The effect of uncertainty avoidance and social trust on supply chain collaboration

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Abstract:

Supply chain collaboration (SCC) is strategically important in today's business world, and the use of inter-organizational systems (IOS) much facilitates SCC. The present study examines: (1) the differential effects of two types of IOS—open and closed—on firms' use of SCC; (2) the impact of a country's uncertainty avoidance and social trust on firms' use of SCC; and (3) the moderating role of uncertainty avoidance and social trust on the firm-level relationships between open/closed IOS and SCC. Using a large dataset from twenty-four countries, a multi-level analysis suggests that, not only uncertainty avoidance and social trust affect SCC directly, but uncertainty avoidance also moderates the relationship between open IOS and SCC at the firm level. These findings are important for the research and practice of SCC, as they provide novel angles for researchers and managers to look at the factors that may affect the success of SCC.

Keywords: uncertainty avoidance | social trust | supply chain collaboration (SCC) | open inter-organizational systems (IOS) | closed IOS

Article:

1. Introduction

Increasingly, supply chains are replacing individual firms as the competitive unit in many industries (Kumar, 2001, Swaminathan and Tayur, 2003). Effectively managing resources and collaborations across partnering firms in a supply chain has become the dominant concern. More and more firms have begun to coordinate their production and distribution networks and collaborate with supply chain partners rather than manage their internal resources alone (Baraldi et al., 2012, Dyer and Singh, 1998). Supply chain collaboration (SCC)—such as information sharing, collaborative forecasting, and joint new product development—can be a source of strategic advantage (Rai et al., 2006, Subramani, 2004). Wal-Mart's success is an excellent example. In the late 1980s, Wal-Mart was only a small retailer. To reduce its inventory level from 30-day to 5-day, Wal-Mart was the leading pioneer in the industry in developing collaborative commerce, using an EDI-based supply chain management system to connect its largest suppliers to its inventory management system. This approach has allowed Wal-Mart to secure its cost leadership in the industry and to establish competitive advantages over its competitors.

Due to the importance of SCC in business practices, previous researchers have investigated SCC-related issues. Mainly two streams of research exist in this domain, one focusing on firm-level factors and the other focusing on country-level factors that can potentially affect the success of SCC. At the firm-level, prior researchers have examined the effect of inter-organizational systems (IOS) on SCC (e.g., Chae et al., 2005, Chatfield and Yetton, 2000, Rai et al., 2006). IOS refers to the application systems that link various business partners, using a public or private telecommunication infrastructure (Robey, Im, & Wareham, 2008). These systems provide the ability for computer-to-computer communication of business transactions and documents. Electronic data interchange (EDI) is one of the earliest IOS technologies. More recently, firms have used XML-based standards such as RosettaNet to provide information flow between suppliers and customers. A significant impact of IOS on SCC would suggest that the technology infrastructure of the firm is an effective predictor of its future success in collaborative activities (e.g., information sharing, and joint new product development) with its supply chain members.

In addition to the firm-level predictors, prior researchers (e.g., Griffith and Myers, 2005, Zhao et al., 2007, Zhao et al., 2011) have also compared SCC-related issues across different nations. Zhao et al. (2011), for example, report that for Chinese-controlled companies, relationship commitment has significant impact on collaboration with suppliers and customers. However, for foreign-controlled companies, such effect does not exist. Moreover, Griffith and Myers (2005) show that firm performance is enhanced when US firms establish a low level of information exchange with their US partners while simultaneously establishing a high level of information exchange with their Japanese partners. All these cross-national studies attribute the country-level discrepancies mainly to the differences in cultural value orientations.

Prior studies provide intriguing findings; nevertheless, three gaps exist in this line of literature. First, all these studies use anecdotal evidence from two or three countries. External validity of the findings is questionable with the limited sample size. Second, prior cross-national research usually infers rather than measures culture. According to Hofstede (2001), culture has multiple dimensions, including uncertainty avoidance, collectivism/individualism, masculinity/femininity, and power distance. Without measuring the cultural values, research cannot show which dimension of culture is the key attributor for the success of SCC at the firm level. Finally, little research has thus far examined the possible interplay between country- and firm-level factors. A cross-level investigation is of great significance in advancing the research stream because such studies provide novel insights on how country-level factors may set up boundary conditions for the firm-level effects. Studying country-level effects on the firm-level SCC can also advance the understanding of what exact role that specific cultural dimensions play in facilitating or hindering SCC.

