td>FP4</td>
<td>0.862</td>
<td>16.234</td>
<td>0.719</td>
</tr>
<tr>
<td></td>
<td>FP5</td>
<td>0.835</td>
<td>15.424</td>
<td>0.757</td>
</tr>
<tr>
<td></td>
<td>FP6</td>
<td>0.910</td>
<td>17.732</td>
<td>0.777</td>
</tr>
</tbody>
</table>

**Notes:** χ^2 = 1,092.055, df = 601, χ^2/df = 1.817, RMSEA = 0.044, CFI = 0.931, GFI = 0.800, AGFI = 0.766, NFI = 0.859, TLI = 0.923

### Table IV. Discriminant validity

<table>
<thead>
<tr>
<th></th>
<th>AVE</th>
<th>MC</th>
<th>EC</th>
<th>II</th>
<th>PI</th>
<th>OI</th>
<th>FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>0.676</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>0.638</td>
<td>0.404</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>II</td>
<td>0.563</td>
<td>0.058</td>
<td>0.011</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>PI</td>
<td>0.681</td>
<td>0.023</td>
<td>0.041</td>
<td>–0.092</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>OI</td>
<td>0.608</td>
<td>–0.016</td>
<td>0.003</td>
<td>0.273</td>
<td>–0.064</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>FP</td>
<td>0.733</td>
<td>0.306</td>
<td>0.273</td>
<td>0.000</td>
<td>0.012</td>
<td>–0.014</td>
<td>–</td>
</tr>
</tbody>
</table>

**SCI in OCR:**
As shown in Table V, the significant coefficient of MC in Model 1 ($\beta = 0.337$, $p < 0.001$) indicated that MC is positively related to II, supporting $H1a$. The result also showed that the regression coefficient of EC was 0.641 at a significance level of 0.001, indicating that II was determined by EC in OC retailers ($H2a$). Similarly, $H1b$–$H2b$ and $H1c$–$H2c$ are accepted, meaning that both MC and EC have positive effects on SCI. Regarding the impact of SCI on FP, the results from Model 7 indicate that all three dimensions of SCI are significant, and the OI presented more positive and significant effects compared to II and PI. Therefore, $H3$, $H4$ and $H5$ are accepted. Moreover, the results of Models 2, 4 and 6 revealed that PV had a significant effect on the relationship between HC and SCI ($p < 0.01$), whereas the moderating effect on the relationship between SCI and performance was not found ($p > 0.1$). Therefore, $H6$ is supported, but $H7$ is rejected. Additionally, the $F$-test and the value of the adjusted $R^2$ of each model confirm that the output of the regression models is accepted.

On the basis of the correlation matrix (see Table VI), there is a strong correlation among the three dimensions of SCI and performance is weak. This result further verifies the moderating effect of PV on the relationship between HC and SCI. A slope test was then conducted to further understand the mechanism of the moderating effect. In this study, we divided the samples into the two following categories: high PV (> 500 SKU) and low PV (≤ 500 SKU). The two-way controlling effects are illustrated in Figure 2, presenting the higher PV of retailers, which strengthens the relationship between HC and SCI. Therefore, it positively affected HC on SCI, moderated by PV.

<table>
<thead>
<tr>
<th>Model</th>
<th>Information integration</th>
<th>Process integration</th>
<th>Organization integration</th>
<th>Firm performance</th>
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<tbody>
<tr>
<td>Direct effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>0.337***</td>
<td>2.194***</td>
<td>0.358***</td>
<td>1.544***</td>
</tr>
<tr>
<td>EC</td>
<td>0.641***</td>
<td>3.288***</td>
<td>0.569***</td>
<td>2.682***</td>
</tr>
<tr>
<td>II</td>
<td>0.189*</td>
<td>0.208*</td>
<td>0.17*</td>
<td>0.273*</td>
</tr>
<tr>
<td>PI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC × PV</td>
<td>0.105**</td>
<td>0.079*</td>
<td>0.109**</td>
<td></td>
</tr>
<tr>
<td>EC × PV</td>
<td>0.114**</td>
<td>0.134**</td>
<td>0.107**</td>
<td>0.044</td>
</tr>
<tr>
<td>II × PV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI × PV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OI × PV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>3.143***</td>
<td>3.429***</td>
<td>3.302***</td>
<td>3.572***</td>
</tr>
</tbody>
</table>

**Table V.** Result of hierarchical regression analysis

**Notes:** *p < 0.05; **p < 0.01; ***p < 0.001

<table>
<thead>
<tr>
<th>MC</th>
<th>EC</th>
<th>II</th>
<th>PI</th>
<th>OI</th>
<th>FP</th>
<th>PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>0.977**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>0.281**</td>
<td>0.290**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>0.203**</td>
<td>0.235**</td>
<td>0.780**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OI</td>
<td>0.247**</td>
<td>0.265**</td>
<td>0.849**</td>
<td>0.829**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>FP</td>
<td>0.174**</td>
<td>0.188**</td>
<td>0.704**</td>
<td>0.675**</td>
<td>0.717**</td>
<td>1</td>
</tr>
<tr>
<td>PV</td>
<td>0.867**</td>
<td>0.949**</td>
<td>0.281**</td>
<td>0.260**</td>
<td>0.270**</td>
<td>0.204**</td>
</tr>
</tbody>
</table>

**Table VI.** Correlation analysis

**Note:** **p < 0.01
Discussion

Critical HC to SCI

The results of this study showed that both MC and EC are significant to all the three dimensions of SCI in OCR, drawing from the support of $H1$ and $H2$. These results are fully supported by previous studies, which reported a positive relationship between HC and SCI (e.g., Shub and Stonebraker, 2009; Ataseven et al., 2018). The confirmed result could be explained through two reasons. On the one hand, based on the DCV, a highly qualified HR tends to show great ability to sense changes and monitor environment variables, promoting and creating DCs (Barrales-Molina et al., 2015). On the other hand, HC can promote the progress of integration by knowledge sharing, generation, codification and application (Wu and Chen, 2014).

Our results also revealed that EC generates stronger impact than MC. This is a very different finding from that of current literature, which states that MC is more important.
because of their greater responsibilities, power and enforcement. However, those previous studies may ignore that the real practitioners of the firm’s strategy are the employees, particularly for the labor-intensive retailing. The SCM is a very practical issue; despite the strategic decisions made by top management, the success of integration activities largely depends on the qualification of the workforce conducting routine operations because employees create value directly and interact more closely with supply chain partners and customers (Nejati et al., 2017). Therefore, employee’s capital plays a dominant role in SCI to OC retailers.

