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IOS-ENABLED COLLABORATIVE KNOWLEDGE CREATION AND SUPPLY CHAIN FLEXIBILITY: THE MODERATE ROLE OF MARKET UNCERTAINTY

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Abstract

Understanding the formation of supply chain flexibility is important. We draw on the organizational learning perspective to examine how inter-organizational systems (IOS) enabled collaborative knowledge creation can enhance the supply chain flexibility. Empirical results from 141 supply chain enterprises support most of our hypotheses. The results show that, (1) IOS use for exploration has positive effects on supply chain flexibility and collaborative knowledge creation plays a partially mediated role between them; (2) Market uncertainty moderates the relationship between IOS use for exploration for collaborative knowledge creation. And (3) under the greater uncertainty in the market environment, the relationship between company's collaborative knowledge creation and supply chain flexibility becomes stronger. This result suggests when supply chain enterprises face market uncertainty, they need to improve the level of IOS use for exploration to facilitate understanding of the market, which will improve the supply chain flexibility.

Keywords: Collaborative knowledge creation, Supply chain flexibility, IOS use for exploration, Market uncertainty.

1. INTRODUCTION

When facing the global competition and uncertainty, supply chain enterprises are enhancing their flexibility to get a quick and efficient response to either short term or long term changes (Liao and Marsillac 2015). Intensive competition urges enterprises to shorten their product life cycles, increase product variety, and response efficiently to the short or long term changes in the market. Defined as the ability to respond to environmental change, supply chain flexibility has been deemed as one of the critical factors for enterprises to gain competitive advantages when facing uncertainty (Angkiriwang et al. 2014; Tiwari et al. 2015; Blome et al. 2014; Lee 2004)

Scholars have studied the impact of supply chain flexibility, external environment on supply chain performance. They find that supply chain flexibility can affect the financial performance and operational efficiency of enterprises(Merschmann and Thonemann 2010). In addition, the match between flexibility and environmental uncertainty will affect the business performance, at the high environmental uncertainty, higher flexibility will improve the performance; but in a stable environment, lower flexibility will improve the efficiency of supply chain significantly(Chang 2012; Merschmann and Thonemann 2010). Although the impact of flexibility on supply chain performance has been investigated extensively (Tiwari et al. 2015), the formation of the flexibility in supply chain circumstances has not been open up yet.

From the perspective of organizational learning (OL), we argued that the inter-organizational systems (IOS) enabled collaborative knowledge creation (CKC) will make the supply chain enterprises more insightful on their customers, internal operations and environment. CKC in turn will enhance the ability of supply chain enterprises to make a quick response to changes. IOS is the cross boundary contacts based on information technology(Sodero et al. 2013). For example, Rosetta Net is widely used in the electronics industry, as well as DMS system is used in the automotive industry. IOS can support the flow of information and a series of processes among supply chain enterprises. IOS use for exploration is aimed at increasing innovation by speeding up the development of new product and process innovations (Kane and Alavi 2007; March 1991; Lavie et al. 2010). Examples of IOS use for exploration includes collaboration systems and product data management systems for supporting innovation (Xue et al. 2012). Some researchers argue that learning can strengthen a firm's ability to recognize opportunities, to pursue new ventures effectively, and to achieve continuous alignment with its environment (Beer et al. 2005; Lumpkin and Lichtenstein 2005). OL is reflected in changes in organizational knowledge (March 1991) and exemplified by sensing environmental changes and responding to them (Yu et al. 2013). Learning allows a continuous adaptation to rapidly changing market requirements as a true dynamic capability (Santos-Vijande et al. 2012). OL is an important determinant of long-term performance and firms' flexibility (Liebeskind et al. 1996). From the OL perspective, IOS use for exploration and CKC are the two critical antecedents which influence the supply chain flexibilities. Our research model is presented in figure 1.

