Transportation Research Part E 145 (2021) 102181

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

Matching traceability and supply chain coordination: Achieving operational innovation for superior performance

Yongyi Shou [a,b], Xinyu Zhao [a], Jing Dai [c,*], Dong Xu [c]

[a] School of Management, Zhejiang University, Hangzhou 310058, China
[b] School of Management, Hangzhou Dianzi University, Hangzhou 310018, China
[c] Nottingham University Business School, The University of Nottingham China, Ningbo, China

ARTICLE INFO

Keywords:
Traceability
Supply chain coordination
Operational innovation
Socio-technical system
Operational performance
Customer satisfaction

ABSTRACT

Operational innovation is effective in overcoming supply chain challenges and achieving superior performance. In this study, we build on the socio-technical system (STS) perspective to explore operational innovation in the supply chain context. Specifically, a system comprising traceability and supply chain coordination (SCC) is proposed as a type of Internet-based operational innovation. Survey data of manufacturing firms were analyzed by a configuration approach. Three clusters of firms were identified with distinct configurations of traceability and SCC. As predicted by the STS perspective, firms can realize operational innovation by matching traceability and SCC properly, thereby achieving superior operational performance and customer satisfaction. Our findings expand the understanding of operational innovation in the supply chain context. This study contributes to the literature of operational innovation, STS and supply chain management. Managerial implications about operational innovation in Internet-based supply chain management are provided.

1. Introduction

Supply chain management (SCM) is confronted with urgent challenges such as short lead time and fast delivery (Dai et al., 2015), strict standards of safety and security (Marucheck et al., 2011), clear provenance (Dutta et al., 2020), high requirements on transparency (Hastig and Sodhi, 2020) and product lifecycle management (Corallo et al., 2020). Given the increasing complexity and dynamics of supply chains, firms attempt to introduce operational innovation in order to address the above-mentioned challenges and achieve better performance. Operational innovation is the creation and deployment of deep changes or new methods about how firms provide products and services, which bring strategic, marketplace and operational benefits (Oke and Kach, 2012). Toyota production system (TPS) is recognized as a typical operational innovation in the last century (Hammer, 2004; Oke and Kach, 2012), which integrates just-in-time (JIT), total quality management, total production maintenance and human resource systems (Shah and Ward, 2003). The recent supply chain challenges in the Internet era are beyond the purpose of TPS, and hence new types of operational innovation are required. For instance, Walmart, together with IBM and JD.com, initiates new systems to build safe and transparent supply chains (Aitken, 2017).

Currently, Internet and other emerging platforms, such as those based on Internet-of-Things (IoT) and blockchain technologies, are considered as innovative means to meet supply chain challenges (Dutta et al., 2020; Fatorachian and Kazemi, 2018; Hastig and Sodhi,

* Corresponding author.
E-mail address: Jing.Dai@nottingham.edu.cn (J. Dai).

https://doi.org/10.1016/j.tre.2020.102181
Received 29 April 2020; Received in revised form 22 October 2020; Accepted 28 November 2020
Available online 10 December 2020
1366-5545/

2020; Li et al., 2020). Advanced information technology (IT) enabled operational innovation helps transform firms in their ways to interact with supply chain partners. Internet-based traceability systems may enhances a firm's capabilities in overcoming cross-boundary challenges like increasing supply chain transparency or reducing product recall (Hastig and Sodhi, 2020; Wowak et al., 2016). Therefore, we consider traceability as an important element of operational innovation in the new era. Meanwhile, industrial observation shows that achieving better effects of traceability needs the coordination of supply chain members on various technical processes (Leong et al., 2018).

Prior studies on operational innovation such as TPS suggest that successful operational innovation is an integrated system with multiple components rather than just the adoption of new technologies. Therefore, we choose the socio-technical system (STS) perspective to investigate Internet-based operational innovation in the supply chain context. Specifically, the system comprising Internet-based traceability and supply chain coordination (SCC) is proposed as a new type of operational innovation. Traceability refers to the technical system enabled by the Internet and other platforms to supervise the supply chain, which facilitates the resolution of above-mentioned supply chain challenges (Hastig and Sodhi, 2020; Marucheck et al., 2011). SCC is the social system of inter-firm communication and information sharing, which enables supply chain partners to jointly plan their production and service offering (Sanders, 2008; Xu et al., 2001). A socio-technical configuration is the set of social or technical constituent elements which can fulfill certain functions (Canitez, 2019; Fuenfschilling and Truffer, 2014). In this study, we propose that there may be different socio-technical configurations of traceability and SCC.

The STS perspective suggests that "the extent of fit between the social and technical systems, and how it aligns with the demands of the external environment, determines an organization's effectiveness" (Chaudhuri and Jayaram, 2019, p.1479). A well-aligned socio-technical configuration should not only contain proper social and technical subsystems but also match the subsystems properly. Previous studies indicate that a traceability system could not work alone (Rábade and Alfaro, 2006; Stranieri et al., 2017). Some studies have suggested the complementary effects of technologies and SCC (e.g., Marucheck et al., 2011; Vosooghidizaji et al., 2020). Since applying traceability system requires most supply chain partners to reach a consensus on interfirm processes and procedures (Leong et al., 2018), SCC is a requisite social element for superior performance (Hastig and Sodhi, 2020; Shankar et al., 2018). Without coordination, a focal firm will lack the trust of supply chain partners, which leads to poor connectivity, low incentives and inefficient traceability usage (Leong et al., 2018). Although we still have little knowledge on whether and how traceability and SCC match as two subsystems in an STS, these explorative studies and reports have indicated a complex, non-linear relationship between SCC and traceability.

A configuration approach is appropriate in investigating the alignment or match among multiple components (Flynn et al., 2010). Configurations may emerge from the complex relationships of components, which could not be observed through non-configurational approaches (Shou et al., 2018). By contrast, a configuration approach can generate a holistic understanding about the configurations of traceability and SCC. We used the data from the fourth-round High Performance Manufacturing (HPM) survey, which contains 214 manufacturing firms from multiple countries. Three configurations of matching traceability and SCC were found by cluster analysis. *Post hoc* Kruskal-Wallis test was conducted to distinguish the performance of each configuration. The results show that firms with different configurations have significant difference in operational performance and customer satisfaction.

This study contributes to the relevant literature in several ways. First, we propose a specific socio-technical system comprising traceability and SCC as a kind of Internet-based operational innovation. It enriches the literature of operational innovation by highlighting the importance of matching social and technical subsystems. Our study suggests that operational innovation of traceability and SCC provides a potential solution to improve operational performance and customer satisfaction. Second, this study extends the application of STS perspective in the supply chain context. Using cluster analysis, we find that there exist three different social-technical configurations of traceability and SCC. It suggests that SCC is an essential social dimension to complement traceability. Third, we provide empirical evidence to the different performance outcomes of social-technical configurations of traceability and SCC. Our results show that only when both traceability and SCC are at high levels, firms would achieve superior performance in both operations and marketplace. Firms with high-level traceability but low-level SCC may obtain good operational performance but not perform well for customer satisfaction. This study also provides managerial implications to firms on matching traceability and SCC.

2. Literature review and theoretical foundation

2.1. Socio-technical system

The STS perspective aims to investigate how complex systems and actors interact within their environment (Bostrom and Heinen, 1977; Siawsh et al., 2020). Organizations generally include a social subsystem and a technical subsystem to provide products or services and satisfy customer needs (Chaudhuri and Jayaram, 2019). The technical subsystem refers to value-adding operations and relevant devices, procedures, technologies, knowledge and etc., while the social subsystem refers to the individuals, teams and interpersonal parts like attitudes, behavior, relations, power, cultures, norms and so on (Kull et al., 2013; Siawsh et al., 2020).

When the technical and social subsystems match with each other properly, superior organizational performance can be expected (Chaudhuri and Jayaram, 2019; Kull et al., 2013). For instance, after studying the companies in the dilemma of soaring product complexity, Closs et al. (2008) suggest establishing "congruence'' between the technical procedures and social systems of decision making processes to eliminate unnecessary complexity. The interdependence of established technical and social subsystems may create valuable, unique advantage (Siawsh et al., 2020). If some sets of social or technical constituent elements can fulfill certain functions together, these sets are named as socio-technical configurations (Canitez, 2019; Fuenfschilling and Truffer, 2014).

The STS perspective has been widely applied in operations management research to examine social interactions, internal practices and transition processes. Some researchers focus on the social side of STS and discuss how people's behavior, delegation or empowerment influence operational performance (Brown et al., 2000; Manz and Stewart, 1997). Recent works pay attention to the interaction of both social and technical processes in various contexts: Das and Jayaram (2007) investigate the joint effect of adopting advanced manufacturing technologies and employee involvement; and Hadid, Mansouri and Gallear (2016) test the synthesized effects of lean bundles. The STS perspective is used to not only explain the complex phenomena in production processes but also guide innovative applications or transition processes of technologies (Wesseling et al., 2020). For instance, Solaimani et al. (2019) have identified the internal drivers of lean productions and Li et al. (2020) have observed social challenges of introducing advanced digital technologies. As advanced Internet or platform-based technologies bring vast changes in organizations, this study tries to investigate Internet-based operational innovation from the STS perspective.