Enablers of performance in SCI
In this study, the results found that there is a positive relationship between SCI and performance when retailers implement an integrative strategy. This finding not only supports extant SCI literature in OCR but also proves that a firm’s DCs enable competitive advantages in a rapidly changing market.

In detail, our results revealed that there is a positive relationship between II and performance in OCR (H3). This finding further confirms some previous studies (e.g. Wong et al., 2015; Zhao et al., 2015) in which intra- and inter-organizational II could better streamline the supply chain and eliminate non-value-adding activities while information could develop dynamic learning resources to integrate internal and external competence to achieve sustainable competitive advantage (Rajaguru and Matanda, 2019).

Our results also indicated the significant relationship between PI and performance in OCR (H4), because it directly improves operational flexibility and creates superior value for consumers via share existing facilities, aggregation of stock levels and integration of control policies (Bernon et al., 2016). However, the previous study found that PI has no significant positive impact on FP for OC retailers, such as Song et al. (2019), and found that the positive effect of PI on OC retailers’ performance is not obvious. Therefore, this result also showed that the management capability of OC retailers in China has evolved in the past couple of years. The improvement of HC level enables retailers to cultivate more dynamic capabilities and improves the SCI level, ultimately the FP.

Furthermore, the results not only support that OI is positively related to FP (H5) but also show that this dimension is the most significant enabler of performance in OCR, which is consistent with the findings of some studies (e.g. Cao et al., 2015; Zhu et al., 2018). On the basis of the DCV and knowledge management, organizations could connect people and encourage multidisciplinary activities, leveraging the knowledge flow via OI, which enables retailers to reconstruct their DCs. Otherwise, organizational issues have been regarded as the most serious barrier in OCR because retailers must redesign the mechanism of both organizational and HRs issues (Rai, Verlinde and Macharis, 2019).

Effects of moderators in OCR
The results of this study confirmed the positive moderating effect of PV on the relationship between HC and SCI (H6). This finding agrees with some previous studies that claimed that a high-level PV could facilitate a firm’s motivation to collaborate (e.g. Um et al., 2017). Therefore, management will focus on the cultivation of employees’ quality and ability to respond to market instability caused by high PV (Syam and Bhatnagar, 2015).

Although the results of some prior studies showed that PV negatively moderates the relationship between SCI and performance in manufacturing, our study revealed that this moderating effect is insignificant in the context of OCR (H7). The different results can be explained as follows. In manufacturing, SCM involves many issues such as design, procurement, production, distribution and after-sales service (Wan and Sanders, 2017). Physical source management includes not only raw materials but also semi-finished and final products. Therefore, the increase of PV indicates many changes for each SCM issue.
In the context of OCR, the scope and the complexity of SCM is less than that of the manufacturers because fewer stages of SCM are involved. Moreover, the downstream customers faced by retailers are mostly individuals with small demand and low power in the supply chain (Rai, Verlinde and Macharis, 2019), reducing the difficulty of retailer’s SCM. Therefore, industry characteristics have determined that the impact of PV on SCM in OCR is insignificant.

Conclusion, implications and future research
Applying DCV, this study identifies the relationships among HC, SCI and performance in the context of OCR. The results revealed that the capital of both managers and employees affects SCI, generating significant influence on FP when implementing OC strategy. Moreover, this study found the moderating effect of PV on the relationship between HC and SCI in OCR.

This study contributes to literature in three ways. First, we not only developed a HC framework including three aspects based on literature research but also identified their synthesized effect on OC retailers’ SCI. Therefore, this research might be the first empirical-based study that links HC and SCI in the context of OCR. Second, the three most widely discussed integration dimensions (i.e. II, PI and OI) are considered together in this study to examine their enabling effects on retailers’ performance. Therefore, this study can be regarded as an extension of SCI literature in retail sector. Third, this study not only found a positive relationship between HC, SCI and performance in OCR but also examined the moderating effects on these relationships. The potential impact of moderators on SCM has been discussed less in OCR literature. Therefore, this study offers new theoretical insight in the SCM under the context of OCR.

Furthermore, this study offers valuable insights for practitioners, which can be summarized as follows. First, retailers should improve individual competencies based on effective HR practices to implement SCI under OCR strategy. Particularly, the retailers must invest more resources into the enhancement of employee capabilities to solve the problem of low education level of ordinary employees of traditional retailers in China’s market. Although employees in online channels have received at least college education, it is still difficult to find multi-skilled stuffs. Second, the retailers that own a wider PV should pay more attention to the HC to achieve more effective SCI. Although high PV makes the SCM more complex, it can accelerate the progress of SCI to enterprises via the highlight of managers, the training of employees’ skills and the reconstruction of organization culture. Third, our study can strengthen the confidence of top managers in implementing an integrative strategy because the positive effect has been proved. Moreover, the management level should consider OI as the primary task to facilitate the achievement of superior performance.

Although this study contributes to both academics and practice, some limitations remain, and several issues could be further studied in detail. First, HR practices can improve a firm’s dynamic capabilities and generate competitive advantages. Therefore, it might be an opportunity to examine the effect of HR practices on SCM in the context of OCR, whereas this issue has been neglected in this study. Second, new insights could be found if research of SCI in OCR were conducted in mature markets and benchmarking with developing countries because the influence of unpredictable rules is less prevalent in advanced nations. Third, China is a developing country with unbalanced economic development and obvious regional and industrial differences, so more moderators should be considered because the complexity of the market environment causes retailers to face more difficulties when implementing OCR. For example, this paper did not consider the related industry sectors and geographical location of respondents during the investigation; in the future, researchers can study OCR strategy by taking these two factors into consideration.
References


Chopra, S. (2016), "How omni-channel can be the future of retailing", Decision, Vol. 43 No. 2, pp. 135-144.