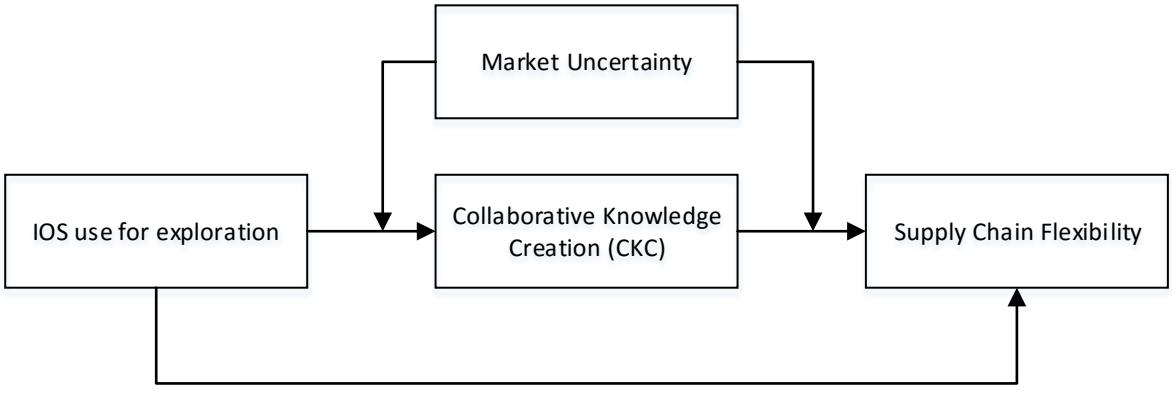

Figure 1. Research Model

The rest of this paper is organized as follows. First, we discuss the research hypotheses. Next, we describe the data and hypotheses testing. Finally, we present the empirical analyses and discuss the implications of our research.

2. THEORY AND HYPOTHESIS DEVELOPMENT

2.1. The collaborative knowledge creation and supply chain flexibility

Facing uncertain environments, enterprises have strived to achieve greater supply chain collaboration to leverage the resources and knowledge of their suppliers and customers(Cao and Zhang 2011). Knowledge is the information that actively guides problem solving, decision making and task implement (Kankanhalli et al. 2005). Knowledge creation is a dynamic process and can be enacted by social interactions among organizations (Alavi and Leidner 2001; Becerra-Fernandez and Sabherwal 2001). Knowledge creation occurs at the individual level firstly, then with the collaborative process, individual knowledge will spread among organizations and become organizational knowledge (Nonaka and Takeuchi 1995). CKC is the process that the supply chain enterprises create new knowledge by co-operation and co-creation in order to gain insights about the environments, developing a better understanding of and response to the market and competitive environment by working together(Malhotra et al. 2005). The effective transfer of knowledge, supply chain management and innovation of organizations can improve customer responsiveness, so that enterprises have powerful capabilities to solve the uncertain problems in the production process(Blome et al. 2014). Enterprises can better cope with the change and uncertainty by designing and operating supply chain and obtain the new understanding of manufacturing, inventory, marketing and customers. Based on the above analysis, we propose that:

H1: Collaborative knowledge creation positively influences supply chain flexibility.

2.2. IOS use for exploration and CKC

IOS are profoundly affecting buyer-supplier relationships and CKC (Xue et al. 2012; Lu and Ramamurthy 2011; Rai and Tang 2010; Saeed et al. 2011). Information sharing and communicating platforms are important facilitators and enablers for knowledge creation among partners (Nambisan et al. 1999; Allameh and Zare 2011; Nejatian et al. 2013). With the rapid increase of global supply chain, IOS are becoming even more valuable. When successfully implemented, IOS can help supply chain partners improve the information sharing, facilitate integration of business process and collaborative, and allow them to create knowledge more effectively (Johnston and Gregor 2000). Based on the above analysis, we propose that:

H2: IOS use for exploration positively influences CKC.

2.3. IOS use for exploration and supply chain flexibility

Studies have found that information technologies implementations can improve the innovation performance of the supply chain between organizations(Acar and Uzunlar 2014; Eservel 2014), and enhance supply chain competitive advantage(Marinagi et al. 2014). In addition, some studies have found the application of IT has a positive effect on inter-organizational flexibility (Lu and Ramamurthy 2011; Lucas and Olson 1994). With the more intensive market competition, companies are increasingly focused on information technology use for exploration. Based on the above analysis, we propose that:

H3: IOS use for exploration positively influences supply chain flexibility.

2.4. The mediating role of CKC

This article further tests the CKC as a mediating role in the relationship between IOS use for exploration and supply chain flexibility. Knowledge creation as a dynamic organization ability is the essential source to maintain the vitality of enterprises in the dynamic environment. CKC based on the IOS acts as "intermediary" from IOS use for exploration to supply chain flexibility. Therefore, we propose:

H4: CKC play a mediating role in the relationship between IT use for exploration and supply chain flexibility.

2.5. The moderating role of market uncertainty

In dynamic and uncertain business environment, it is imperative for enterprises to effectively adapt to rapidly change of end-customer demands. So in this paper, we hypothesize the moderating effects of market uncertainty on relationships between IOS use for exploration, CKC and supply chain flexibility. Because the existing of market uncertainty, new knowledge is being applied at a faster rate, several of new products are being created over time. The cycle time of innovation is decreasing, and the technology diffusion becomes faster. As the fast development of technology and the shortening of product life cycles, and the obsolescence of technology becomes rampant.