Specific to SCM field, STS also guides firms to conducting complex interfirm operations successfully (Liboni et al., 2019). STS is regarded as an open system from its very beginning (Emery, 1959). Based on STS perspective, researchers identify the close linkages between cross-boundary technologies and partner interactions (Power and Singh, 2007). However, the linkages of technical and social subsystems in SCM context might be a double-edge sword, which can either help firms improve performance (Bailey and Francis, 2008; Xu et al., 2014) or bring troubles like behavior constraints (Kull et al., 2013) and supply risks (Yang and Fernandes, 2010). In the extant literature, Internet-based technologies that connect supply chain actors are frequently-discussed technical components (Bailey and Francis, 2008; Power and Singh, 2007; Xu et al., 2014) and coordination is an effective relational component (Bailey and Francis, 2008; Siawsh et al., 2020). Although Internet-based traceability technologies have the potential to overcome emerging supply chain challenges (Hastig and Sodhi, 2020), technical subsystem alone is insufficient according to STS perspective (Bailey and Francis, 2008). Therefore, this study aims to investigate the performance effects of socio-technical systems of traceability and SCC, which is observed as a type of operational innovation in the digital supply chain context.

The STS literature implies that the fit of inter-organizational technical and social subsystems is likely to form an integrated system of high efficiency and thus enhance firm performance. Recently, firms are implementing traceability and SCC, by which they can proactively influence their supply chain partners and respond to supply chain challenges (Hastig and Sodhi, 2020; Sanders, 2008). The cost and benefit of implementing advanced SCM technologies (e.g., traceability) could be unbalanced between focal firms and partners, which needs to be addressed with better coordination (Li, 2020). However, how traceability and SCC match as an integrated system to achieve operational innovation for superior performance remains unexplored in the extant literature.

2.2. Traceability

Traceability is the ability to identify and trace the history, distribution, location and application of products, parts, materials and services (Garcia-Torres et al., 2019). For a manufacturing firm, traceability is the capability about tracing the origins, inventory or delivery of materials and products, identifying the use of product components and strengthening the understanding of complex products. Traceability also enables firms continuously observe, record and react to product information flow in supply chains.

In the Internet era, traceability is closely related to the application of advanced IT. Traceability is applied within supply chains to collect data of products or services (Shankar et al., 2018). Traceability has been linked to technologies like Internet and radio-frequency identification (RFID) since its infant stage (Kamann et al., 2019). IT progresses provide technical solutions for diversified tracing or tracking demands. Traceability nowadays begins to be implemented based on IoT and blockchain platforms (Chamekh et al., 2019; Hastig and Sodhi, 2020). The upgrade of technology foundation further enhances transparency and makes traceability more powerful in overcoming information processing bottlenecks (Chamekh et al., 2019; Marucheck et al., 2011). However, utilizing advanced traceability technologies may experience several complicated stages to fully fulfill firms' expectation (Basole and Nowak, 2018).

Extant studies have suggested various benefits of traceability. Traceability can guarantee product quality while reduce the risk of opportunism and information asymmetry among supply chain partners (Cousins et al., 2019). Wowak et al. (2016) advocate that when products become increasingly complex, manufacturers and retailers shall turn to traceability to cope with supply ambiguity or obstacles. To some extent, traceability could alter information asymmetry into centralized information (Fiala, 2005). Via cases in fashion industry, Guercini and Runfola (2009) illustrate that traceability has impact beyond organization boundary, as a tool for inter-organizational control and market power.

Nonetheless, not all firms are willing to adopt traceability practices due to operational complexity or costs (Stranieri et al., 2017). There are negative outcomes of traceability. For example, increasing traceability may lead to the risk of information leakage and undesired intervention from supply chain partners (Marucheck et al., 2011). In other words, traceability alone cannot promise business success. According to Stranieri et al. (2017), successful adoption of traceability needs both technical and relational support from supply chain partners to dispel concerns about external interventions. Shankar et al. (2018) and Hastig and Sodhi (2020) also point out that SCC is a critical success factor of traceability. In short, traceability is a vital technical subsystem of an STS, which still needs the support of its social counterpart.

2.3. Supply chain coordination

SCC refers to the joint planning and implementation practices in supply chains by frequent and efficient upstream or downstream communication (Castañer and Oliveira, 2020). The prevalence of SCC is closely related to the high inventory cost and supply uncertainty from the "bullwhip effect" (Xu et al., 2001). Coordination enables supply chain members to plan their outputs and schedule their orders together, among which Internet-based technologies play a critical role (Yu et al., 2018).

Supply chain partners could benefit from SCC by mitigating disruption, reducing overall operational expenses and gaining better performance (Xu et al., 2001; Zhao et al., 2020). Owing to higher stakeholder pressures from triple bottom lines and regulation requirements, SCC has been expanded to reverse supply chains or close-loop supply chains (Biswas et al., 2018; Krapp and Kraus, 2019). SCC changes the way that products are designed, developed and manufactured by involving suppliers and customers in R&D and operational processes. Products manufactured in a highly coordinated supply chain are more standardized and modularized (Wang et al., 2018). In this way, supply chains are more flexible and reliable. In sum, SCC is an important and helpful strategic response to manage the complex interdependence and various uncertainties along the supply chain (Xu and Beamon, 2006).

SCC helps fully leverage the technologies used to supervise the supply chain but also needs the support of enabling technologies. SCC is regarded as a relational approach to ensure that supply chain partners keep the same pace with focal firms (Handley and Benton, 2013). The cross-boundary planning behaviors of SCC facilitate stable dyadic relationship with trust and common interests (Sanders, 2008; Shou et al., 2020a). Building social bonds between supply chain partners also requires the technical carriers of effective communication and information sharing. Xu et al. (2001) and Yu et al. (2018) demonstrate that Internet-based technologies are a supporting brick of SCC. Researchers have provided abundant evidence that SCC can be more helpful when aligned with information technologies.

2.4. Socio-technical configurations and performance

The STS perspective predicts that firms could achieve superior performance through matching social and technical subsystems (Emery, 1959; Kull et al., 2013). This suggests that multiple configurations of traceability and SCC may be observed in the reality, and the relationship between the two subsystems and their performance effects may not be linear or contingent (Zhou et al., 2014). Specifically, industrial observation shows that achieving better effects of traceability needs the coordination of supply chain members on various technical processes (Leong et al., 2018). Adopting traceability requires collaborative efforts to provide complete, pervasive and continuous information along supply chains (Basole and Nowak, 2018). In other words, slight improvement of low-level SCC may bring few benefits and only the well-aligned, traceable supply chain will derive considerable benefits. The advance of traceability systems will be in vain if few suppliers are willing to record and share their production information. Traceability is proposed as a feasible solution to support SCC since it keeps complete supply chain information for partners (Corallo et al., 2020; Thakur et al., 2020). As the traceability subsystems are gradually adopted in internal operations, SCM, market sensing and other dimensions (Hastig and Sodhi, 2020), firms may achieve different performance outcomes. Moreover, firms at early stages of implementing traceability and SCC may have difficulty in fully realizing the potential benefits due to technical and organizational complexity. Therefore, this study proposes that there are multiple socio-technical configurations of traceability and SCC in manufacturing firms.

H1.. *There exist different social-technical configurations of traceability and SCC.*

This study investigates two types of performance which are highly related with operational innovation, i.e., operational performance (OP) and customer satisfaction (CS) (Hammer, 2004). OP represents the efficiency and effectiveness that firms manage their production and operations. OP is closely related to material flows and information flows within supply chains. CS reflects how customers perceive the value of their relationship with the focal firm, such as responsiveness, assurance and empathy (Gligor and Holcomb, 2012; Zhang et al., 2003). High CS may yield better customer retention as well as better supply chain influence (Hammer, 2004). Operational innovation improves the efficiency and transparency along the supply chain, thereby increasing customer satisfaction.

Based on the existing literature, we believe that a proper match between traceability and SCC contributes to improving OP. Traceability provides the capability to oversee the whole production lifecycle (Marucheck et al., 2011). From the STS perspective, if traceability can match with SCC, the whole system could supervise, support and guide supply chain partners and thus help focal firms to manufacture products with customized designs, reliable supplies and low overall expenses, which means better OP. Moreover, firms that create inter-connected innovative functions based on the good fit of traceability and SCC may obtain unique competitive advantages in their interactions with supply chain partners (Sinha and Van de Ven, 2005).