This study aims to fill these voids by investigating not only the main effect of relevant cultural values on SCC, but also the interaction between cultural values and firm-level effects. This study centers on uncertainty avoidance and social trust at the country level to examine their direct impact on SCC, as well as their moderating effect on the relationship between IOS and SCC at the firm level. The reason for focusing on the uncertainty avoidance dimension of national culture in this study is that a country's uncertainty avoidance should directly influence the success of SCC. SCC requires relationship-specific investments that involve opportunistic risks

(Klein et al., 2007, Subramani, 2004, Williamson, 1985). Since SCC is accompanied by a lot of behavioral uncertainty, the uncertainty avoidance orientation of a country may serve as an important contextual factor in facilitating or hindering the success of SCC for firms. The nature of SCC suggests that, compared to uncertainty avoidance, other cultural dimensions (i.e., collectivism/individualism, power distance, and masculinity/femininity) are more distal in influencing its success.

In addition to uncertainty avoidance, the study also includes social trust as another important cultural dimension in the model. Social trust influences people's perception of opportunistic risks (Fukuyama, 1995, Yamagishi et al., 1998) and serves as an important dimension of cultural values that has direct impact on business decisions that involve opportunistic risks (Uslaner, 2002). Lazzarini, Miller, and Zenger (2008), for example, find that firms in countries with a higher level of social trust are more proactive in seeking new business partners than those in countries with a lower level of social trust. These research findings suggest that social trust is an important cultural dimension that influences SCC.

This study makes several important contributions to both theory and practice. First, the study represents the first attempt to identify the key dimensions of culture that play critical roles in affecting the success of SCC. Extending previous studies on this topic that treat country and culture interchangeably, this study examines unique contributions of specific dimensions of cultural values on SCC and shows that a country's uncertainty avoidance and social trust are the most relevant aspects in culture to affect SCC. These findings open a new way for managers to screen their environment and to develop effective strategies to facilitate their SCC plan. Second, this study breaks IOS into open-IOS and closed-IOS, and simultaneously examines how these two distinct types of IOS may have differential effects on SCC. Third, the study shows that the key dimensions of cultural values can also interplay with firm-level factors in influencing SCC. These findings are new and important to managers, especially when their firms engage in global SCC. The framework suggests that uncertainty avoidance and/or social trust may set boundaries for the success of IOS-based SCC; as a result, one important decision in global SCC is to determine how to manage open IOS and closed IOS differently in different countries.

The structure of the rest of paper is as follows. The paper starts with a literature review on IOS and SCC, and then develops hypotheses about the direct effects of country-level uncertainty avoidance and social trust on the firm-level SCC, as well as their moderating roles in the effects of open/closed IOS on SCC. Afterwards, the paper presents the multi-level analysis and the results. The paper ends with theoretical and practical implications and discussion on limitations and future research directions.

2. Literature review

A few studies have investigated the effect of IOS on SCC. For instance, Grover, Teng, and Fiedler (2002) show a positive role of IOS in partially offsetting the negative relationship between transaction costs and inter-firm collaboration. The results suggest that the use of IOS within a supply chain can encourage the commitment to establish collaboration between transaction partners. Subramani (2004) finds that the use of IOS increases inter-firm asset specialty in business processes (e.g., operating processes, administrative processes, and quality-

control processes), and inter-firm knowledge specificity in business activities (e.g., competitive analysis, strategy formulation, and new-product development). Rai et al. (2006) report that inter-firm IT infrastructure integration for supply chain management (e.g., data consistency, and IT application integration) can enhance the supply chain process integration in information flow, physical flow, and financial flow. These findings are consistent with the traditional vendors-to-partners view, namely, that the use of IOS may lead to a partner relationship between firms along a supply chain (Bakos and Brynjolfsson, 1993, Clemons et al., 1993).

Other studies suggest that contextual factors matter in the success of IOS-based SCC. For instance, Chatfield and Yetton (2000) report that only firms with good relationships with their trading partners will make strategic use of the EDI by adopting EDI-enabled joint economic actions and thus gaining strategic payoff. Similarly, Chae et al. (2005) show that the effect of IT on inter-organizational collaboration is the emergent property of the interplay between IT and the existing relationships among partners. IT often reinforces and stabilizes the already existing inter-organizational structures and arrangements. Saeed, Malhotra, and Grover (2011) find that firms at the lower end of SCC configure IOS features to support supplier evaluation and automatic alerts. But firms at the upper end pay greater attention to features associated with systems integration, planning, and forecasting.

This paper extends the existing literature on IOS—SCC in two ways. First, the paper distinguishes between two types of IOS, namely, open IOS and closed IOS, and examines their effect on SCC. Second, the paper focuses on uncertainty avoidance and social trust to understand how national level cultural dimensions may differentially moderate the effect of open/closed IOS on SCC at the firm level.