Under conditions of high market uncertainty, it is expected that IOS use for exploration will be more important for CKC. For the IOS provide efficient platforms for the information exchanging, which is more critical for CKC under high uncertainty environment. CKC is recognized as a core mechanism for absorbing and solving uncertainty. When companies operating at a stable trajectory, they don't need to fully utilize their collaborative knowledge creation when making market decisions. However, under conditions of market uncertainty, firms need to use information technology to better understand the market, to enhance supply chain flexibility. Therefore, we propose:

H5: IT use for exploration will have a stronger, positive relationship with the CKC when market uncertainty is high.

H6: CKC will have a stronger, positive relationship with supply chain flexibility when market uncertainty is high.

3. METHODOLOGY

3.1. Research methodology

Taking enterprise as our research unit, we made a survey among supply chain enterprises based in Mainland China. Mainland China is employed as the research setting for the following 2 reasons: Firstly although CKC, supply chain flexibility, and IOS use for exploration have been widely studied in developed economies, only a few studies have been conducted in emerging economies (Wang et al. 2011). Secondly, there is a high variation in terms of innovative product development among Chinese firms(Yuan et al. 2011).We developed a questionnaire to measure IOS use for exploration, CKC, supply chain flexibility, market uncertainty, all of which we combined into an the model. All measurement items in the questionnaire were measured with a seven-point Likert-type scale, with answers ranging from ‘‘strongly disagree (1)’’ to ‘‘strongly agree (7).’’ Most items in the survey were adopted directly from existing literature that had already been validated by other researchers. Some item definitions were converted into a questionnaire format because our situation was different from those used in previous studies. To secure content validity, we refined the initial version of the survey through pretesting of 100 employees in supply chain companies, correcting the terms to ensure that the members of organizations could understand them. We checked all items with experts and related researchers.

3.2. Data collection and sample characteristics

The data collection of this study mainly through the following three methods: (1) Working with Logistics institute of Fudan University in Shanghai, we got the directory database of supply chain companies, and send questionnaires. (2) We send our questionnaires to MBA students in the Wuhan University. (3) Cooperating with economic and information commission in Hubei province, we asked some located supply chain enterprises to answer the questionnaires by emails. We received 180 responses after two rounds reminds. If respondents supplied inconsistent or incomplete information or did not participate in our activities in their position, their responses were eliminated from the dataset. In the end, we got 141 valid questionnaires. The demographic characteristics of our 141 respondents were shown in table 1. From the percentage of data in the table 1, firm size, firm age and the ownership were distributed in each class, and the distribution was relatively scattered, showed that samples have certain representativeness.

Table 1 Demographic characteristics of sample.

Sample characteristics	Number	Percentage	Sample characteristics	Number	Percentage
Firm size	Total：141	100%	**Firm age**	Total: 141	100%
<100	28	19.9%	1-2	1	0.7%
100-499	33	23.4%	2-5	19	13.5%
500-999	22	15.6%	5-10	31	22.0%
1000-4999	26	18.4%	10-15	41	29.1%
>5000	32	22.7%	>15	49	34.7%
Ownership	Total: 141	100%			
State-Owned	32	22.7%			
Private	44	31.2%			
Joint venture	18	12.8%			
Foreign	40	28.3%			
Other	7	5.0%			

3.3. Reliability and construct validity

In this study, we used PLS to test the measurements and hypotheses (Wetzels et al. 2009). PLS is a structural equation modelling tool which uses a component based approach for estimation and places minimal restrictions on the residual distribution and sample size(Chin 1998). Therefore, PLS is mainly used in areas where there is weak theory and difficult understanding of relationships between some variables. PLS also help us to simultaneously cope with the problems of construct measurement and the structural relationships among different constructs. .

We undertook reliability and validity analyses to examine whether or not the questionnaire items matched our intent. Firstly, we tested the scale reliability. We require the Cronbach alpha scores are 0.7 and over (Seo et al. 2015). Table 2 indicates that the Cronbach alpha scores ranged from 0.747 to 0.900. All our constructs have high internal consistency.