On the other hand, firms may face a dilemma if they fail to achieve a proper match between traceability and SCC. Traceability may increase the cost and complexity of supply chains (Sarpong, 2014). Lam and Chang (2019) show that overwhelming information provision is detrimental to the performance of the whole supply chain due to the negative outcome perceptions of focal firms. When it comes to those highly coordinated supply dyads, opportunism risks and behavior constraints bring “hidden costs” which harm the business performance (Handley and Benton, 2013). Furthermore, close relationship with supply chain partners may hinder the strategic decision-making of focal firms who are confined by negative network externality (Xu et al., 2018). A proper match of traceability and SCC could restrain the above-mentioned negative outcomes and realize complementarity between the two subsystems, thereby improving OP. Therefore, we propose the following hypothesis:

H2.. *The configuration with a proper match between traceability and SCC contributes to operational performance.*

CS is another important dimension that reflect market-based performance (Bozarth et al., 2009; Christopher and Towill, 2001). CS is based on the understanding and fulfillment of supply chain partners’ needs and expectations (Stank et al., 1999). The interdependence between supply chain partners represents interorganizational advantages and relational rents (Shi and Liao, 2013). Operational innovation through a suitable socio-technical configuration of traceability and SCC could further help focal firms to deploy processes that can fulfill new business requirements as soon as possible. Consequently, the firm will earn a higher-level CS. In addition, a good match of SCC and traceability could provide balanced stability and flexibility of buyer–supplier relationship, which is a prerequisite of higher CS (Manz and Stewart, 1997; Zhang et al., 2003). On the other hand, supply chain partners may be reluctant to join the traceability system due to concerns about information leakage and losing bargaining power in case of poor SCC (Marucheck et al., 2011). Hence, a system with an inappropriate match of traceability and SCC may be built at the cost of inter-firm relationship, which leads to lower CS. In conclusion, we posit the following hypothesis:

H3.. *The configuration with a proper match between traceability and SCC contributes to customer satisfaction.*

3. Method

3.1. Data collection and sample

The data used in this study were from the fourth round HPM project, which completed in 2017 (Ortega-Jimenez et al., 2020). The international survey was initiated in 1989 to analyze the success of manufacturing plants along many dimensions of organizational performance. Participating plants are located around the world and from three manufacturing industries (i.e., machinery, electronics and transportation components). The sample was randomly selected from a master list of plants in each country. Each country's research team contacted the plant CEOs to explain the aim of the research project and the content of the questionnaire. The survey questionnaire encompassed a set of twelve sections, and each focused on a specific topic and targeted at specific management positions to minimize the risk of common method bias (CMB). In particular, for each questionnaire section the research team attempted to identify two managers who were considered as the best informed about the topic of that questionnaire section, except for the accounting section that was administered to only one respondent (i.e., plant manager) (Danese et al., 2019).

The questionnaire was originally designed in English, and then translated into the local language by each country's research team. The response rate was approximately 65%, thus reducing the need to check for non-response bias (Danese et al., 2019; Flynn et al., 1990; Huo et al., 2019). The present study is based on the data from 214 plants. Table 1 reports the sample distribution by sector and region.

3.2. Measures

Our measurements were developed based on the literature and most of them had been examined in the previous three rounds of the HPM project. The constructs are measured with five-point Likert scales (1 for strongly disagree or poorer, 3 for neither agree nor disagree or average, 5 for strongly agree or superior). Table 2 shows the constructs and measurement items. Since the questionnaire sections that contain CS, traceability and SCC were answered by two managers separately, mean values of items are used for each plant, which is beneficial to the quality of measurement (Peng et al., 2008; Yuan et al., 1997). The measurements used in this research were tested with Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO value is 0.83 and the significance of Bartlett's test is at the 0.001 level, indicating that the data are normally distributed and no obvious outliers exist (Podsakoff et al., 2003). Harmon's one-factor test was also conducted to address the CMB concern. The first factor explained only 25 percent of the total variance, and all constructs were explicitly extracted, which further guaranteed the quality of our dataset (Podsakoff et al., 2003).

Operational performance (OP) is measured by the throughput, inventory, and operating expense compared to its competitors (Rahman, 1998; Watson et al., 2007). Customer satisfaction (CS) is operationalized as customers' perception toward products or services and is measured by six items (Bozarth et al., 2009).

Traceability is operationalized to evaluate the technical capability in tracking material flows in the supply chain and is measured by a four-items scale. This scale is newly developed by the HPM research team with rigorous procedures, in order to detect the rising phenomena in SCM. SCC is a second-order formative construct, comprising two first-order reflective constructs (i.e., buyer coordination and supplier coordination). Buyer coordination and supplier coordination are operationalized as strategic and operational coordination with upstream and downstream partners, and are measured with six items, respectively (Sanders, 2008).

Table 1
Demographics of the sample.

Industry	Machinery	Electronics	Transportation	Total
Brazil	2	4	7	13
China	7	13	3	23
Finland	6	6	4	16
Germany	5	7	8	20
Israel	3	0	0	3
Italy	5	15	5	25
Japan	6	4	8	18
South Korea	7	5	11	23
Spain	4	4	5	13
Sweden	3	2	0	5
Taiwan	19	9	1	29
United Kingdom	2	5	2	9
Vietnam	8	3	6	17
Total	77	77	60	214

Table 2
Survey items, convergent validity and reliability.

No.	Items	Factor loading	Indices
Operational performance			
(Source: Rahman (1998), Watson et al. (2007); Respondent: Plant Manager)			
How your plant compares to its competitors in its industry, on a global basis.			
OP1	Throughput: the rate at which the plant generates money through sales	0.780	Cronbach's α = 0.741
OP2	Inventory: raw materials, work-in-process and finished goods	0.817	CR = 0.852
OP3	Operating expense: funds spent to generate turnover, including direct labor, indirect labor, rent, utility expenses and depreciation	0.835	AVE = 0.658
Customer satisfaction			
(Source: Bozarth et al. (2009); Respondent: Quality Management manager)			
CS1	Our customers are pleased with the products and services we provide for them.	0.881	Cronbach's α = 0.888
CS2	Our customers seem happy with our responsiveness to their problems.	0.824	CR = 0.918
CS3	We have a large number of repeat customers.	0.409*	AVE = 0.691
CS4	Customer standards are always met by our plant.	0.799	
CS5	Our customers have been well satisfied with the quality of our products, over the past three years.	0.804	
CS6	Our plant satisfies or exceeds the requirements and expectations of our customers.	0.843	
Traceability			
(Newly developed in the 4th round HPM survey; Respondent: Production Control manager)			
Trace1	Our product identification and traceability system is able to identify and trace products from production to delivery.	0.728	Cronbach's α = 0.813
Trace2	Our product identification and traceability system can effectively identify and trace the source of raw materials and parts.	0.818	CR = 0.886 AVE = 0.619
Trace3	Each batch of products that we produce is uniquely identified.	0.816	
Trace4	Each of the suppliers that provide raw materials or components for us can be identified by our product identification and traceability system.	0.782	
Buyer coordination			
(Source: Sanders (2008); Respondent: Downstream Supply Chain Management manager)			
Please indicate the extent of involvement of your plant in the following activities with your primary buyers:			
BC1	Strategic planning with buyers	0.822	Cronbach's α = 0.888
BC2	Planning for new products and programs with buyers	0.823	CR = 0.915
BC3	Planning for product conception and design with buyers	0.827	AVE = 0.643
BC4	Sharing operational information	0.796	
BC5	Coordination of production planning	0.778	
BC6	Utilization of integrated database for information sharing	0.772	
Supplier coordination			
(Source: Sanders (2008); Respondent: Upstream Supply Chain Management manager)			
Please indicate the extent of involvement of your plant in the following activities with your primary suppliers:			
SC1	Strategic planning with suppliers	0.729	Cronbach's α = 0.890
SC2	Planning for new products and programs with suppliers	0.768	CR = 0.916
SC3	Planning for product conception and design with suppliers	0.832	AVE = 0.646
SC4	Sharing operational information	0.825	
SC5	Coordination of production planning	0.848	
SC6	Utilization of integrated database for information sharing	0.803	

* The item was dropped for low factor loading.

Since there are both reflective and formative constructs in our measurement model, we follow Hair et al. (2020) and Ringle et al. (2020)'s guidance to test the validity and reliability of our measurements.

Convergent validity is quantitatively established by showing that a group of observed variables (indicators) measure a single common factor. A loading of 0.70 indicates that about one-half of the item's variance (the squared loading) can be attributed to the construct; thus, 0.70 is the suggested minimum level for item loadings on established scales (Hair et al., 2011). Indices of all reflective constructs exceed the suggested standard of Cronbach's α (>0.7), composite reliability (CR, > 0.7) and average variance extracted (AVE, > 0.5) (Hair et al., 2011). Table 2 presents all of these values and suggests sufficient convergent validity.

Discriminant validity is assessed by comparing the AVE square root for each construct with the correlation between all possible

Table 3
Discriminant validity test.

Construct	Mean	S.D.	1	2	3	4	5
1. Operational performance	3.427	0.679	0.811[a]				
2. Customer satisfaction	3.882	0.631	0.268*	0.831			
3. Traceability	3.913	0.776	0.159*	0.181*	0.787		
4. Buyer coordination	3.284	0.860	0.175*	0.254*	0.107	0.802	
5. Supplier coordination	2.993	0.814	0.221*	0.193*	0.018	0.293*	0.804

[a] The square root of AVE is shown on the diagonal of the matrix.
* $p < 0.05$.

pairs of constructs (Hair et al., 2011). In all cases, the AVE square root values are higher than the correlations reported in Table 3. Thus, the results offer support for discriminant validity among the constructs.