3. Hypothesis development

3.1. Country-level hypotheses

Uncertainty avoidance refers to how people feel either uncomfortable or comfortable in novel and unusual situations (Hofstede, Hofstede, & Minkov, 2010). In countries with a high level of uncertainty avoidance, people often try to minimize all kinds of uncertainty by enacting strict laws and rules and by enforcing security measures because they feel anxiety in uncertain situations (Hofstede et al., 2010). To the contrary, in countries with a low level of uncertainty avoidance, people feel more comfortable with uncertain situations and usually tolerate different opinions and behaviors.

Although SCC may provide firms with strategic advantages, SCC also involves certain behavioral uncertainty. In order to make SCC effective, supply chain partners usually need to make relationship-specific investments in supply chain processes (Subramani, 2004). Klein et al. (2007) show that relationship-specific investments are necessary for developing collaborative activities such as sharing strategic information. However, a firm's unilateral relationship-specific investments may result in its partner firms' opportunistic behaviors (Klein et al., 1978, Williamson, 1985). For example, a partner firm may exploit this situation by asking for a lower price. In this case, the focal firm may have no choice but to accept the lower price because

the unilateral relationship-specific investments by the firm may have little value if the transaction relationship does not continue.

Another type of uncertainty comes from the sharing of strategic information on key markets or technologies. In order to facilitate SCC, such as collaborative forecasting and joint new product development, supply chain partners need to exchange strategic information on markets and technologies. However, one party may occasionally exploit such information to gain its own economic benefit at the expense of the other party (e.g., providing such strategic information to the other party's rivals). As a result, the sharing of strategic information between transaction partners becomes a very real concern for firms in a supply chain (Feldmann & Müller, 2003). Foreseeing that supply chain partners may behave opportunistically by exploiting their relationship-specific investments and their strategic information, firms will be unwilling to make relationship-specific investments on SCC (Subramani & Venkatraman, 2003) and share strategic information with their supply chain partners (Feldmann & Müller, 2003). This argument is especially true for firms in countries with a high level of uncertainty avoidance because people in such countries tend to avoid uncertain situations (Hofstede et al., 2010). Prior empirical studies have also shown that the uncertainty-avoiding culture of a country discourages firms from engaging in activities with high uncertainty (Kogut and Singh, 1988, Png et al., 2001). Therefore, this paper proposes a negative relationship between uncertainty avoidance culture and firms' SCC adoption.

H1. A country's level of uncertainty avoidance negatively impacts firms' use of SCC in that country.

In addition to uncertainty avoidance, social trust may also negatively affect SCC at the firm level. Social trust refers to the average level of generalized trust of people in a country (Fukuyama, 1995, Knack and Keefer, 1997), where generalized trust is the faith people have in other people in general (including in those they have never met). Unlike particularized trust, that is a characteristic of an interpersonal relationship and develops over time through interactions between the two parties in a relationship (Zucker, 1986), generalized trust is a general belief that people have about others which arises from one's environment (i.e., upbringing, laws, and cultural norms and values) (Nooteboom, 2002). Research suggests that good institutions may create and maintain incentives for behaving trustworthily and thus result in social trust (Levi, 1996, Rothstein and Stolle, 2008). The reason is that appropriate institutions in a country are more likely to detect and sanction betrayal so that people may not behave opportunistically. As a result, appropriate institutions provide a rational basis for trusting other people.

Social trust is an important influence on human behavior. For instance, in countries with a low level of social trust, people tend to form committed relationships with specific trading partners in order to avoid being exploited in social interactions (Kollock, 1994). Committed relationships reduce the risks of partners' opportunistic behaviors for three reasons (Yamagishi & Yamagishi, 1994). First, people in committed relationships accumulate information which allows them to know more about the intentions of a partner. Second, a variety of bonds may develop in committed relations (e.g., relation-specific assets), which disappear once the relationship discontinues. Such bonds can serve as hostages for a continuous relationship. Finally, committed

relationships provide people with more mutual control over each other (Yamagishi & Yamagishi, 1994).

However, such committed relationships may be unnecessary in countries with a high level of social trust because people in these countries perceive low opportunism risk. Empirical findings from cross-cultural comparison studies clearly show that transaction partners tend to shy away from committed relationships in countries with high levels of social trust (Yamagishi et al., 1998). Furthermore, relief from having to enter into committed relationships to reduce risks becomes an important advantage for firms. A high level of social trust emancipates firms from committed relationships and, as such, allows them to seek out potentially better partners and not commit to any particular one. Research finds that market participants with high generalized trust are more willing to initiate exchange with new partners in response to potential better deals than will market participants with low generalized trust (Lazzarini et al., 2008).