By reviewing the T-test for factor loading, we first assessed convergent validity. All the values of the items were sufficient to meet the criteria(above 1.96)(Gefen and Straub 2005). Furthermore, convergent validity can also be assessed by examining the composite reliability and the variance extracted by

measures. In this study, we employed 0.7 as the recommended value for composite reliability(Fornell and Larcker 1981). From the table 2, the composite reliability values ranged from 0.841 to 0.937, which were above the value of expectation. For variance extracted by measures, 0.5 as the acceptable value(Fornell and Larcker 1981). As show in table 2, the variance extracted by measures ranged from 0.618to 0.832, which were above the acceptable levels.

In this study, the discriminant validity of the instrument was evaluated by inspecting correlations among questions. For discriminant validity, a measure should correlate greater with all measures of the same construct than it does with any measures of other constructs. For satisfactory discriminant validity, the average variance extracted (AVE) from the construct should be greater than the variance shared between the construct and other constructs in the model. Table 3 lists the correlation matrix with correlations among the constructs and the square root of AVE on the diagonal. As shown in Table 3, the analysis of the discriminant validity was acceptable.

Table 2 Reliability and convergent validity

Construct	Measurement item	Factor loadings	T Value	Cronbach's a	Composite reliability	AVE
IOS use for exploration(IOSE)	IOSE1	0.841	13.696	0.900	0.937	0.832
	IOSE2	0.945	53.120			
	IOSE3	0.947	49.776			
Collaborative knowledge creation(CKC)	CKC1	0.866	25.890	0.873	0.908	0.660
	CKC2	0.870	29.331			
	CKC3	0.838	15.506			
	CKC4	0.773	9.944			
	CKC5	0.724	9.863			
Supply chain flexibility(SCF)	SCF1	0.828	14.547	0.796	0.880	0.710
	SCF2	0.856	13.049			
	SCF3	0.839	16.346			
Market uncertainty(MU)	MU1	0.773	4.847	0.747	0.841	0.618
	MU2	0.812	7.011			
	MU3	0.774	6.293			

Table 3 Discriminant validity

Construct	IOSE	CKC	SCF	MU
IOS use for exploration	0.912			
CKC	0.275	0.812		
Supply chain flexibility	0.305	0.372	0.843	
Market uncertainty	0.380	0.312	0.277	0.786

Note 1: The number on the diagonal denotes the square root of average variance extracted.

3.4. Hypotheses testing

We use smart PLS 3.0 and conducted three steps to examine the mediating effect (table 4). First, we examine the effects of the control variables (firm age, firm size, ownership) on supply chain flexibility

(model 1). Then, based on model 1, we add IOS use for exploration as independent variable to test the effect on supply chain flexibility (model 2). As the results of model 2 suggest that IOS use for exploration is positively related to supply chain flexibility. In step two, we test the effects of IOS use for exploration and control variables on CKC (model 3b). Then we test the effects of CKC and control variables on supply chain flexibility. Result in model 3a show that CKC has a significantly positive effect on supply chain flexibility. In step three, we add IOS use for exploration and CKC as two independent variables to test the effects of them on supply chain flexibility. As the results of model 4 suggest that both IOS use for exploration and CKC are positively related to supply chain flexibility. That is to say, H1, H2, H3, H4 are supported by our data.

Table 4 Mediation models

Variables	SCF(DV)				CKC(DV)
	model 1	model 2	model 3a	model 4	model 3b
Firm size (CV)	0.231*	-0.162	0.175*	0.136	0.071
Ownership(CV)	-0.024+	-0.055	-0.06	-0.077	0.076
Firm age (CV)	-0.091	-0.031	-0.045	-0.008	-0.068
IOSE (IV)		0.286**		0.207*	0.259*
CKC (IV)			0.361***	0.311**	
R square	0.044	0.119	0.168	0.206	0.10

Note: N=151; +p<.1; *p<.05; **p<.01; ***p<.001.

From the table 4, we can find that IOS use for exploration has a significant positive impact on CKC. The results of the moderation effects are shown at table 5. Model 5 is also to show the positive effects of the IOS use for exploration and market uncertainty on supply chain flexibility(β=0.168 , p<0.05 and β=0.247 , p<0.05), then adds the interaction term (IOSE × MU), the interaction term coefficient is significantly (model 6: β=0.340 , p<0.001). Therefore, the moderating effect (hypothesis 5) of market uncertainty on the relationship between IT uses for exploration for CKC is verified.