SCC is a second-order formative construct. The two first-order constructs of SCC, namely, buyer coordination and supplier coordination, are measured by managers at different positions. The two constructs are not interchangeable in measuring upstream and downstream SCC and may not covary with each other, which indicates that SCC should be modelled as formative (Jarvis et al., 2003; Petter et al., 2007). The identical number and expression of items to measure both buyer coordination and supplier coordination are ideal for precisely specifying a second-order formative construct (Hair et al., 2018). As suggested by Hair et al. (2018), a repeated indicators approach is adopted. Each first-order construct has a significant path weight and a variance inflation factor (VIF) value lower than 3.3 as shown in Table 4, which demonstrates the validity of first-order constructs (MacKenzie et al., 2011; Petter et al., 2007). Theoretically, SCC is considered as an integrated concept and both first-order constructs contribute to SCC. Empirically, the two first-order constructs have very close path weights in our study. Prior studies (Da Silveira and Arkader, 2007; Hill and Scudder, 2002) measured SCC from both buyer and supplier sides and none reported either side as more influential. As recommended by Petter et al. (2007) and Lee and Cadogan (2013) that the weighting of each dimension in forming the final construct should be specified *a priori*, following prior studies using formative constructs (e.g., George, 2011; Shou et al., 2020b; Wiklund and Shepherd, 2003), we *a priori* weight the two first-order constructs equally and estimate SCC by the average of both. The adequacy coefficient (R_a^2) of SCC is 0.647, which exceeds the recommended threshold value 0.5 and indicates the validity of the second-order construct (Edwards, 2001). Moreover, to examine the discriminant validity between SCC and other constructs in this study, the heterotrait-monotrait (HTMT) test is conducted. All HTMT ratios are<0.4, far below the cutoff value of 0.85, indicating acceptable discriminant validity (Henseler et al., 2014).

3.3. Cluster analysis

Cluster analysis has contributed a lot in revealing the possible taxonomies and enriched the theories of operations and supply chain management (Brusco et al., 2017; Buttermann et al., 2008; Flynn et al., 2010). With the guidance of STS perspective, this research disentangles the underlying configurations of traceability and SCC. Following the suggestion of Brusco et al. (2017) that summated scales help consolidating variables into concise constructs, we use the mean value of each construct for analysis. As for SCC, we use the mean value of the two first-order constucts of buyer coordination and supplier coordination.

Following Hair et al. (2011) and Brusco et al. (2017), a hierarchical cluster analysis with Ward method followed by non-hierarchical K-means analysis was adopted. Hierarchical cluster procedures generate a dendrogram and an agglomeration schedule table. According to Lehmann's rule of thumb (Lehmann, 1979), the number of clusters should be between $n/30$ and $n/60$, where n is sample size. In our study, the candidate cluster number ranges from three to seven (214/60 and 214/30). Then, the greatest incremental change in the agglomeration coefficients provides statistical evidence for determining the cluster number. A large increase of agglomeration coefficient indicates that heterogeneous clusters are merged, while merging homogenous clusters bring little change in agglomeration coefficient (Flynn et al., 2010; Zhu et al., 2011). Fig. 1 shows that the greatest percentage change of agglomeration coefficient happened during the cluster number shift from three to two, indicating the appropriate selection of three clusters. The final cluster taxonomy was generated by K-means analysis.

A discriminant analysis was conducted. We set traceability and SCC as independent variables and the cluster membership as dependent variable. Two functions are generated with eigenvalue above 1 (see Table 5). All loadings in the two functions exceed the threshold value of 0.4, indicating that the canonical functions have substantial explaining power (Shou et al., 2018). In addition, the similarity between standardized coefficients and cross-loadings (structure correlations) indicates stability of the result (Hair et al., 2011).

4. Results and robustness check

4.1. Results

The cluster analysis demonstrates three clusters, as shown in Table 6 and Fig. 2. Since Kolmogorov-Smirnov test shows that the mean values of traceability and OP constructs are non-normal, *post hoc* analysis was carried out by non-parametric Kruskal-Wallis (KW) test (Christiansen et al., 2003; Hair et al., 2011). KW test compares the population distributions of configurations' variables and tells whether configurations differ significantly (Chandrasekaran et al., 2015; Christiansen et al., 2003). Between-group differences are highly significant in both traceability and SCC. Configuration 1 is a composition of companies with significantly high-level traceability and SCC. Configuration 2 contains a group of companies that hold the highest level of traceability (slightly higher than that of Configuration 1 with no significant difference) but the lowest level of SCC. Each of the two configurations contains around 40% case companies. Configuration 3 includes the companies with the lowest level of traceability and a moderate level of SCC. Therefore, H1 is

Table 4
Validity of the second-order construct SCC.

First-order construct	Path weight	VIF	Significance
Buyer coordination	0.622	1.095	<0.001
Supplier coordination	0.621	1.095	<0.001

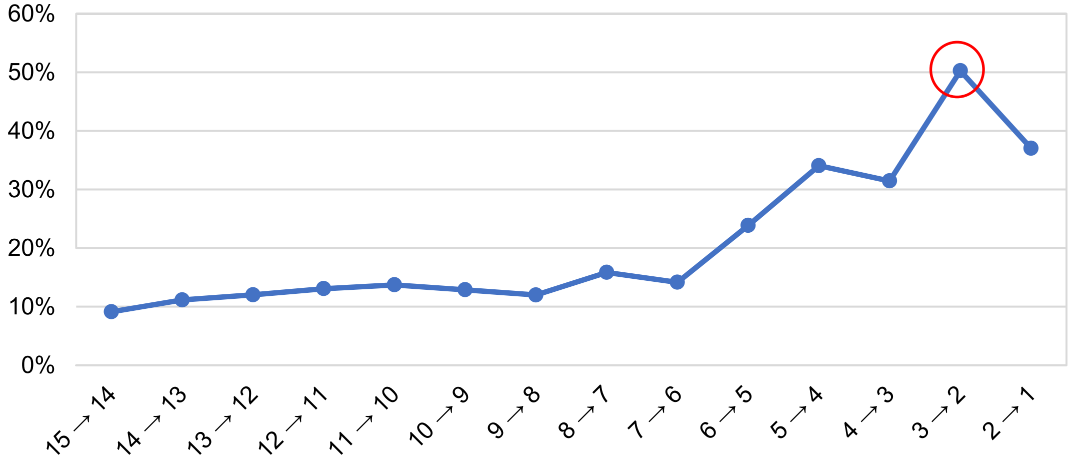

Fig. 1. Percentage change in agglomeration coefficient.

Table 5
Cluster discriminant analysis.

Function	Eigenvalue	% of variance	Cumulative %	Canonical correlation
1	1.657	57.1	57.1	0.790***
2	1.245	42.9	100	0.745***
	Standardized coefficients		Canonical cross-loadings	
Variable	Function 1	Function 2	Function 1	Function 2
SCC	*0.773*	*0.655*	*0.648*	*0.762*
Traceability	*−0.772*	*0.657*	*−0.646*	*0.763*

Notes: The number in italic has an absolute value larger than 0.4. ***p < 0.001.

Table 6
Results of cluster analysis.

	Configuration 1 $n = 84$	Configuration 2 $n = 93$	Configuration 3 $n = 37$	$\chi^2(2)$
Traceability				
Mean	4.119 (3)	4.241 (3)	2.622 (1,2)	91.641***
S.D.	0.53	0.46	0.51	
SCC				
Mean	3.756 (2,3)	2.632 (1,3)	3.010 (1,2)	139.556***
S.D.	0.39	0.42	0.26	

Notes: S.D. denotes for standard deviation. Chi-square statistics and associated p-values are derived from two-sided KW test. Numbers in parentheses indicate the configuration number from which this configuration is significantly different at the 0.01 level according to the paired KW test. *** p < 0.001

supported.

To examine the performance difference between configurations, another KW test was adopted. The results are presented in Table 7. Configuration 1 has the highest OP, which is significantly higher than that of Configuration 3 but not significantly higher than that of Configuration 2. Therefore, H2 is supported. Moreover, Configuration 1 has the highest CS, which is significantly higher than that of Configurations 2 and 3. Besides, Configurations 2 and 3 have no significant difference in CS. The results provide strong evidence for H3.

In addition, we carried out *post hoc* analysis on firm size and country characters. No difference was observed regarding firm size. We also compared the distribution of cases from developed economies (Finland, Germany, Israel, Italy, Japan, South Korea, Spain, Sweden, Taiwan and the United Kingdom) with that of developing economies (Brazil, China and Vietnam) in different configurations. We found that Configuration 2 contains a significantly higher percentage of cases from developed economies (90%) than that of Configuration 1 (69%) and Configuration 3 (49%).

4.2. Robustness check

To ensure that the results are reliable, supplementary tests were conducted. First, we expected that the clusters of this study are

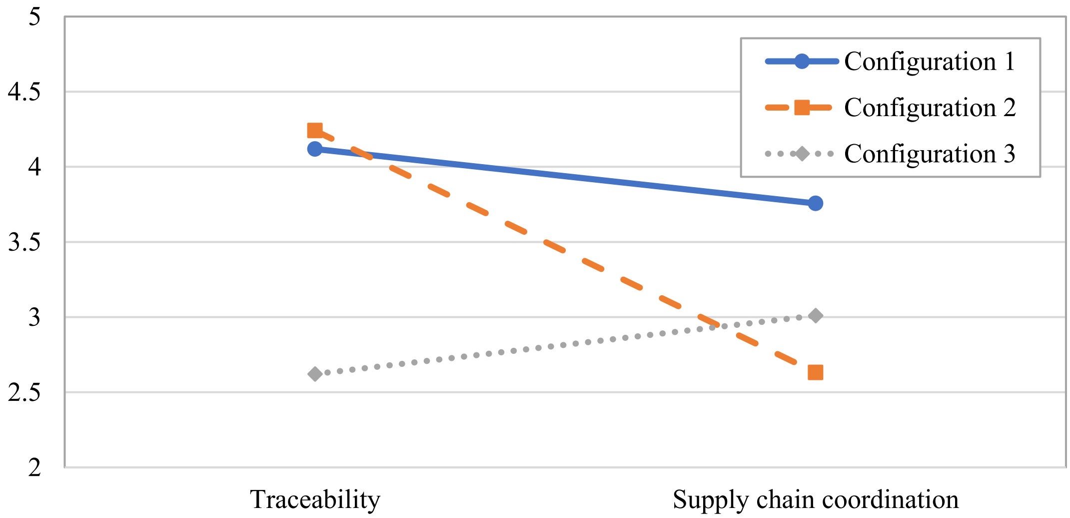

Fig. 2. Cluster means.