As managers in countries higher in social trust are less likely to commit to a particular trading partner, they are usually adverse to the use of SCC. This is because, by its very nature, SCC requires trading partners to make committed relationship-specific investments such as those related to joint processes and knowledge sharing/creation (Klein et al., 2007, Subramani, 2004). In other words, because SCC requires committed investments from trading partners, but managers in countries with higher social trust are less likely to commit to trading partners, a high level of social trust may actually inhibit firms from engaging in SCC.

H2. A country's level of social trust negatively impacts firms' use of SCC in that country.

3.2. Firm-level hypotheses

Research to date distinguishes between two types of IOS standards: open standards and closed standards (Gosain et al., 2003, Zhu et al., 2006). A closed standard is a standard that is developed by and available only to a closed set of firms, and requires a private communication platform (e.g., the customized system between Wal-Mart and its suppliers). In contrast, if a standard is available to the public and uses public communication platforms and software, the standard is an open standard (e.g., RosettaNet and ebXML) (Zhu et al., 2006).

As stated earlier, prior studies on the relationship between IOS and SCC by and large suggest that the use of IOS promotes SCC. Nowadays, the IOS used in supply chains usually provides advanced functions such as information sharing, communication, and collaborative work, which can much facilitate the collaboration among supply chain partners (Richey et al., 2008, Seggie et al., 2006, Subramani, 2004). Furthermore, by standardizing the data format and the business processes in transactions, the use of IOS allows firms to communicate and work with each other easier, and thus promotes SCC (Gosain et al., 2003). Previous research has also shown that the use of IOS, either open or closed standards based, positively contributes to the collaboration between trading partners (Grover et al., 2002, Malhotra et al., 2007, Rai et al., 2006). Therefore, the use of IOS should facilitate SCC, no matter whether the IOS is open or closed.

H3a. Firms' use of open standards-based IOS positively impacts the use of SCC.

H3b. Firms' use of closed standards-based IOS positively impacts the use of SCC.

3.3. Cross-level hypotheses

In addition to their direct effects on SCC, country-level uncertainty avoidance and social trust are also likely to moderate the influence of IOS on SCC at the firm level, and in such a way that the positive relationship between open/closed IOS and SCC becomes weaker when the uncertainty avoidance and social trust of a country is higher. SCC requires supply chain partners to make relationship-specific investments (Klein et al., 2007, Subramani, 2004) which involve certain opportunistic risks (Williamson, 1985). For example, the sharing of strategic information between business partners may cause the leak of such strategic information and bring risks to the focal firm (Feldmann & Müller, 2003). Because people in countries higher in uncertainty avoidance are more likely to avoid risky situations (Hofstede et al., 2010), firms in such countries may be less willing to engage in SCC. This low willingness, in turn, may negatively influence the facilitating role of IOS in SCC. Namely, even if IOS provides a great platform for firms to develop SCC, those in uncertainty-avoiding countries tend to hold back for SCC development because they are afraid of the potential risks in the partnership building process. Conversely, firms in countries with lower uncertainty avoidance have fewer concerns about such risks and are more likely to engage in IOS-enabled SCC. As a result, the facilitating role of IOS in SCC can be different between countries with high uncertainty avoidance and those with low uncertainty avoidance. The forgoing discussion leads to the following hypothesis:

H4a. The positive relationship between open/closed IOS and SCC becomes weaker when the uncertainty avoidance of a country is higher.

Similar to uncertainty avoidance, social trust may mitigate the facilitating role of IOS on SCC as well. People in countries higher in social trust are more likely to shy away from committed relationships, as committed relationships are unnecessary in such countries due to the low perceived opportunism risk (Yamagishi et al., 1998). Also, being free from a committed relationship provides firms with an advantage to pursue better opportunities. As a result, firms in countries with higher social trust tend to have a lower level of willingness to engage in SCC, despite their IOS status. Conversely, firms in lower social trust society have an inherent motivation to form alliances with business partners (Yamagishi et al., 1998). Since SCC requires supply chain partners to make committed relationship-specific investments in collaborative activities (Klein et al., 2007, Subramani, 2004), in countries with a lower level of social trust, the firms with an existing IOS platform are motivated to utilize IOS for SCC development. Namely, the strength of the IOS–SCC relationship is stronger when the level of social trust in a society is weaker.

H4b. The positive relationship between open/closed IOS and SCC becomes weaker when the social trust of a country is higher.

4. Method

4.1. Data and variables

The data for this study come from several sources, including e-Business Watch (www.ebusiness-watch.org), the World Values Survey (www.worldvaluessurvey.org), and Hofstede's scores for national culture (www.geert-hofstede.com).