## Appendix

<table>
<thead>
<tr>
<th>Measured variable</th>
<th>Item</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving</td>
<td>MC1</td>
<td>Flothmann, Hoberg and Gammelgaard (2018)</td>
</tr>
<tr>
<td>Coordination</td>
<td>MC2</td>
<td>Fu et al. (2013)</td>
</tr>
<tr>
<td>Eager to give suggestions</td>
<td>MC3</td>
<td>Mandal (2018)</td>
</tr>
<tr>
<td>Honest to colleagues</td>
<td>MC4</td>
<td>Mandal (2018)</td>
</tr>
<tr>
<td>Internal relationship</td>
<td>MC5</td>
<td>Gómez et al. (2015)</td>
</tr>
<tr>
<td>External relationship</td>
<td>MC6</td>
<td>Shou et al. (2018)</td>
</tr>
<tr>
<td>Sophisticated skills</td>
<td>EC1</td>
<td>Prajogo and Oke (2016)</td>
</tr>
<tr>
<td>Useful experience</td>
<td>EC2</td>
<td>Mandal (2018)</td>
</tr>
<tr>
<td>Creativeness</td>
<td>EC3</td>
<td>Mandal (2018)</td>
</tr>
<tr>
<td>Be willing to contribute ideas</td>
<td>EC4</td>
<td>Gómez et al. (2015)</td>
</tr>
<tr>
<td>Be willing to cooperate</td>
<td>EC5</td>
<td>Gómez et al. (2015)</td>
</tr>
<tr>
<td>Relationship with partners</td>
<td>EC6</td>
<td>Fu et al. (2013)</td>
</tr>
<tr>
<td>Integrated information system</td>
<td>II1</td>
<td>Zhang et al. (2015)</td>
</tr>
<tr>
<td>Real-time data sharing</td>
<td>II2</td>
<td>Macarena et al. (2018)</td>
</tr>
<tr>
<td>Mechanism of confidentiality</td>
<td>II3</td>
<td>Zhang et al. (2015)</td>
</tr>
<tr>
<td>Sharing information</td>
<td>II4</td>
<td>Yu et al. (2018)</td>
</tr>
<tr>
<td>Sharing performance matrix</td>
<td>II5</td>
<td>Macarena et al. (2018)</td>
</tr>
<tr>
<td>Unified data interface</td>
<td>II6</td>
<td>Yu et al. (2018)</td>
</tr>
<tr>
<td>Process integration internally</td>
<td>PI1</td>
<td>Cao et al. (2015)</td>
</tr>
<tr>
<td>Integrative inventory management</td>
<td>PI2</td>
<td>Ailawadi and Farris (2017)</td>
</tr>
<tr>
<td>Joint decision-making</td>
<td>PI3</td>
<td>Huo et al. (2017)</td>
</tr>
<tr>
<td>Integrative inventory management externally</td>
<td>PI4</td>
<td>Alfalla-Luque et al. (2015)</td>
</tr>
<tr>
<td>Accurate delivery</td>
<td>PI5</td>
<td>Macarena et al. (2018)</td>
</tr>
<tr>
<td>Jointly process design</td>
<td>PI6</td>
<td>Cheng et al. (2016)</td>
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<tr>
<td>Relationship with suppliers</td>
<td>PI7</td>
<td>Cheng et al. (2016)</td>
</tr>
<tr>
<td>Regular inter-departmental meetings</td>
<td>OI1</td>
<td>Cao et al. (2015)</td>
</tr>
<tr>
<td>Working together internally</td>
<td>OI2</td>
<td>Zhang et al. (2015)</td>
</tr>
<tr>
<td>Specialized team for joint decision-making</td>
<td>OI3</td>
<td>Flynn et al. (2010)</td>
</tr>
<tr>
<td>Stable external cooperation</td>
<td>OI4</td>
<td>Xu et al. (2014)</td>
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<tr>
<td>Regular communication externally</td>
<td>OI5</td>
<td>Alfalla-Luque et al. (2015)</td>
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<tr>
<td>Compatibility of culture</td>
<td>OI6</td>
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<td>Service level</td>
<td>FP1</td>
<td>Govindan et al. (2016)</td>
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<tr>
<td>Responsiveness</td>
<td>FP2</td>
<td>Liu and Lai (2016)</td>
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<td>FP3</td>
<td>Tseng and Liao (2015)</td>
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<tr>
<td>Revenue</td>
<td>FP4</td>
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<tr>
<td>Operations cost</td>
<td>FP5</td>
<td>Liu and Lai (2016)</td>
</tr>
<tr>
<td>ROA</td>
<td>FP6</td>
<td>Huo et al. (2015)</td>
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### Corresponding author
Guang Song can be contacted at: songguang@bjtu.edu.cn

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Sustainable supply chain management: continuing evolution and future directions

Craig R. Carter, Marc R. Hatton, Chao Wu and Xiangjing Chen

Department of Supply Chain Management, Arizona State University, Tempe, Arizona, USA

Abstract

Purpose – The purpose of this paper is to update the work of Carter and Easton (2011), by conducting a systematic review of the sustainable supply chain management (SSCM) literature in the primary logistics and supply chain management journals, during the 2010–2018 timeframe.

Design/methodology/approach – The authors use a systematic literature review (SLR) methodology which follows the methodology employed by Carter and Easton (2011). An evaluation of this methodology, using the Modified AMSTAR criteria, demonstrates a high level of empirical validity.

Findings – The field of SSCM continues to evolve with changes in substantive focus, theoretical lenses, unit of analysis, methodology and type of analysis. However, there are still abundant future research opportunities, including investigating under-researched topics such as diversity and human rights/working conditions, employing the group as the unit of analysis and better addressing empirical validity and social desirability bias.

Research limitations/implications – The findings result in prescriptions and a broad agenda to guide future research in the SSCM arena. The final section of the paper provides additional avenues for future research surrounding theory development and decision making.

Originality/value – This SLR provides a rigorous, methodologically valid review of the continuing evolution of empirical SSCM research over a 28-year time period.

Keywords Environment, Economic performance, Sustainability, Social responsibility, Triple bottom line, Sustainable supply chain management, Systematic literature review

1. Introduction

Sustainability has increasingly become a part of how firms manage their production and operations, with 82 percent of S&P 500 companies publishing separate sustainability reports in 2016 compared with only 20 percent in 2011 (GreenBiz, 2018). However, over 90 percent of the impact on natural resources, including air, soil and land, is due to supply chain management (SCM) activities, and over 80 percent of greenhouse-gas emissions for consumer-goods products occur in the supply chain (Bové and Swartz, 2016). As noted by Gary Hirshberg, President and CEO of Stonyfield Farms, “Even though we were the first manufacturer in America to offset 100% of the CO2 emissions from our manufacturing plants, these incredible offsets amounted to a rounding error in terms of our total carbon footprint […] despite the great things we did in our plant, unless we tackled our supply chain’s carbon footprint, we were nowhere” (Sustainable Supply Chain Foundation, 2019). For most organizations, focusing on sustainability beyond the four walls – i.e. sustainable supply chain management (SSCM) – has the greatest overall impact (Schmidt et al., 2017).