Table 7
KW test for performance difference.

	Configuration 1	Configuration 2	Configuration 3	$\chi^2(2)$
OP				
Mean	3.576 (3)	3.382	3.194 (1)	8.318*
S.D.	0.693	0.669	0.596	
CS				
Mean	4.053 (2,3)	3.789 (1)	3.730 (1)	9.955**
S.D.	0.584	0.631	0.590	

Notes: S.D. denotes for standard deviation. Numbers in parentheses indicate the configuration number from which this configuration is significantly different at the 0.05 level according to paired KW test. * $p < 0.05$. ** $p < 0.01$.

stable. We compared the cluster centers derived from the K-means analyses with different initial seed points and no difference was found (Shou et al., 2018). Then, the discriminant function drawn from all other 213 firms was used to predict the cluster membership of a single company (Zhou et al., 2014). Only six firms were misclassified, with an overall accuracy of 97.2%. In addition, split-half replications were carried out (Brusco et al., 2017). A random selected sub-sample containing 112 firms was created and the K-means procedures were applied to this sub-sample. Only three firms changed their affiliation and highly identical clusters were displayed. The results indicate that the cluster classification is valid and stable.

Second, following Cheng and Farooq (2018), Tamhane comparison test is carried out to further verify the difference between configurations. The identical results were observed with significant distinctions, which guarantees the reliability of the *post hoc* analysis.

Third, an additional analysis was conducted using the two first-order constructs (supplier coordination and buyer coordination) instead of the second-order construct SCC for both cluster analysis and *post hoc* analysis. The results are similar except that Configurations 2 and 3 do not show significant difference in supplier coordination. Overall, the above-mentioned robustness checks demonstrate the reliability of this study.

5. Discussion

5.1. Findings

We found three configurations of traceability and SCC in manufacturing firms. Firms in Configuration 1 build high-level, balanced traceability and SCC, achieving superior OP and CS. This result suggests that significantly high levels in both traceability and SCC could bring deep organizational changes as operational innovation and thus gain better performance. Although high-level traceability and SCC need vast investment in devices, Internet platforms, communication channels, cooperative decision-making and so on, superior OP and CS manifest the worthiness of these investments. In other words, the system of traceability and SCC may help supply chain members share the cost and benefits properly for better performance (Li, 2020). High-level traceability and SCC can support each other in realizing high efficiency and overcoming cross-boundary challenges. High-level SCC could reduce supply chain partners' unwillingness to adopt traceability systems because of established trust and mutual understanding (Stranieri et al., 2017). Meanwhile, traceability could enhance transparency which further reduces operational deficiency along the supply chain, thus SCC can focus more on strategic issues toward long-term success (Manz and Stewart, 1997). In addition, traceability generates up-to-date, accurate market information to guide the joint product design based on SCC, making future products more promising (Hastig and Sodhi, 2020). Thus, operational innovation is achieved through matching high-level traceability with high-level SCC, which creates an effective and balanced transparency and flexibility within supply chains and overcomes the difficulty of managing complexity and costs.

Firms in Configuration 2 have the highest level of traceability (although not significantly higher than that of Configuration 1) but the lowest level SCC (even significantly lower than that of Configuration 3). The firms in this configuration produce relatively good OP (slightly lower than that of Configuration 1 with no significant difference) but low-level CS (significantly lower than that of Configuration 1). It is noted that most firms in Configuration 2 are from developed economies. These firms mainly rely on technical subsystems for SCM. Although Internet-based technologies could facilitate firms' efficiency in SCM, technologies alone cannot improve their relationships with supply chain partners. Without high-level SCC, traceability could not fully realize its potential to enhance supply chain performance. For instance, although high-level traceability helps obtain huge volume of data, without an effective joint planning through SCC, these data may just be stored in siloes but contribute nothing to value-adding activities. Even worse, frequent data updating may cause negative impact on supply chain decision-making, which may damage the inter-firm relationship (Lam and Chang, 2020). Obviously, the firms in Configuration 2 do not make a proper match between deploying high-level traceability and maintaining good supply chain relationships.

Firms in Configuration 3 possess the lowest level traceability and a moderate level SCC (still significantly higher than that of Configuration 2). Their OP and CS are both significantly lower than that of Configuration 1. Literature has noted that close coordination with external partners is risky due to asset specificity and negotiation efforts, especially when it is hard for firms to "deploy monitoring mechanisms to reduce information asymmetry" (Handley and Benton, 2013, p.123). Moon and Feng (2017) also point out that SCC does not necessarily benefit every supply chain member. Firms in Configuration 3 have a modest level of SCC, which is significantly higher than that of Configuration 2, but with lowest traceability, they are not able to achieve higher performance than Configuration 2. One possible reason is that high level SCC still needs technical solutions (i.e., traceability) to address the complexity of inter-organizational information flow. In short, low level traceability impedes the potential positive effect of SCC on firm performance.

6. Theoretical contributions

Our study provides several theoretical contributions. First, this study builds on the STS perspective and proposes that the system matching traceability and SCC is a type of operational innovation which could enhance firm performance. As an IT-enabled capability, traceability has the potential to fulfill various SCM challenges (Hastig and Sodhi, 2020). Following the STS perspective, we note that traceability alone is not sufficient to achieve top-level performance. Neither is SCC due to coordination costs (Vosooghidizaji et al., 2020). This study confirms the value of operational innovation by investigating traceability-SCC configurations and their performance effects. The empirical results indicate that operational innovation with a proper match of traceability and SCC leads to superior performance. Grounded in the STS perspective, we suggest that operational innovation should adapt to the changing environment and the traceability-SCC system is such an innovation for the digital supply chain context.

Second, this study extends the STS literature in the supply chain context. To our best knowledge, this present study is among the first empirical studies that propose traceability and SCC as dimensions to identify specific socio-technical configurations and test the configuration's performance difference in the supply chain context. We extend the application of STS by not only identifying configurations from both social and technical dimensions but also confirming the basic assumption of STS (fit between subsystems) in SCM. SCM practices should be carefully designed and applied, in order to ease their applications and benefit supply chain members. When firms consider the advantages of advanced IT like traceability systems from the technical perspective, they should also take the stakeholders into account from the relational perspective. We would expect more supply chain related research questions addressed from the STS perspective.

Third, our study discloses the complexity of inter-organizational interactions and demonstrates the value of configuration approaches, particularly in the supply chain context. Via the configuration approach, we identify that Configuration 1 (firms with high-level traceability and SCC) is associated with superior performance. Our findings empirically verify the non-linear, interdependent relationship of operational innovation components and firm performance. Our results suggest that firms should have a long-term plan about integrating traceability and SCC since configurations at low levels or early stages show less improvement of performance. A possible reason is that achieving better supply chain performance needs wide and deep coordination of supply chain members (Leong et al., 2018). For example, to trace products, a large number of suppliers or buyers along the whole supply chain must participate in recording information and dealing with disruptions. This also partially explains why only Configuration 1 (with high-level traceability and SCC) generates substantial operational and marketplace benefits. Given the high complexity and dynamics of SCM, the configuration approach is valued to provide holistic understandings of the interactions among multiple subsystems and actors, which may not be easily discerned by non-configurational approaches (Flynn et al., 2010; Zhou et al., 2014).

6.1. *Managerial implications*

This research contributes to supply chain managers and their decision making. First, this study can provide practical guidelines to supply chain managers. While SCC is regarded as a best practice of implementing traceability in practical reports (Business for Social Responsibility and United Nations Global Compact, 2014; Leong et al., 2018), this study suggests that an integrated system comprising high-level traceability and SCC is desirable to managers who want to bring operational changes and better shape their supply chains.

Therefore, firms should have a long-term plan about integrating traceability and SCC and have a clear understanding that configurations at low levels or early stages are less helpful. Meanwhile, our findings suggest potential strategies in terms of traceability and SCC for laggards or new entrants. For those firms who want to achieve superior performance, balanced and high-level traceability and SCC would be a long-term goal. While firms have limited resources, they could consider the following stepwise strategies. Firms are suggested to build up good relationship with partners at the beginning. Then, they could introduce traceability systems into the supply chain and after that, go on strengthening the SCC with the help of traceability. The other strategy is to implement a high-level traceability system and then continuously improve their SCC with supply chain partners to leverage the potential of a matched system. These two strategies suit different companies and situations. The former one could be a proper choice for firms who have stable partners or with little variation in the supply chain. As external pressures increase, firms could improve traceability together with partners to deal with emerging challenges such as transparency, sustainability or servitization needs (Garcia-Torres et al., 2019). However, manufacturers with complex supply chains and producing modular commercials may prefer the second strategy. The quality and understanding of supplies should be firstly guaranteed by traceability. If there are constraints within firms, managers should choose the appropriate strategy that can fulfill the operations and supply chain management priorities, and gradually implement operational innovation by matching high-level traceability with high-level SCC for superior performance.