The data for supply chain collaboration (SCC) and the use of open/closed IOS are from e-Business Watch, a European Commission organization aiming to promote the growth and development of EU enterprises. In 2006, e-Business Watch interviewed decision makers in general or IT decision makers (mainly the head/senior members of IT department, the owner, and managing directors/board members) of 14,065 firms in 10 sectors across 29 countries (including 25 EU member countries as well as Norway, Bulgaria, Romania, and Turkey) about their uses of e-business and related issues. Before the survey, e-Business Watch translated the questionnaire in English into the countries' respective languages. As a step for the quality assurance of translation, e-Business Watch conducted back-translation and made necessary amendments. Due to missing data, the final sample contains 9380 firms in 10 industries from 24 countries (see Table 1 for sample characteristics). The analysis removed five countries from the sample due to missing value in social trust and/or uncertainty avoidance. E-Business Watch carried out interviews in March or April 2006, using computer-aided telephone interview technology. Previous research has used data from e-Business Watch (e.g., Koellinger, 2008).

Table 1. Sample characteristics at the firm level (N = 9380).

Country	N	%	Industry	N	%
Austria	317	3.4	Construction	1438	15.3
Belgium	330	3.5	Consumer electronics	530	5.7
Bulgaria	251	2.7	Food and beverages	1193	12.7
Czech	581	6.2	Footwear	766	8.2
Denmark	262	2.8	Hospital activities	551	5.9
Estonia	193	2.1	ICT Manufacturing	1307	13.9
Finland	594	6.3	Pulp and Paper	903	9.6
France	663	7.1	Shipbuilding and repair	91	1.0
Germany	667	7.1	Telecommunications	1075	11.5
Greece	276	2.9	Tourism	1526	16.3
Hungary	626	6.7			
Ireland	303	3.2	Firm size	N	%
Italy	651	6.9	Micro (1–9 employees)	3518	37.5
Luxembourg	81	0.9	Small (10–49)	2449	26.1
Malta	84	0.9	Middle (50–249)	1841	19.6
Netherlands	328	3.5	Large (250 +)	503	5.4
Poland	629	6.7			
Portugal	319	3.4			
Romania	247	2.6			
Slovakia	255	2.7			
Spain	549	5.9			
Sweden	303	3.2			
Turkey	281	3.0			
UK	590	6.3			

The study measures the dependent variable, *SCC*, using two questions related to the firm's collaboration with supply chain partners in the e-Business Watch survey: (1) “Does your

company use online applications other than e-mail to collaborate with business partners to forecast product or service demand?"; and (2) "Does your company use online applications other than e-mail to collaborate with business partners in the design of new products or services?". Respondents chose "yes" (1) or "no" (0) or "don't know" according to the situation of their firms. Following previous studies in this domain (Kulp et al., 2004, Rai et al., 2006), the combination of the values of these two items forms the score for SCC.

The measurement for the firm-level independent variable, *the use of open IOS*, applies the question in the e-Business Watch survey: "Does your company use XML-based standards such as ebXML, RosettaNet, UBL?" Respondents selected "yes" (1) or "no" (0) or "don't know" according to the situation of their firms. The measurement for another firm-level independent variable, *the use of closed IOS*, uses the question in the survey: "Does your company use proprietary standards agreed between you and your business partners?" Again, respondents could choose "yes" (1) or "no" (0) or "don't know."

The country-level independent variable, *uncertainty avoidance*, is from Hofstede's website. Hofstede (2001) demonstrates the reliability and validity of the 4-dimension instrument (i.e., uncertainty avoidance, collectivism/individualism, power distance, and masculinity/femininity) by a thorough analysis of all cross-national studies (up to the late 1990s) published in a variety of disciplines that have used these scales. Thus, this study adopts Hofstede's scores to measure uncertainty avoidance.

Data on the other country-level variable, *social trust*, are from the World Values Survey. One question in this survey is: "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?" The social trust indicator is the percentage of the respondents in each country selecting the option of "most people can be trusted" (after deleting the "don't know" responses). This measure has been widely used in prior research (e.g., Knack and Keefer, 1997, Paxton, 2007) to reflect a country's level of social trust.

This study focuses on the influence of a country's uncertainty avoidance and social trust on SCC. However, some firms that have a foreign link (e.g., exporting firms) may also expose themselves to foreign culture and values, which might influence the effect of uncertainty avoidance and social trust. Therefore, this study uses a dummy variable to capture whether a firm's most significant market is an international market. The analysis controls for both the main effect of this dummy variable and its interaction with uncertainty avoidance and social trust on SCC.