SSCM has also become one of the primary areas of research in the SCM discipline. As evidence of this statement, numerous systematic literature reviews (SLRs) have appeared in the literature, to the point where a recent SLR of SLRs was conducted (Carter and Washispack, 2018). In their meta-review, Carter and Washispack (2018) note that one of the remaining opportunities for SSCM SLRs is periodic updates of extant, high-visibility SLRs.

This paper was invited by the journal’s outgoing editor, with the objectives of providing an update to Carter and Easton’s (2011) SSCM SLR and offering guidance for future
SSCM research. The rationale for this periodic update is that while only nine years have passed since Carter and Easton’s work was published, we have seen both a tremendous growth in the interest in and publication of SSCM research. In addition, a priori, we posited a substantial increase in both theoretical and methodological rigor. Our findings, based on this update, do indeed suggest that SSCM research continues to evolve in a positive direction in terms of theory and methodological rigor. However, there are opportunities to further improve methodological rigor – including more fully addressing empirical validity and social desirability bias – and to investigate under-researched substantive areas including diversity and human rights. Furthermore, in the final section of the paper we outline two key opportunities – theory development and decision making – that we believe are particularly in need of additional research. Addressing each of these areas of research will result in not only improved theory and methods, but in findings that will benefit SSCM practice by providing rigorous research that will facilitate SSCM measurement and managerial decision making.

The remainder of this paper is organized as follows. In the next two sections, we describe the methodology used to collect the study’s data and the analysis of these data. We then present the results of this analysis in a table that updates the findings from Carter and Easton (2011). We conclude by discussing these results, comparing the findings with earlier data and presenting prescriptions for future SSCM research.

2. Methodology

In this section of the paper, we describe the methodology, used by Carter and Easton (2011) in their SLR of SSCM research, which we employed for this updated SLR. An SLR allows researchers to perform an objective, transparent and replicable review of the literature (Denyer and Neely, 2004). In particular, we aligned our methodology with Carter and Washispack’s (2018) Modified AMSTAR criteria (see Appendix 1).

To allow a direct comparison with Carter and Easton’s (2011) findings, our review incorporated the same seven journals, which are commonly recognized as encompassing the primary outlets for empirical, SCM research (Giunipero et al., 2008; Cantor, 2008):

(3) *Journal of Business Logistics.*
(4) *Journal of Operations Management.*
(5) *Journal of Supply Chain Management.*
(6) *Transportation Journal.*
(7) *Transportation Research Part E.*

Like Carter and Easton, we adopted Carter and Roger’s (2008, p. 368) definition of SSCM as, “the strategic, transparent integration and achievement of an organization’s social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains.” Articles which centered on topics that fell within this definition of SSCM were considered for inclusion in our analysis, based on topic. A broad, secondary inclusion criterion was that the paper employed an empirical methodology, including, “the collection and analysis of primary or secondary data […] as well as conceptual theory building” (Carter and Easton, 2011, p. 50).

Following Carter and Easton’s exclusion criteria, we omitted articles that focused on the following subjects: consumer issues (e.g. automobile safety); macro/policy issues (as compared
to micro, company and supply chain specific issues; reverse logistics and waste disposal; supply chain security; technical issues surrounding life cycle analysis, end-of-life, cost modeling, hazardous materials, etc., including the regulatory issues surrounding these subjects; and papers where sustainability was an ancillary part of the article's focus. We also excluded papers that employed non-empirical approaches (e.g. mathematical modeling) as well as articles that were opinion based, relied on anecdotal evidence and did not fall under the rubric of conceptual theory building.

The time period of Carter and Easton's (2011) review ended at the end of June 2010. We began data collection by manually reviewing all content published in the seven journals over the eight-year period from July 2010 through the end of June 2018. We reviewed the title, keywords and abstracts of the 2,610 pieces appearing in the above journals over the eight-year time period. The first author reviewed all 2,610 articles for possible inclusion, and the second, third and fourth authors divided the 2,610 articles into three groups with each of these three authors reviewing one of the groups of articles. There were 75 initial disagreements of whether to include or exclude a paper across the 2,610 published papers (an initial inter-coder agreement rate of 97.13 percent). These disagreements were settled through discussion and consensus.

This review resulted in the initial inclusion of 194 potential articles. We next performed a keyword search of the same journals and time period, using both the EBSCO and SCOPUS databases, using the same keywords employed by Carter and Easton (2011, p. 51) in the text and abstract fields. No additional papers were identified through this keyword search. The initial shortlist of 194 papers is displayed in Appendix 2.

Next, we manually reviewed the full articles for each of the 194 papers on the shortlist. Based on the inclusion and exclusion criteria, we eliminated 30 of these papers (denoted by “excluded” in Appendix 2), resulting in a final set of 164 papers used in our analysis.

3. Data coding
The first author coded each of the 164 articles, using Carter and Easton's (2011) coding scheme (Table I). The second, third and fourth authors coded subsamples of the 164 articles, so that each article was coded by two researchers. Following Carter and Easton (2011), we calculated the reliability of the data coding using the proportion of all pairwise agreements between coders.

This resulted in an inter-coder agreement rate of 96.16 percent. Based on the large number of classification categories, this reliability rate is comparable to Cronbach's (1951) coefficient $\alpha$ (Perreault and Leigh, 1989). This reliability rate is far in excess of the recommended minimum value of 0.70, indicating a high level of replicability of the data coding process.

We also evaluated the validity of our SLR methodology using Carter and Washispack's (2018) Modified AMSTAR criteria. Each of these criteria was met: an $a$ priori selection process with explicit inclusion and exclusion criteria; clearly referenced keywords; the use of multiple databases; the use of two or more reviewers for article selection and article coding and reporting of inter-rater reliability statistics; a shortlist of included and excluded papers; and reporting of aggregate study data in table form.

4. Results
Our results are displayed in Table II. Extending Carter and Easton's (2011) analysis, we compare the 2010–2018 time period (Column 2 of Table II) with the two earlier time periods reported in Carter and Easton (2011) (Columns 3 and 4 of the table). We discuss these results and comparisons in the next section of the paper.
5. Discussion and prescriptions for future research

5.1 Subject

Environmental facets of SCM continue to lead the focus of research over the 28-year time period (Section A of Table II). While the focus on environmental topics decreased from the 1991–2000 time period to the 2001–2010 time period, this focus increased from 35.42 percent during the 2001–2010 time period to 45.73 percent during the 2010–2018 time period.

One explanation for this greater proportion of environmental articles during the most recent time period may be the elevated focus by the media on climate change and by industry due to related supply chain disruptions and emissions reporting consortia such as the GRI.