Second, managers are suggested to adopt the STS thinking to design or evaluate the whole picture of Internet-based operational innovation. Advanced IT enables plentiful connections between internal functions and cross-boundary interactions. Meanwhile, innovation based on Internet or platforms increases the complexity of operations and supply chain management because of the consequent systematic changes. The STS perspective provides a systematic view to understand and overcome the complexity (Closs et al., 2008). It is important for supply chain managers to figure out how to run the subsystems compatibly and efficiently for more supply chain actors. Managers who want to find innovative ways to mitigate negative outcomes and generate promising gains from supply chains should take a careful look at their social and technical subsystems.

Last, we remind managers that technology is a double-edge sword. Our findings challenge the recently surging industrial trend that focuses on new technological solutions of traceability (Kamble et al., 2020; Pisa and McCurdy, 2019). Indeed, advanced Internet-based technologies like RFID, IoT and blockchain enhance the power and versatility of traceability systems (Hastig and Sodhi, 2020). Traceability is more than an information system that keeps production data to achieve supply chain transparency. It also builds up better connection and improves relationship between partners when properly matched with SCC. However, the performance of Configuration 2 manifests that a high-level technical subsystem with no matched social subsystem fails to improve firm performance. In a worse case, traceability may burden firms and partners in an isolated, seldom-coordinated supply chain (Stranieri et al., 2017).

6.2. Limitations and future research

This study has limitations, which also open new avenues for future research. First, our sample is limited to the manufacturing industry. Therefore, the findings are only valid in manufacturing supply chains and may not be able to generalize to service supply chains. We would suggest future research to expand into service industries. Industries with high transparency requirements, such as agriculture, healthcare, mining etc. (Dutta et al., 2020; Hastig and Sodhi, 2020; Kamble et al., 2020), are also worth investigation. Second, although this study suggests that a system matching traceability and SCC contributes to supply chain performance, it does not reveal the detailed mechanism within the system. Case studies are expected to provide insightful details of the implementation of the traceability-SCC system. Third, coordination with third-party actors may influence the performance of traceability-SCC systems. For example, logistic service providers and technological solution providers play important roles in modern supply chains (Aitken, 2017; Hastig and Sodhi, 2020). How third-party actors involve in the traceability-SCC system is worth exploration. In addition, this study exemplifies the application of the STS perspective in the supply chain context and calls for more research to explore SCM challenges from this perspective.

CRediT authorship contribution statement

Yongyi Shou: Conceptualization, Investigation, Methodology, Writing - review & editing. **Xinyu Zhao:** Formal analysis, Writing - original draft. **Jing Dai:** Conceptualization, Writing - original draft, Writing - review & editing, Supervision. **Dong Xu:** Validation, Writing - review & editing.

Acknowledgements

This work was supported by the National Natural Science Foundation of China [grant numbers: 72010107002, 71602096, 71821002].

Declaration of Competing Interest

None.

References

Aitken, R., 2017. IBM & Walmart Launching Blockchain Food Safety Alliance In China With Fortune 500's JD.com. Forbes. https://www.forbes.com/sites/rogeraitken/2017/12/14/ibm-walmart-launching-blockchain-food-safety-alliance-in-china-with-fortune-500s-jd-com/#96133d67d9c5 (accessed 7.1.20).

Bailey, K., Francis, M., 2008. Managing information flows for improved value chain performance. Int. J. Prod. Econ. 111 (1), 2–12. https://doi.org/10.1016/j.ijpe.2006.11.017.

Basole, R.C., Nowak, M., 2018. Assimilation of tracking technology in the supply chain. Transp. Res. Part E Logist. Transp. Rev. 114, 350–370. https://doi.org/10.1016/j.tre.2016.08.003.

Biswas, I., Raj, A., Srivastava, S.K., 2018. Supply chain channel coordination with triple bottom line approach. Transp. Res. Part E Logist. Transp. Rev. 115, 213–226. https://doi.org/10.1016/j.tre.2018.05.007.

Bostrom, R.P., Heinen, J.S., 1977. MIS problems and failures: A socio-technical perspective. part I: The causes. MIS Q. 1 (3), 17–32. https://doi.org/10.2307/248710.

Bozarth, C.C., Warsing, D.P., Flynn, B.B., Flynn, E.J., 2009. The impact of supply chain complexity on manufacturing plant performance. J. Oper. Manage. 27 (1), 78–93. https://doi.org/10.1016/j.jom.2008.07.003.

Brown, K.A., Willis, P.G., Prussia, G.E., 2000. Predicting safe employee behavior in the steel industry: development and test of a sociotechnical model. J. Oper. Manage. 18 (4), 445–465. https://doi.org/10.1016/S0272-6963(00)00033-4.

Brusco, M.J., Singh, R., Cradit, J.D., Steinley, D., 2017. Cluster analysis in empirical OM research: survey and recommendations. Int. J. Oper. Prod. Manage. 37 (3), 300–320. https://doi.org/10.1108/IJOPM-08-2015-0493.

Business for Social Responsibility, United Nations Global Compact, 2014. A guide to traceability. https://www.unglobalcompact.org/library/791 (accessed 10.15.20).

Buttermann, G., Germain, R., Iyer, K.N.S., 2008. Contingency theory "fit" as gestalt: an application to supply chain management. Transp. Res. Part E Logist. Transp. Rev. 44 (6), 955–969. https://doi.org/10.1016/j.tre.2007.05.012.

Canitez, F., 2019. Pathways to sustainable urban mobility in developing megacities: a socio-technical transition perspective. Technol. Forecast. Soc. Change 141, 319–329. https://doi.org/10.1016/j.techfore.2019.01.008.

Castañer, X., Oliveira, N., 2020. Collaboration, coordination, and cooperation among organizations: establishing the distinctive meanings of these terms through a systematic literature review. J. Manage. 46 (6), 965–1001. https://doi.org/10.1177/0149206320901565.

Chamekh, M., Asmi, S. El, Hamdi, M., Kim, T.H., 2019. IoT based tracking system for supply chain management. Proc. - 2018 Int. Conf. Wirel. Networks Mob. Commun. WINCOM 2018. 10.1109/WINCOM.2018.8629607.

Chandrasekaran, A., Linderman, K., Schroeder, R., 2015. The role of project and organizational context in managing high-tech R&D projects. Prod. Oper. Manage. 24 (4), 560–586. https://doi.org/10.1111/poms.12253.

Chaudhuri, A., Jayaram, J., 2019. A socio-technical view of performance impact of integrated quality and sustainability strategies. Int. J. Prod. Res. 57 (5), 1478–1496. https://doi.org/10.1080/00207543.2018.1492162.

Cheng, Y., Farooq, S., 2018. The role of plants in manufacturing networks: a revisit and extension. Int. J. Prod. Econ. 206, 15–32. https://doi.org/10.1016/j.ijpe.2018.09.001.

Christiansen, T., Berry, W.L., Bruun, P., Ward, P., 2003. A mapping of competitive priorities, manufacturing practices, and operational performance in groups of Danish manufacturing companies. Int. J. Oper. Prod. Manage. 23 (10), 1163–1183. https://doi.org/10.1108/01443570310496616.

Christopher, M., Towill, D., 2001. An integrated model for the design of agile supply chains. Int. J. Phys. Distrib. Logist. Manage. 31 (4), 235–246. https://doi.org/10.1108/09600030110394914.

Closs, D.J., Jacobs, M.A., Swink, M., Webb, G.S., 2008. Toward a theory of competencies for the management of product complexity: six case studies. J. Oper. Manage. 26 (5), 590–610. https://doi.org/10.1016/j.jom.2007.10.003.

Corallo, A., Latino, M.E., Menegoli, M., Pontrandolfo, P., 2020. A systematic literature review to explore traceability and lifecycle relationship. Int. J. Prod. Res. 58 (15), 4789–4807. https://doi.org/10.1080/00207543.2020.1771455.

Cousins, P.D., Lawson, B., Petersen, K.J., Fugate, B., 2019. Investigating green supply chain management practices and performance: The moderating roles of supply chain ecocentricity and traceability. Int. J. Oper. Prod. Manage. 39 (5), 767–786. https://doi.org/10.1108/IJOPM-11-2018-0676.

Da Silveira, G.J.C., Arkader, R., 2007. The direct and mediated relationships between supply chain coordination investments and delivery performance. Int. J. Oper. Prod. Manage. 27 (2), 140–158. https://doi.org/10.1108/01443570710720595.

Dai, H., Tseng, M.M., Zipkin, P.H., 2015. Design of traceability systems for product recall. Int. J. Prod. Res. 53 (2), 511–531. https://doi.org/10.1080/00207543.2014.955922.

Danese, P., Lion, A., Vinelli, A., 2019. Drivers and enablers of supplier sustainability practices: a survey-based analysis. Int. J. Prod. Res. 57 (7), 2034–2056. https://doi.org/10.1080/00207543.2018.1519265.