This study also controls for the effect of firms' IT competence in the analysis as IT competence might help the development of SCC (Rai et al., 2006). IT competence is measured by two questions asking whether a firm uses: (1) enterprise resource planning (ERP, an integrated enterprise-wide system), and (2) knowledge management systems. Firms using these IT applications should have better IT competence than firms not using them. In addition, firms in different industries may have different willingness to engage in SCC due to different industrial environments. Therefore, the study divides industries into IT-related industries (including ICT Manufacturing, consumer electronics, and telecommunications industry) and non-IT-related industries, as well as into service industries (including tourism, hospital activities, and telecommunications industry) and non-service industries. The study uses two dummy variables

to represent these two characteristics of industries. This study also controls for the effect of firm sizes with three dummy variables by dividing firms into four categories: micro (1–9 employees), small (10–49 employees), middle (50–249 employees), and large (250 + employees). Further, to control for respondents' knowledge about their firms' SCC and IOS status, this study uses three dummies to represent the four types of respondents' job titles: (1) owner (27.5%), (2) business manager (24.3%), (3) IT manager (31.1%), and (4) others (16.8%). Table 2 summarizes the operationalization of the key country-level and firm-level constructs.

Table 2. Variable descriptions and data sources.

Variables	Data sources	Measures
SCC (supply chain collaboration)	e-Business Watch	1) Does your company use online applications other than e-mail to collaborate with business partners to forecast product or service demand? 2) Does your company use online applications other than e-mail to collaborate with business partners in the design of new products or services?
Uncertainty avoidance	geert-hofstede.com	Hofstede's index of uncertainty avoidance.
Social trust	World Values Survey	The percentage of the respondents in a country replying “most people can be trusted” to the following question: “Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?”
Use of open IOS	e-Business Watch	Does your company use XML-based standards such as ebXML, RosettaNet, UBL?
Use of closed IOS	e-Business Watch	Does your company use proprietary standards agreed between you and your business partners?
Control variables	e-Business Watch	Use of knowledge management system, use of ERP, industry, firm size, and the respondent's job title.

Table 3 shows the mean statistics and correlation matrix of the key model variables. The values of open IOS, closed IOS, and SCC in Table 3 are at the country-level values, referring to the proportions of firms that have used open IOS, closed IOS, and SCC in a country. However, please note that the hypotheses testing uses the firm-level, rather than the country-level, open IOS, closed IOS, and SCC scores as model inputs.

Table 3. Means and correlation matrix of main variables.

	Mean	1	2	3	4	5
Uncertainty avoidance	71	1.00				
Social trust	0.31	– 0.68**	1.00			
Open IOS	0.12	– 0.33	0.56**	1.0		
Closed IOS	0.18	0.04	– 0.33	– 0.02	1.0	
SC collaboration	0.38	0.06	– 0.32	0.08	0.50*	1.0

* $p < 0.05$. ** $p < 0.01$.

4.2. Analytical approach

To test the hypotheses, the study uses a multi-level model to simultaneously estimate firm-level and country-level effects. The level-1 (firm-level) model for SCC is:

$$SCC_{ij} = \beta_{0j} + \beta_{1j}OpenIOS_{ij} + \beta_{2j}ClosedIOS_{ij} + \beta_{3j}InktMkt_{ij} + \beta_{4j}KM_{ij} + \beta_{5j}ERP_{ij} + \beta_{6j}IT\ related_{ij} + \beta_{7j}Service_{ij} + \beta_{xj}Dummy_{ij}(FirmSize\ and\ JobTitle) + r_{ij}$$

where SCC_{ij} is the SCC score of firm i in country j . β_{0j} is the intercept. $\beta_{1j} \dots \beta_{xj}$ are regression coefficients for Open IOS (*OpenIOS*), Closed IOS (*ClosedIOS*), and control variables, including whether a firm's most significant market is international (*IntMkt*), whether a firm adopts knowledge management systems (*KM*) or ERP (*ERP*), whether a firm belongs to IT-related industries (*IT-related*) or service industries (*Service*), firm sizes, and participants' job titles. r_{ij} is the firm-level error term.

The level-2 (country-level) model is as below:

$$\begin{aligned}\beta_{0j} &= \gamma_{00} + \gamma_{01}UA_j + \gamma_{02}Trust_j + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11}UA_j + \gamma_{12}Trust_j + u_{1j} \\ \beta_{2j} &= \gamma_{20} + \gamma_{21}UA_j + \gamma_{22}Trust_j + u_{2j} \\ \beta_{3j} &= \gamma_{30} + \gamma_{31}UA_j + \gamma_{32}Trust_j + u_{3j} \\ \beta_{4j} &= \gamma_{40} + u_{4j} \\ &\dots \\ \beta_{xj} &= \gamma_{x0} + u_{xj}\end{aligned}$$

where β_{0j} is the intercept of the level-1 model, which depends on a country's uncertainty avoidance (UA_j) and social trust ($Trust_j$). β_{1j} , β_{2j} and β_{3j} are the coefficients of Open IOS, Closed IOS, and international market in the level-1 model, respectively, which also depend on a country's uncertainty avoidance (UA_j) and social trust ($Trust_j$). u_{0j} , u_{1j} , u_{2j} , and u_{3j} represent the level-2 error terms. Also, due to the under-identification problem, this study constrains the β s of some control variables ($\beta_{4j} \dots \beta_{xj}$) to be constant across countries in data analyses, following Raudenbush and Bryk (2002).