While the environment as a topic increased during the most recent time period, the use of corporate social responsibility as a framework for an article’s conceptualization decreased substantially – from 18.75 to 4.88 percent – between the 2001–2010 and 2010–2018 time periods.
### Section A: subject

<table>
<thead>
<tr>
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<td>Environment</td>
<td>45.73</td>
<td>35.42</td>
<td>53.13</td>
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<tr>
<td>Diversity</td>
<td>0.61</td>
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<td>31.25</td>
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<td>Human rights/Quality of life</td>
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<td>9.38</td>
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<td>0.00</td>
<td>0.00</td>
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### Section B: industry

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<td>4.76</td>
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<td>Consumer products</td>
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<td>16.67</td>
</tr>
<tr>
<td>Food and beverage</td>
<td>7.35</td>
<td>2.38</td>
<td>3.33</td>
</tr>
<tr>
<td>Transportation</td>
<td>35.29</td>
<td>23.81</td>
<td>16.67</td>
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<tr>
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<td>47.62</td>
<td>50.00</td>
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<tr>
<td>Other</td>
<td>11.76</td>
<td>9.52</td>
<td>13.33</td>
</tr>
</tbody>
</table>

### Section C: theoretical lens(es)

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<td>Transaction cost economics</td>
<td>2.44</td>
<td>8.33</td>
<td>3.13</td>
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<tr>
<td>Resource-based view</td>
<td>12.80</td>
<td>16.67</td>
<td>3.13</td>
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<td>Knowledge-based view/Organizational learning</td>
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<td>4.17</td>
<td>0.00</td>
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<td>Stakeholder theory</td>
<td>15.85</td>
<td>35.42</td>
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<td>Other</td>
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<td>9.38</td>
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<td>Multiple lenses</td>
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<td>3.13</td>
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<tr>
<td>None</td>
<td>29.88</td>
<td>33.33</td>
<td>87.50</td>
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### Section D: validity

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<tr>
<td>Addressed (reliability and multiple, additional facets of validity)</td>
<td>66.67</td>
<td>64.44</td>
<td>18.75</td>
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<td>Partially addressed (reliability, but no additional facets of validity)</td>
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<td>8.89</td>
<td>15.63</td>
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<tr>
<td>Not addressed</td>
<td>23.68</td>
<td>26.67</td>
<td>65.63</td>
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### Section E: social desirability bias

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<td>3.45</td>
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<tr>
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<td>75.00</td>
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### Section F: unit of analysis

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<td>Individual</td>
<td>13.41</td>
<td>17.78</td>
<td>25.00</td>
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<tr>
<td>Function or group</td>
<td>1.22</td>
<td>8.89</td>
<td>9.38</td>
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<tr>
<td>Firm (including plant or SBU)</td>
<td>67.68</td>
<td>60.00</td>
<td>65.63</td>
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<td>Supply chain (at least at dyad)</td>
<td>17.68</td>
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<tr>
<td>Other</td>
<td>5.49</td>
<td>6.67</td>
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### Section G: methodology

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<td>Survey</td>
<td>30.49</td>
<td>47.92</td>
<td>78.13</td>
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<td>(Multiple) case study</td>
<td>22.56</td>
<td>22.92</td>
<td>9.38</td>
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<tr>
<td>Archival data</td>
<td>22.56</td>
<td>10.42</td>
<td>6.25</td>
</tr>
<tr>
<td>Empirical/Systematic literature review</td>
<td>7.32</td>
<td>8.33</td>
<td>0.00</td>
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<tr>
<td>Conceptual theory building</td>
<td>10.98</td>
<td>4.17</td>
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</tr>
<tr>
<td>Focus group interviews</td>
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<tr>
<td>Individual interviews</td>
<td>7.93</td>
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### Section H: analysis

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<tr>
<td>Descriptive statistics (summary statistics, means testing, rank analysis)</td>
<td>1.83</td>
<td>11.11</td>
<td>54.29</td>
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<tr>
<td>Regression analysis</td>
<td>7.95</td>
<td>19.05</td>
<td>11.43</td>
</tr>
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</table>

Table II.

Results

(continued)
time periods. There were also decreases in diversity (from 4.17 to 0.61 percent) and human rights/quality of life (from 4.17 to 2.44 percent) as subject foci. Finally, sustainability served as a foundational conceptualization for 48.17 percent of the articles during the 2010–2018 time period (increasing from 25.00 percent during the 2001–2010 time period).

The increased focus on the environmental pillar of SSCM is encouraging. However, the decreased emphasis on diversity and human rights/quality of life suggests an opportunity for future research. These topics might be investigated in a standalone fashion using a number of different methodologies. For example, lab experiments could be used to investigate minority supplier selection decisions and decisions surrounding diversity hiring for transportation and warehousing positions. Archival and field studies could be used to identify firms that are outliers in terms of diversity, human rights and working conditions in their supply chains, and investigate potential differences and key success factors for these outlying conditions. Events studies could be employed to study the impact of human rights and working conditions on stock prices – perhaps at both a focal firm vs its supplier.

Diversity, human rights and working conditions could also be studied in conjunction with other sustainability topics. For example, researchers might consider the potential tradeoffs between improving one pillar of the triple bottom line (e.g. a decreased carbon footprint resulting from reshoring manufacturing) and possibly harming another (e.g. removing the sole source of viable income from a community in an emerging economy). Such tradeoffs can also occur within a pillar of the triple bottom line. For instance, plastic grocery bags have a lower carbon footprint than paper grocery bags, but plastic bags can cause greater damage to the aquatic ecosystem. Such research might begin by identifying tradeoffs via archival and field research, and then investigating how managers might decide among tradeoffs (e.g. by employing a policy capturing approach). Finally, this research stream could ascertain potential workarounds such that tradeoffs are minimized and synergies created.

5.2 Industry

Overall, there were not substantial changes in the industries from which data were collected. The largest change was in the transportation sector, particularly in the case of studies focusing on safety (e.g. Miller and Saldanha, 2016) and emissions (e.g. Rodrigues et al., 2015). Multi-industry studies continue to account for a large proportion of the total. While Carter and Easton (2011) suggested that researchers might narrow their focus to specific industries, with the goals of both developing industry-specific measures and testing the
The use of theory in SSCM research continues to increase. During the 2010–2018 time period, 29.88 percent of studies employed no theoretical lens, compared to 33.33 and 87.50 percent during the 2001–2010 and 1991–2000 time periods, respectively. While recognizing that a theoretical lens is not required across all types of SSCM research and that there are differing missions across the seven journals from which we collected data, this is nonetheless an encouraging trend.