Das, A., Jayaram, J., 2007. Socio-technical perspective on manufacturing system synergies. Int. J. Prod. Res. 45 (1), 169–205. https://doi.org/10.1080/00207540500381039.

Dutta, P., Choi, T.M., Somani, S., Butala, R., 2020. Blockchain technology in supply chain operations: applications, challenges and research opportunities. Transp. Res. Part E Logist. Transp. Rev. 142, 102067 https://doi.org/10.1016/j.tre.2020.102067.

Edwards, J.R., 2001. Multidimensional constructs in organizational behavior research: an integrative analytical framework. Organ. Res. Methods 4 (2), 144–192. https://doi.org/10.1177/109442810142004.

Emery, F., 1959. Characteristics of Socio-Technical Systems. Tavistock Institute, London.

Fatorachian, H., Kazemi, H., 2018. A critical investigation of Industry 4.0 in manufacturing: theoretical operationalisation framework. Prod. Plan. Control 29 (8), 633–644. https://doi.org/10.1080/09537287.2018.1424960.

Fiala, P., 2005. Information sharing in supply chains. Omega 33 (5), 419–423. https://doi.org/10.1016/j.omega.2004.07.006.

Flynn, B.B., Huo, B., Zhao, X., 2010. The impact of supply chain integration on performance: a contingency and configuration approach. J. Oper. Manage. 28 (1), 58–71. https://doi.org/10.1016/j.jom.2009.06.001.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A., Flynn, E.J., 1990. Empirical research methods in operations management. J. Oper. Manage. 9 (2), 250–284. https://doi.org/10.1016/0272-6963(90)90098-X.

Fuenfschilling, L., Truffer, B., 2014. The structuration of socio-technical regimes – conceptual foundations from institutional theory. Res. Pol. 43 (4), 772–791. https://doi.org/10.1016/j.respol.2013.10.010.

Garcia-Torres, S., Albareda, L., Rey-Garcia, M., Seuring, S., 2019. Traceability for sustainability – literature review and conceptual framework. Supply Chain Manage. 24 (1), 85–106. https://doi.org/10.1108/SCM-04-2018-0152.

George, B.A., 2011. Entrepreneurial orientation: a theoretical and empirical examination of the consequences of differing construct representations. J. Manage. Stud. 48 (6), 1291–1313. https://doi.org/10.1111/j.1467-6486.2010.01004.x.

Gligor, D.M., Holcomb, M.C., 2012. Antecedents and consequences of supply chain agility: establishing the link to firm performance. J. Bus. Logist. 33 (4), 295–308. https://doi.org/10.1111/jbl.12003.

Guercini, S., Runfola, A., 2009. The integration between marketing and purchasing in the traceability process. Ind. Mark. Manage. 38 (8), 883–891. https://doi.org/10.1016/j.indmarman.2009.03.016.

Hadid, W., Mansouri, S.A., Gallear, D., 2016. Is lean service promising? A socio-technical perspective. Int. J. Oper. Prod. Manage. 36 (6), 618–642. https://doi.org/10.1108/IJOPM-01-2015-0008.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2011. Multivariate Data Analysis, 7th ed. China Machine Press, Beijing.

Hair, J.F., Howard, M.C., Nitzl, C., 2020. Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. J. Bus. Res. 109, 101–110. https://doi.org/10.1016/j.jbusres.2019.11.069.

Hair, J.F., Sarstedt, M., Ringle, C.M., Gudergan, S.P., 2018. Advanced Issues in Partial Least Squares Structural Equation Modeling. Sage Publications Inc, Los Angeles, CA.

Hammer, M., 2004. Deep change: how operational innovation can transform your company. Harv. Bus. Rev. 82 (4), 84–93.
Handley, S.M., Benton, W.C., 2013. The influence of task- and location-specific complexity on the control and coordination costs in global outsourcing relationships. J. Oper. Manage. 31 (3), 109–128. https://doi.org/10.1016/j.jom.2012.12.003.
Hastig, G.M., Sodhi, M.S., 2020. Blockchain for supply chain traceability: business requirements and critical success factors. Prod. Oper. Manage. 29 (4), 935–954. https://doi.org/10.1111/poms.13147.
Henseler, J., Ringle, C.M., Sarstedt, M., 2014. A new criterion for assessing discriminant validity in variance-based structural equation modeling. J. Acad. Mark. Sci. 43 (1), 115–135. https://doi.org/10.1007/s11747-014-0403-8.
Hill, C.A., Scudder, G.D., 2002. The use of electronic data interchange for supply chain coordination in the food industry. J. Oper. Manage. 20 (4), 375–387. https://doi.org/10.1016/S0272-6963(02)00017-7.
Huo, B., Ye, Y., Zhao, X., Zhu, K., 2019. Supply chain quality integration: a taxonomy perspective. Int. J. Prod. Econ. 207, 236–246. https://doi.org/10.1016/j.ijpe.2016.05.004.
Jarvis, C.B., MacKenzie, S.B., Podsakoff, P.M., 2003. A critical review of construct indicators and measurement model misspecification in marketing and consumer research. J. Consum. Res. 30 (2), 199–218. https://doi.org/10.1086/376806.
Kamann, D.J.F., Alfaro, J.A., Sebrek, S.S., 2019. 28 years of traceability management: trends, bottlenecks and opportunities. Int. J. Procure. Manage. 12 (1), 56–87. https://doi.org/10.1504/IJPM.2019.096997.
Kamble, S.S., Gunasekaran, A., Sharma, R., 2020. Modeling the blockchain enabled traceability in agriculture supply chain. Int. J. Inf. Manage. 52, 101967 https://doi.org/10.1016/j.ijinfomgt.2019.05.023.
Krapp, M., Kraus, J.B., 2019. Coordination contracts for reverse supply chains: a state-of-the-art review. J. Bus. Econ. 89 (7), 747–792. https://doi.org/10.1007/s11573-017-0887-z.
Kull, T.J., Ellis, S.C., Narasimhan, R., 2013. Reducing behavioral constraints to supplier integration: a socio-technical systems perspective. J. Supply Chain Manage. 49 (1), 64–86. https://doi.org/10.1111/jscm.12002.
Lam, M.H., Chang, W.S., 2020. The effect of information on supply chain coordination: a model of value discounting. Asia Pacific Manage. Rev. 25 (3), 134–141. https://doi.org/10.1016/j.apmrv.2019.06.003.
Lee, N., Cadogan, J.W., 2013. Problems with formative and higher-order reflective variables. J. Bus. Res. 66 (2), 242–247. https://doi.org/10.1016/j.jbusres.2012.08.004.
Lehmann, D.R., 1979. Market Research and Analysis. Irwin, Homewood, IL.
Leong, C., Viskin, T., Stewart, R., 2018. Tracing the supply chain. Accenture. https://www.accenture.com/us-en/insights/blockchain/food-traceability (accessed 7.1.20).
Li, A.Q., Rich, N., Found, P., Kumar, M., Brown, S., 2020. Exploring product–service systems in the digital era: a socio-technical systems perspective. TQM J. https://doi.org/10.1108/TQM-11-2019-0272.
Li, X., 2020. Reducing channel costs by investing in smart supply chain technologies. Transp. Res. Part E Logist. Transp. Rev. 137, 101927 https://doi.org/10.1016/j.tre.2020.101927.
Liboni, L.B., Cezarino, L.O., Jabbour, C.J.C., Oliveira, B.G., Stefanelli, N.O., 2019. Smart industry and the pathways to HRM 4.0: implications for SCM. Supply Chain. Manage. An Int. J. 24 (1), 124–146. https://doi.org/10.1108/SCM-03-2018-0150.
MacKenzie, S.B., Podsakoff, P.M., Podsakoff, N.P., 2011. Construct measurement and validation procedures in MIS and behavioral research: Integrating new and existing techniques. MIS Q. 35 (2), 293–334. https://doi.org/10.2307/23044045.
Manz, C.C., Stewart, G.L., 1997. Attaining flexible stability by integrating total quality management and Socio-technical Systems Theory. Organ. Sci. 8 (1), 59–70. https://doi.org/10.1287/orsc.8.1.59.
Marucheck, A., Greis, N., Mena, C., Cai, L., 2011. Product safety and security in the global supply chain: issues, challenges and research opportunities. J. Oper. Manage. 29 (7–8), 707–720. https://doi.org/10.1016/j.jom.2011.06.007.
Moon, I., Feng, X., 2017. Supply chain coordination with a single supplier and multiple retailers considering customer arrival times and route selection. Transp. Res. Part E Logist. Transp. Rev. 106, 78–97. https://doi.org/10.1016/j.tre.2017.08.004.
Oke, A., Kach, A., 2012. Linking sourcing and collaborative strategies to financial performance: the role of operational innovation. J. Purch. Supply Manage. 18 (1), 46–59. https://doi.org/10.1016/j.pursup.2012.01.001.
Ortega-Jimenez, C.H., Garrido-Vega, P., Cruz Torres, C.A., 2020. Achieving plant responsiveness from reconfigurable technology: intervening role of SCM. Int. J. Prod. Econ. 219, 195–203. https://doi.org/10.1016/j.ijpe.2019.06.001.
Peng, D.X., Schroeder, R.G., Shah, R., 2008. Linking routines to operations capabilities: a new perspective. J. Oper. Manage. 26 (6), 730–748. https://doi.org/10.1016/j.jom.2007.11.001.
Petter, S., Straub, D., Rai, A., 2007. Specifying formative constructs in information systems research. MIS Q. 31 (4), 623–656. https://doi.org/10.2307/25148814.
Pisa, M., McCurdy, D., 2019. Improving global health supply chains through traceability. CGD Policy Pap. https://www.cgdev.org/publication/improving-global-health-supply-chains-through-traceability (accessed 10.15.20).
Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., Podsakoff, N.P., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. J. Appl. Psychol. 88 (5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879.
Power, D., Singh, P., 2007. The e-integration dilemma: The linkages between Internet technology application, trading partner relationships and structural change. J. Oper. Manage. 25 (6), 1292–1310. https://doi.org/10.1016/j.jom.2007.01.006.
Rábade, L.A., Alfaro, J.A., 2006. Buyer-supplier relationship's influence on traceability implementation in the vegetable industry. J. Purch. Supply Manage. 12 (1), 39–50. https://doi.org/10.1016/j.pursup.2006.02.003.
Rahman, S., 1998. Theory of constraints: a review of the philosophy and its applications. Int. J. Oper. Prod. Manage. 18 (4), 336–355. https://doi.org/10.1108/01443579810199720.
Ringle, C.M., Sarstedt, M., Mitchell, R., Gudergan, S.P., 2020. Partial least squares structural equation modeling in HRM research. Int. J. Hum. Resour. Manage. 31 (12), 1617–1643. https://doi.org/10.1080/09585192.2017.1416655.
Sanders, N.R., 2008. Pattern of information technology use: The impact on buyer-suppler coordination and performance. J. Oper. Manage. 26 (3), 349–367. https://doi.org/10.1016/j.jom.2007.07.003.
Sarpong, S., 2014. Traceability and supply chain complexity: confronting the issues and concerns. Eur. Bus. Rev. 26 (3), 271–284. https://doi.org/10.1108/EBR-09-2013-0113.
Shah, R., Ward, P.T., 2003. Lean manufacturing: context, practice bundles, and performance. J. Oper. Manage. 21 (2), 129–149. https://doi.org/10.1016/S0272-6963(02)00108-0.
Shankar, R., Gupta, R., Pathak, D.K., 2018. Modeling critical success factors of traceability for food logistics system. Transp. Res. Part E Logist. Transp. Rev. 119, 205–222. https://doi.org/10.1016/j.tre.2018.03.006.
Shi, X., Liao, Z., 2013. The mediating effects of interfirm business process integration and joint teamwork on firm performance in supply chains. Asia Pacific J. Manage. 30 (4), 1243–1264. https://doi.org/10.1007/s10490-012-9308-6.
Shou, Y., Che, W., Dai, J., Jia, F., 2018. Inter-organizational fit and environmental innovation in supply chains: a configuration approach. Int. J. Oper. Prod. Manage. 38 (8), 1683–1704. https://doi.org/10.1108/IJOPM-08-2017-0470.
Shou, Y., Prester, J., Li, Y., 2020a. The impact of intellectual capital on supply chain collaboration and business performance. IEEE Trans. Eng. Manage. 67 (1), 92–104. https://doi.org/10.1109/TEM.2018.2870490.
Shou, Y., Zhao, X., Chen, L., 2020b. Operations strategy of cloud-based firms: achieving firm growth in the Big Data era. Int. J. Oper. Prod. Manage. 40 (6), 873–896. https://doi.org/10.1108/IJOPM-01-2019-0089.
Siawsh, N., Peszynski, K., Young, L., Vo-Tran, H., 2020. Exploring the role of power on procurement and supply chain management systems in a humanitarian organisation: a socio-technical systems view. Int. J. Prod. Res. 10.1080/00207543.2019.1634293.