4.3. Results

The statistical package HLM 6 serves as the tool to test the hypotheses. The study standardizes all country-level independent variables and SCC to simplify the interpretation of the results (Raudenbush & Bryk, 2002). H_1 states that a country's level of uncertainty avoidance would negatively impact firms' use of SCC in that country. Consistent with H_1 , a negative relationship exists between uncertainty avoidance and SCC ($\beta = -0.08$, $p < .05$). H_2 specifies that a country's level of social trust would negatively affect firms' use of SCC in that country. As Fig. 1 shows, the link from social trust to SCC is negative and significant ($\beta = -0.11$, $p < .05$), lending support for H_2 . H_{3a} , H_{3b} specify that firms would be more likely to use SCC if they have open or closed IOS. As Fig. 1 indicates, the link from open IOS to SCC ($\beta = 0.35$, $p < .01$), and that from closed IOS to SCC ($\beta = 0.50$, $p < .01$) are both positive and significant. Thus, the results support H_{3a} , H_{3b} .

In terms of the cross-level interactions, H_{4a} , H_{4b} propose that a country's uncertainty avoidance and social trust would reduce the positive association between open/closed IOS and SCC. Partially supporting H_{4a} , the results show that uncertainty avoidance moderates the relationship between open IOS and SCC negatively ($\beta = -0.07$, $p < .05$). However, the moderating effect of uncertainty avoidance on closed IOS is not significant ($\beta = 0.01$, $p > .10$). Regarding the moderating role of social trust, the results indicate that both coefficients are in the hypothesized

direction, but not significant (open IOS: $\beta = -0.05$, $p > .10$; closed IOS: $\beta = -0.03$, $p > .10$). Therefore, the findings do not support H_{4b}.

Fig. 1. Research model and results.

As for control variables, the results indicate that a firm is more likely to engage in SCC when its most significant market is international ($\beta = 0.08$, $p < .01$). However, whether a firm targets for an international market or not does not significantly influence the relationships between country-level factors (i.e., uncertainty avoidance and social trust) and SCC. The results also show that a firm is more likely to adopt SCC when the firm engages knowledge management systems ($\beta = 0.32$, $p < .01$) and/or ERP ($\beta = 0.22$, $p < .01$). In addition, firms in IT-related industries (ICT manufacturing, consumer electronics, and telecommunications) are more likely to use SCC than other industries ($\beta = 0.14$, $p < .01$). But the difference between service industries and non-service industries is not significant ($\beta = 0.01$, $p > .10$). Firm size has a significant effect on SCC in a way that large firms are more likely to use SCC ($\beta = 0.15$, $p < .01$). However, the result shows no significant difference between micro-size firms and small/middle-size firms. Finally, the respondent's job title has no significant impact on SCC.

To test the earlier argument that other cultural dimensions are more distal in influencing SCC than uncertainty avoidance, the study replaces uncertainty avoidance with other cultural dimensions (i.e., collectivism/individualism, power distance, and masculinity/ femininity) in the analysis. The results show that, consistent with the argument, neither collectivism/individualism nor masculinity/femininity has a significant effect on SCC. Although the effect of power distance on SCC reaches statistical significance, the effect goes away if uncertainty avoidance is in the model. Moreover, none of the three cultural dimensions significantly moderates the relationship between open/closed IOS and SCC.

This study investigates the effects of national culture on SCC, including direct effects and interaction effects. The results indicate that uncertainty avoidance and social trust may negatively affect firms' use of SCC. Furthermore, uncertainty avoidance moderates the relationship between open IOS and SCC, and in such a way that the positive association between open IOS and SCC is weaker when uncertainty avoidance becomes higher. The moderating role of uncertainty avoidance on closed IOS, however, is not significant. In addition, social trust does not moderate the relationship between closed IOS and SCC, or the relationship between open

IOS and SCC. One reason for such non-significant findings may be the small sample size at the country level. Due to the difficulty in collecting data from a large number of countries, cross-culture studies often have small sample sizes at the country level. Although such a sample size is sufficient to catch the direct effects of national culture, this size may not be enough to catch some complex cross-level interaction effects such as these examined in the current study. Another possible reason is that the samples are mostly from European countries, which may limit the variety in cultural values. Commonalities among European countries may be so strong as to prevent the study from finding the hypothesized relationships.