The proportion of papers employing the specific theories examined by Carter and Easton (2011) – transaction cost theory, resource-based theory, the knowledge-based view/organizational learning and stakeholder theory – decreased for each theoretical lens during the 2010–2018 time period. Researchers instead employed “Other” theoretical lenses to a greater extent (57.32 percent for the 2010–2018 time period compared to 45.83 percent during the 2001–2010 time period and 9.38 percent during the 1991–2000 time period). The most common theoretical lenses within the “Other” category for the 2010–2018 time period were institutional theory (6.10 percent), resource dependence theory (3.05 percent), behavioral decision theory (2.44 percent), high reliability theory (2.44 percent) and normal accident theory (2.44 percent). Finally, several studies (5.49 percent) employed a theory building approach as their sole lens.

There seem to be at least two likely reasons for these trends. First, the dominant theories from the earlier time periods have been extensively tested and used in the SSCM and broader SCM literature. Thus, we may have reached a point of saturation (real or perceived). Second, the SCM discipline as a whole seems to be reaching a point of maturation, where scholars are facile with a broader palette of theories and can draw upon the most appropriate theory(ies) to help answer a study’s specific research questions. Our discipline is also increasingly developing SCM-specific theory (Carter, 2011).

The use of a wider range of established theories is encouraging, suggesting that SSCM researchers are employing a wider and likely more appropriate palette of theories to advance research. While the use of multiple theoretical lenses within a study decreased somewhat (from 33.33 percent during the 2001–2010 time period to 28.66 percent during the current time period), this may be due to a deeper and more thoughtful reliance on a single theory to develop hypotheses or inductively develop propositions or taxonomies. We advocate that researchers should continue to employ the most appropriate theoretical lens(es), by developing a wider understanding and appreciation of different, potentially relevant theories that might apply to SSCM phenomena. In addition, we encourage researchers to consider potential tensions between theories, and the application of extant theories to SSCM phenomena. For example, agency theory suggests that a buying firm will be held accountable for the sustainability of its suppliers (Eisenhardt, 1989), while the lens of psychological distance suggests that supplier sustainability would be discounted since it occurs at a distance from the buying firm (Trope and Liberman, 2010). Both of these approaches – using a single theory or complementary theories and using competing theories – provide opportunities to test the boundaries of extant theory within the SSCM context.
Our findings suggest that one promising, under-researched lens is behavioral decision theory. Managers are not rational agents (Kahneman, 2011), perhaps particularly in the case of SSCM. For example, Gattiker and Carter (2010) employ intra-organizational influence theory to investigate the most effective influence tactics to gain the commitment of supply managers to sustainability initiatives; they find that inspirational appeals are significantly more effective than rational persuasion (i.e. making a business case) in gaining commitment. Behavioral decision theory would be a valuable lens to investigate related dynamics, cognition and decision making surrounding SSCM.

5.4 Methodology and analysis
5.4.1 Validity. The proportion of studies that have not addressed validity has not changed substantially between the 2010–2018 (23.68 percent) and the 2001–2010 (26.67 percent) time periods. This is a disturbing finding. Validity is often referred to as the *sine qua non* of empirical research (Kerlinger, 1986; Campbell and Stanley, 1963), meaning that without demonstrating validity, researchers cannot be certain about their results. We strongly advocate that authors, along with editors and reviewers, ensure that empirical validity is clearly demonstrated where appropriate. Obviously, the way in which validity is assessed varies across methodologies, as does the nomenclature (e.g. “reliability” and “validity” vs “credibility” and “trustworthiness”).

5.4.2 Social desirability bias. Social desirability bias exists when study participants tend to answer questions, share perspectives and/or behave in a manner that they believe will be viewed favorably by the researcher and group or societal norms (Crowne and Marlowe, 1960). For some studies, such as those that do not involve human subjects, social desirability bias is largely not applicable. For studies where social desirability bias was applicable, we coded whether the study addressed social desirability bias. The proportion of applicable studies that addressed social desirability bias decreased slightly from 25.00 percent during the 2001–2010 time period to 23.47 percent during the 2010–2018 time period.

Social desirability can be potentially mitigated, for example, via ensuring anonymity, using appropriate question wording and designing experiments so that the research objectives are not understood or communicated to subjects until the subjects are debriefed. Researchers can measure the extent of social desirability bias through the use of a social desirability scale. Crowne and Marlowe (1960) develop one of the earliest scales for assessing social desirability bias. More recent scales, such as the BIDR-16, offer a smaller number of scale items that also leverage the multi-dimensional nature of social desirability bias (Hart et al., 2015). Of course, researchers should do both – attempt to mitigate social desirability bias and test for the presence of the bias – when appropriate. And again, editors and reviewers should help to ensure that the effects of social desirability bias are minimized and measured.

5.4.3 Unit of analysis. The most common unit of analysis (Section F of Table II) is the firm. The focus on the firm as the unit of analysis increased somewhat from the 2001–2010 time period (60.00 percent) to the 2010–2018 time period (67.68 percent). This may be due to the increased use of archival data, described in the next section. An even more dramatic increase appears at the supply chain level, which encompasses the interorganizational dyad through broader interorganizational networks. Only 6.67 percent of the 2001–2010 time period articles employed this supply chain-level unit of analysis, compared to 17.68 percent during the 2010–2018 time period. While not displayed in the table, we also coded articles that employed a multi-level approach (6.10 percent for the 2010–2018 time period). Wichmann et al. (2016), for example, investigate both individual and social network characteristics surrounding a large-scale SSCM initiative.

Our findings suggest that there continue to be opportunities to explore group-level phenomena (only 1.22 percent of articles used the function or group as the unit of analysis...
during the 2010–2018 time period). For example, how does group decision making differ from individual decision making for SSCM phenomena? And, are there differences in group decision making between SSCM and non-SSCM phenomena? Most SSCM initiatives involve multiple functions (Carter et al., 2007; Wichmann et al., 2016). Our findings suggest that there is an almost “blank canvas” for studies that investigate the cross-functional interactions surrounding SSCM. In addition, given the inherent nesting of individuals within groups within firms within networks of firms, there are vast opportunities to take a multi-level perspective – conceptually and methodologically – in future SSCM research.