Sinha, K.K., Van de Ven, A.H., 2005. Designing work within and between organizations. Organ. Sci. 16 (4), 389–408. https://doi.org/10.1287/orsc.1050.0130.
Solaimani, S., Talab, A.H., van der Rhee, B., 2019. An integrative view on Lean innovation management. J. Bus. Res. 105, 109–120. https://doi.org/10.1016/j.jbusres.2019.07.042.
Stank, T.P., Goldsby, T.J., Vickery, S.K., 1999. Effect of service supplier performance on satisfaction and loyalty of store managers in the fast food industry. J. Oper. Manage. 17 (4), 429–447. https://doi.org/10.1016/S0272-6963(98)00052-7.
Stranieri, S., Orsi, L., Banterle, A., 2017. Traceability and risks: an extended transaction cost perspective. Supply Chain Manage. An Int. J. 22 (2), 145–159. https://doi.org/10.1108/SCM-07-2016-0268.
Thakur, M., Møen Tveit, G., Vevle, G., Yurt, T., 2020. A framework for traceability of hides for improved supply chain coordination. Comput. Electron. Agric. 174, 105478 https://doi.org/10.1016/j.compag.2020.105478.
Vosooghidizaji, M., Taghipour, A., Canel-Depitre, B., 2020. Supply chain coordination under information asymmetry: a review. Int. J. Prod. Res. 58 (6), 1805–1834. https://doi.org/10.1080/00207543.2019.1685702.
Wang, S., Li, J., Song, J., Li, Y., Sherk, M., 2018. Institutional pressures and product modularity: do supply chain coordination and functional coordination matter? Int. J. Prod. Res. 56 (20), 6644–6657. https://doi.org/10.1080/00207543.2018.1444807.
Watson, K.J., Blackstone, J.H., Gardiner, S.C., 2007. The evolution of a management philosophy: the theory of constraints. J. Oper. Manage. 25 (2), 387–402. https://doi.org/10.1016/j.jom.2006.04.004.
Wesseling, J.H., Bidmon, C., Bohnsack, R., 2020. Business model design spaces in socio-technical transitions: the case of electric driving in the Netherlands. Technol. Forecast. Soc. Change 154, 119950. https://doi.org/10.1016/j.techfore.2020.119950.
Wiklund, J., Shepherd, D., 2003. Aspiring for, and achieving growth: The moderating role of resources and opportunities. J. Manag. Stud. 40 (8), 1919–1941. https://doi.org/10.1046/j.1467-6486.2003.00406.x.
Wowak, K.D., Craighead, C.W., Ketchen, D.J., 2016. Tracing bad products in supply chains: the roles of temporality, supply chain permeation, and product information ambiguity. J. Bus. Logist. 37 (2), 132–151. https://doi.org/10.1111/jbl.12125.
Xu, D., Huo, B., Sun, L., 2014. Relationships between intra-organizational resources, supply chain integration and business performance: an extended resource-based view. Ind. Manage. Data Syst. 114 (8), 1186–1206. https://doi.org/10.1108/IMDS-05-2014-0156.
Xu, K., Dong, Y., Evers, P.T., 2001. Towards better coordination of the supply chain. Transp. Res. Part E Logist. Transp. Rev. 37 (1), 35–54. https://doi.org/10.1016/S1366-5545(00)00010-7.
Xu, L., Beamon, B.M., 2006. Supply chain coordination and cooperation mechanisms: an attribute-based approach. J. Supply Chain Manage. 42 (1), 4–12. https://doi.org/10.1111/j.1745-493X.2006.04201002.x.
Xu, L., Li, Y., Govindan, K., Yue, X., 2018. Return policy and supply chain coordination with network-externality effect. Int. J. Prod. Res. 56 (10), 3714–3732. https://doi.org/10.1080/00207543.2017.1421786.
Yang, B., Fernandes, K.J., 2010. Global supply chain risk management: a socio-technical perspective. Int. J. Bus. Environ. 3 (2), 240–249. https://doi.org/10.1504/ijbe.2010.032717.
Yu, W., Chavez, R., Jacobs, M.A., Feng, M., 2018. Data-driven supply chain capabilities and performance: a resource-based view. Transp. Res. Part E Logist. Transp. Rev. 114, 371–385. https://doi.org/10.1016/j.tre.2017.04.002.
Yuan, K., Bentler, P.M., Kano, Y., 1997. On averaging variables in a confirmatory factor analysis model. Behaviormetrika 24 (1), 71–83. https://doi.org/10.2333/bhmk.24.71.
Zhang, Q., Vonderembse, M.A., Lim, J.-S., 2003. Manufacturing flexibility: defining and analyzing relationships among competence, capability, and customer satisfaction. J. Oper. Manage. 21 (2), 173–191. https://doi.org/10.1016/S0272-6963(02)00067-0.
Zhao, T., Xu, X., Chen, Y., Liang, L., Yu, Y., Wang, K., 2020. Coordination of a fashion supply chain with demand disruptions. Transp. Res. Part E Logist. Transp. Rev. 134, 101838 https://doi.org/10.1016/j.tre.2020.101838.
Zhou, H., Shou, Y., Zhai, X., Li, L., Wood, C., Wu, X., 2014. Supply chain practice and information quality: a supply chain strategy study. Int. J. Prod. Econ. 147, 624–633. https://doi.org/10.1016/j.ijpe.2013.08.025.
Zhu, Q., Geng, Y., Sarkis, J., Lai, K. hung, 2011. Evaluating green supply chain management among Chinese manufacturers from the ecological modernization perspective. Transp. Res. Part E Logist. Transp. Rev. 47 (6), 808–821. 10.1016/j.tre.2010.09.013.