The current study offers two important contributions. First, the study extends the literature on the link between culture and SCC through examining specific dimensions of culture, rather than cross-national comparisons. Studying measured culture, rather than simply inferring culture by countries, allows researchers to examine which cultural dimensions play more important roles in affecting SCC (Qu, Yang, & Wang, 2011). In addition, previous studies regarding cultural influence on SCC usually have evidence only from two or three countries. This study investigates the influence of national culture on SCC based on data from twenty-four countries. In this regard, the study is the first that investigates the effects of national culture on SCC using a large number of countries.

Second, the present research is the pioneer in the exploration of the cross-level interaction between cultural values at the country level and the use of IOS at the firm level. The findings suggest that the increase in uncertainty avoidance may reduce the positive association between open IOS and SCC, although uncertainty avoidance does not moderate the positive association between closed IOS and SCC. These findings indicate that uncertainty avoidance may not only interplay with the firm-level factors in influencing SCC, but also exert differential effects on open versus closed IOS.

5.1. Managerial implications

In today's business world, the collaboration among supply chain partners has become strategically important as this collaboration can be a key source of competitive advantage. At the same time, the findings indicate that advanced tools as well as standardized data structure provided by IOS, either open IOS or closed IOS, may dramatically facilitate supply chain collaboration. Therefore, if firms in a supply chain plan to develop collaborative activities, such as information sharing and joint product design, they may need to set up electronic linkages between supply chain partners first because such electronic linkages are very helpful for developing collaboration.

The study also suggests that firms in countries higher in uncertainty avoidance and social trust may be less likely to engage in SCC. These findings send important messages to managers, especially those in multinational firms, that they should take national culture into account when making decisions on global supply chain management. Firms in some countries with a high level of uncertainty avoidance and social trust may have lower intention to engage in SCC than those in other countries. In order to make the collaboration among global supply chain members effective, managers may need to put more effort into developing SCC in such countries. In other words, firms that plan to develop global supply chains should not naively think that they can

copy the best practice from one country, apply this practice to another country and have similarly favorable results.

More importantly, managers need to consider national culture seriously when developing SCC programs. The study finds that the positive association between open IOS and SCC becomes weaker with an increase in a country's uncertainty avoidance. This finding suggests that the factors that promote SCC may not be universally useful in all countries. For instance, open IOS may not have advantages on facilitating SCC in countries high in uncertainty avoidance. Therefore, firms in these countries need to develop other measures to facilitate collaboration among supply chain members. The findings further suggest that the effect of closed IOS on SCC can be more stable than that of open IOS when facing an influence from nation culture such as uncertainty avoidance. Therefore, in countries with high uncertainty avoidance, firms using closed IOS may have a better chance in the success of SCC than firms using open IOS.

5.2. Limitations and future research

The present study has some limitations that future research may address. One limitation is that this study only measures two dimensions of SCC, namely collaborative forecasting and joint design of new products/services. However, other forms of SCC also exist, such as information sharing and collaborative inventory management. Although previous research has shown that collaborative forecasting and joint design of new products/services go hand in hand with other aspects of SCC (Flynn, Huo, & Zhao, 2010), including more dimensions of SCC can provide a more comprehensive picture of the phenomenon. In addition, this study only contains data from 24 countries. Future research may use data from more countries. Gathering data from other regions outside of Europe also allows researchers to test the robustness of the current model. In addition, this study examines the precursors of SCC at the firm level, focusing on firms' IOS platform. Future research may investigate how the characteristics of the decisions makers of the firms, such as their cultural orientations and background, may play a role in influencing their firms' SCC activities. Finally, the sample of this study may contain foreign subsidiaries of multinational firms that involve cultural value of both host and home countries. This study only takes the culture of host countries into account due to the lack of necessary information. Future researchers may examine how firm ownership (e.g., domestically owned, foreign owned, or jointly owned) affects SCC adoption patterns.

5.3. Conclusion

This study shows that a country's uncertainty avoidance and social trust may have an important impact on firms' use of SCC. More specifically, uncertainty avoidance and social trust of a country negatively impact the level of firms' SCC. In addition, a country's uncertainty avoidance also moderates the relationship between IOS and SCC when the IOS follows open standards, but not when the IOS follows closed standards. These findings suggest that managers should take national culture into account when making decisions related to supply chains, especially in the case of global supply chains. In today's business world, supply chains have become global and strategically important. More research on the cultural aspect of SCC will advance the understanding on how the interplay of cultural values and firm characteristics affects supply chain management.

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