5.4.4 Methodology. Surveys continued to be the most commonly employed primary methodology during the 2010–2018 time period (30.49 percent) (Section G of Table II). However, unlike the prior two time periods, where surveys were the dominant methodology, there is more balance across methodologies during the 2010–2018 time period. Over 22 percent of the authors employed a case study methodology, and a similar percentage of authors used archival data. The use of archival data increased substantially, from 10.42 to 22.56 percent between the 2001–2010 and 2010–2018 time periods. This may be due to an increased awareness of the availability of archival data, along with an increased acceptance of this approach (Carter et al., 2008).

The use of conceptual theory building also increased substantially, from 4.17 to 10.98 percent, across the two most recent time periods. We believe that this is a positive sign. Journals in the SCM discipline have begun to both recognize and encourage high-quality, rigorous conceptual theory building as the discipline continues to mature. The use of conceptual theory building helps the discipline to develop our own, SCM-specific theories rather than relying solely on theory developed in other disciplines. Whether conceptual theory building is used as a standalone methodology or incorporated into another methodology, researchers could consider how SSCM might differ from other SCM phenomena as they develop theory and/or integrate extant theory.

In addition to the categories of methodologies displayed in Table II, 3.66 percent of the articles utilized an experimental design. Given the underrepresentation of this methodology compared to the other methodologies displayed in Table II, we believe that there is an opportunity to use experiments to better understand SSCM phenomena. As one example, researchers might employ a laboratory experimental design to examine group-level decision making concerning whether to implement different types of sustainable supplier development programs.

5.4.5 Analysis. As shown in Section H of Table II, the use of descriptive statistics as a primary analysis has almost disappeared from the SSCM literature (1.83 percent during the 2010–2018 time period). Conversely, the use of qualitative data analysis almost doubled between the two most recent time periods, from 17.46 to 34.76 percent. Qualitative data analysis was used with case study and individual interview data, as well as some archival data (e.g. content analysis).

There are likely numerous, additional data sources which could be subjected to qualitative analysis. Researchers could present a small group of subjects with an SSCM problem or scenario, video record the subsequent discussion and then qualitatively analyze the discussion to generate understanding about the decision-making process. As another example, researchers could take a hybrid, ethnography-case study approach to follow the development and implementation of SSCM initiatives within organizations.

The increased use of structural equation modeling (21.34 percent during the 2010–2018 time period vs 12.70 percent during the 2001–2010 time period) may explain the decreased use of regression analysis (7.93 percent in the current time period vs 19.05 percent during the 2001–2010 time period) and exploratory factor analysis (1.83 vs 11.11 percent in the 2010–2018 and 2001–2010 time periods, respectively). We also included a code for
econometric modeling. Over 12 percent of the articles used econometric modeling during the 2010–2018 time period. We believe that this is a positive trend for SSCM research. Such approaches allow researchers to rigorously investigate inferential relationships by accounting for endogeneity effects (Semadeni et al., 2014) and investigating temporal effects.

Finally, there was a substantial increase in investigating moderation/interaction effects across the two most recent time periods (28.48 vs 13.04 percent) (Section I of Table II). This increase suggests that researchers are moving beyond examining linear effects, to also considering the contexts in which theoretical assertions and inferential relationships exist. Moving forward, SSCM scholars might consider moderators such as SSCM vs non-SSCM phenomena, social vs environmental initiatives, perceived project risk and adversarial vs collaborative supply chain relationships.

5.5 Conclusions based on SLR

Overall, our findings suggest that SSCM research continues to mature, by employing a broader range of theoretical lenses and thus greater richness, a more balanced breadth of methodologies and increased rigor in terms of data analysis. At the same time, there are some continuing weaknesses and imbalances in the research published during the 2010–2018 time period. As described in Sections 5.1 through 5.4, these deficits and omissions can be viewed as opportunities for future research.

Specifically, there are opportunities to investigate diversity (e.g. diversity spend and diversity in a largely Caucasian male-dominated SCM workforce) and human rights (e.g. working conditions at supplier facilities) as subjects, incorporate the group as the unit of analysis and employ a multi-level perspective. SSCM researchers must also better assess empirical validity and social desirability bias, and editors and reviewers should incorporate both as criteria in evaluating manuscripts for publication.

6. Final thoughts about future directions

We see two major and impactful opportunities for future SSCM research: first, continuing to develop and refine middle-range theory that will ultimately result in a grand theory of SSCM, and second, creating a better understanding of how managers can make effective decisions surrounding SSCM. We discuss these opportunities in the two subsections that follow.

6.1 Theory development

Our discipline saw initial efforts to develop middle-range theory using a SLR (Seuring and Müller, 2008), conceptual theory building (Carter and Rogers, 2008) and grounded theory (Pagell and Wu, 2009) approaches. Since that time, much of the research has focused on using both deductive (e.g. Kim et al., 2019) and inductive (e.g. Fayezi et al., 2018) approaches. We have also seen more recent conceptual theory building efforts at the middle range (e.g. Busse, 2016), including calls to expand our paradigm of SSCM and questioning our assumptions of current theorizations (e.g. Matthews et al., 2016; Pagell and Shevchenko, 2014).

As a next step forward, additional theory development of SSCM phenomena seems warranted. One clear approach is for researchers to continue to develop middle-range theory. The above examples include multiple methodological approaches for doing so. Beyond the obvious benefits of incorporating multiple methods in building SSCM theory, it is important for researchers to consider multiple forms of theorization. For example, the introduction of propositions is a popular outcome or “product” of theory development (Brief, 2003). In the case of the above, initial efforts to develop middle-range theory, all three sets of
authors introduce propositions based on their theory building (although each of the three papers introduces a framework or model in addition to developing propositions).

Yet there are many other approaches to theory building, including the use of taxonomies and typologies. These approaches are frequently found in the general management literature. Makadok and Coff (2009), for example, develop a taxonomy of interorganizational governance forms and their relationships with efficiency. Mitchell et al. (1997, p. 853) develop a typology of stakeholders, based on whether stakeholders possess power, legitimacy and urgency, and by doing so move stakeholder theory into the realm of “full theoretical status.” SSCM researchers should keep each of these options in mind when engaging in theory building research. For instance, is there a typology of the supply chain – or as a more tractable unit of analysis, a portion of the supply chain such as a triad – related to sustainability? To ask this question a bit differently, are some triadic forms more likely to have higher sustainability performance than others?

Finally, there is an opportunity to develop a grand theory of SSCM. Such an effort might integrate existing theory. As one example, complex adaptive systems theory (Kauffman, 1993) could be one particularly germane theoretical lens, given the inter-relationships of not only multiple organizations in the supply chain, but also the potential tradeoffs across outcomes (discussed in the next section). The development of a grand theory of SSCM might also include a comparison and contrasting of initial theory development efforts – for instance, Seuring and Müller (2008), Carter and Rogers (2008), Pagell and Wu (2009) and others that follow.

6.2 Decision making surrounding SSCM

At the micro (individual), meso (group) and macro (firm and supply chain) levels, there is an opportunity to better understand how managers make decisions surrounding SSCM. As described in the prior section, SSCM decisions, in particular, involve uncertainty and tradeoffs. Tradeoffs can exist between two or more of the dimensions of the triple bottom line (for instance, driving smaller and lighter vehicles may decrease carbon output but result in decreased driver safety) and even within a dimension of the triple bottom line (e.g. a closed-loop system in which plastic is recycled would likely reduce the amount of plastics in landfills and water systems, but could increase the system’s carbon footprint). In many cases, managers may be unaware of these tradeoffs (Rogers et al., 2019). In addition, uncertainty exists due to a lack of metrics both within and across organizations (Carter and Washispack, 2018).

Construal-level theory is one potential lens that might be employed to investigate how managers value different TBL outcomes (Trope and Liberman, 2010). The theory proposes that as the distance of an event – spatial and/or temporal – increases, decision makers will increasingly discount the consequences of the event. This theory could be used to posit how supply chain managers evaluate the tradeoffs discussed above.

One useful methodology for examining managerial judgments surrounding SSCM tradeoffs is policy capturing (Bottenberg and Christal, 1961, 1968). This approach essentially entails identifying tradeoffs across different criteria (e.g. economic, environmental and social performance) at multiple levels (for example at low, medium and high levels) and presenting managers with all possible combinations – in the above example 27 (3×3) scenarios. This methodology allows researchers to understand the true evaluation and tradeoff preferences of participants, since participants are presented with “tough choices” (e.g. medium economic performance, low social performance and high environmental performance).

Related to tradeoff preferences, the metrics that exist to measure SSCM, particularly across two or more organizations, are at an early stage of development (Goldsby and Zinn, 2018, p. 238). One encouraging initial effort is the aggregated, longitudinal GhG data
collected through CDP. Researchers should consider similar opportunities to accumulate longitudinal data relating to the plant, firm and/or supply chain levels. For example, the high performance manufacturing project (www.linkedin.com/in/hpm-high-performance-manufacturing-6b51575b) – a multi-university initiative that has collected operations data globally, at the plant level, since 1989 – could be modified to collect social and environmental performance data.

Finally, researchers might move beyond what appears to be a paradigm that SSCM is “good,” by asking questions such as:

- What is “good”?
- Is SSCM always “good”?
- What are the potential tradeoffs, and unintended consequences of SSCM?
- And, once identified, how can tradeoffs be mitigated or even turned into complementarities?

Our hope is that the results of our updated SLR motivate researchers to answer these questions, and to address the many additional research opportunities identified throughout the paper.

Note
1. The authors thank the editor and one of the paper’s anonymous reviewers, who recommended and provided the authors with the latitude to craft and include this section of the paper.

References


Campbell, D.T. and Stanley, J.C. (1963), Experimental and Quasi-Experimental Designs for Research, Johns Hopkins University, Baltimore, MD.


Further reading


Appendix 1. Modified AMSTAR Criteria (Carter and Washispack, 2018)

1. **Was an a priori article selection process described?**
The inclusion (and/or exclusion) criteria should be established before the conduct of the review and explicitly outlined in the paper.
- Yes (1 point)
- No
- Can’t answer
- Not applicable

2. **Were keywords clearly described?**
Keywords must be stated and where feasible the search strategy should be provided (Is the search replicable in terms of keywords? Could another researcher reconstruct/perform this search? Are all keywords (rather than, for example, "such as...") listed, b) Boolean operators or a similar clear description of the search provided, c) search fields clearly described AND d) years of search listed?).
- Yes (1 point)
- No
- Can’t answer
- Not applicable

3. **Was a comprehensive literature search performed?**
At least two electronic sources should be searched. The report must include databases used (e.g., ABI/Inform, EBSCO, SCOPUS, etc.) and/or journals searched.
- Yes (Multiple databases) (2 points)
- No (Only one database used) (1 point)
- No (But a complete list of journals was provided AND a clearly articulated rationale was used to explain why only this set of journals was searched) (1 point)
- No

4. **Were two or more reviewers used in study selection?**
There should be at least two independent reviewers, with a comparison of results and a consensus procedure for disagreements should be in place. This would include the reporting of inter-rater/intercoder reliability statistic(s) in reviewing and selecting articles for inclusion.
*Note: At least 2 researchers should perform the selection process, with reliability statistic(s) reported and a consensus process or one person checking the other’s work.*
- Yes (1 point)
- No
- Can’t answer
- Not applicable

5. **Was the status of publication (i.e. grey literature) used as an inclusion criterion?**
The authors should state whether they used grey literature (e.g., conference proceedings, working paper registers such as SSRN or ResearchGate, etc.) or whether they purposefully confined their review to peer reviewed journals.
- Yes (clearly stated) (1 point)
- No
- Can’t answer
- Not applicable

6. **Was a list of studies (included and excluded) provided?**
A list of included and excluded (from full list or short/intermediate list) studies should be provided.
*Note: Acceptable if the excluded studies are referenced (e.g., as an online supplement).*
- Yes (both included and excluded studies were listed) (2 points)
- Yes (included but not excluded studies were listed) (1 point)
- No
7. Were the characteristics of the included studies provided?
Data from the original studies should be provided in an aggregated form such as a table, data from the original studies should be provided, such as focus(es), key variable(s), data type and sample size, outcomes, etc. These data should be reported in a permanent, retrieval fashion such as in the paper, an appendix, or an online supplement (verbiage such as "available from the author upon request" would be a "No." below).

Note: Acceptable if not in table format as long as they are described as above.

- Yes (1 point)
- No
- Can't answer
- Not applicable

8. Were the methods used to combine the findings of studies appropriate?
Were qualitative data appropriately coded (This would include the use of inter-rater/inter-coder reliability statistic(s) and generally terms like “coding”, “categorizing”, etc. to refer to the data.)? Were codes defined/described? For a meta-analysis, were sample sizes used to weight results, and appropriate techniques used to transform beta-values and other inferential statistical values?

- Yes (1 point)
- No
- Can't answer
- Not applicable

Source: Based on: Shea et al. (2007)

Appendix 2. Article shortlist


Corresponding author
Craig R. Carter can be contacted at: crcarter@asu.edu

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