For the hypothesis 6, market uncertainty plays a moderating role in the relationship between CKC and supply chain flexibility. This moderation occurs after the mediation, so this is a moderated mediator. According to the verification step of mediated moderation(Muller et al. 2005), we first make the regression of IOS use for exploration and market uncertainty on supply chain flexibility, as the model 7 shows that IOS use for exploration has a significant positive effect on supply chain flexibility (β = 0.227 p <0.05). Secondly, from the model 5 we find that both IOS use for exploration and market uncertainty have significant positive effects on CKC. Thirdly, we tested the effects of IOS use for exploration, market uncertainty and CKC on supply chain flexibility. Result in model 8 show that CKC has a significantly positive effect on supply chain flexibility (β = 0.286, p <0.01), indicating that the mediating role of knowledge creation is significant. Finally, we added IOS use for exploration, CKC, market uncertainty and the interaction term (CKC × MU) to test the effects of them on supply chain flexibility. As the results of model 9 suggest that the interaction term has significant impact on supply chain flexibility (β = 0.247, p <0.01). From all above results, we know the mediated moderation is existing.

In addition, we should test whether the market uncertainty is mediated moderator, this is to say that whether the interaction term (IOSE × MU) can affects supply chain flexibility through CKC. Therefore, we built the model 10 to examine the effects of IT use for exploration, market uncertainty and their interaction term on supply chain flexibility. Result in model 10 show that the interaction term is not significant (β = -0.124, p >0.1). So there no need to further test the mediated effect of CKC on the interaction term and supply chain flexibility. We know that the technological uncertainty doesn't play mediated moderating role in our model.

Table 5 moderation models

Variables	CKC		SCF			
	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Firm size (CV)	0.048	0.072	0.142*	0.128	0.120	0.155*
Ownership (CV)	0.093	0.133	-0.045	-0.068	-0.095	-0.032
Firm age (CV)	-0.031	-0.028	-0.002	-0.006	-0.004	-0.004
IOSE	0.168*	0.206*	0.227*	0.176+	0.091	0.234*
MU	0.247*	0.224*	0.183+	0.115	0.164	0.150
IOSE×MU		0.340**				-0.124
CKC				0.286**	0.311**	
CKC×MU					0.247**	
R^2	0.142	0.243	0.149	0.216	0.270	0.162

4. RESULTS AND DISCUSSION

4.1. Results

In this study, we take CKC as a dynamic ability to explore the influence of IOS use for exploration on supply chain flexibility and the moderating role of market uncertainty. We propose a "moderated mediator" model and test with empirical data. In this study we find that:

(1) The IOS use for exploration of supply chain enterprises has a significantly positive impact on supply chain flexibility. The result is consistent with the research of Lucas and Olson (Lucas and Olson 1994) and Gosain et al. (Gosain et al. 2004), they demonstrate the application of IT can enhance organizational flexibility of enterprises. And results of our support the currently highlighted view that importance of innovation and cross-organizational information systems in the supply chains(Jasperson et al. 2005).

(2) CKC plays a mediating role in the relationship between IOS use for exploration and supply chain flexibility. Our study shows that knowledge creation as a dynamic ability can enhance the supply chain flexibility. Therefore, the conclusions clearly illustrated that IOS use for exploration is an important link of the supply chain to impact flexibility, knowledge creation capability is a key variable of IOS and supply chain flexibility.

(3) IOS use for exploration have a significant positive impact on CKC. This paper further study find that market uncertainty plays moderating role between the IOS use for exploration and CKC. This is to say, IOS use for exploration will have a stronger, positive relationship with the knowledge creation when market uncertainty is high than when it is low.

(4) CKC has a significant positive impact on supply chain flexibility. The results show that CKC is an important factor to improve the supply chain flexibility, which is consistent with previous findings(Blome et al. 2014). In addition, this study examines the moderating role of market uncertainty between CKC and supply chain flexibility, we find that CKC will have a stronger, positive relationship with supply chain flexibility when market uncertainty is high than when it is low.

4.2. Implications and limitations

This study reveals the impacts of IOS use for exploration on supply chain flexibility, then further examine the role of CKC and market uncertainty in the model, and provides theoretical foundation for the complex supply chain environment. In addition, this is the among the first that taking CKC as a dynamic ability to mediate the influence process of IOS use for exploration on supply chain flexibility.

At the same time, market uncertainty as a moderated mediator variables, further enriching the research on information system applications and enterprise performance.

On the other hand, to some extent, this study provides some inspirations for the application of information, knowledge sharing and information systems in supply chains. Implementations of information technology can enhance inter-organizational information exchange and knowledge sharing, so that supply chain performance can be enhanced through the CKC, in response to a variety of uncertainties and ultimately to improve their supply chain flexibility.

Several limitations also exist and need further investigations. Firstly, we only discuss the relationship of IOS use for exploration, CKC and supply chain flexibility and other associated factors aren't taken into account. Future research can combine Wang and Singh's research to have a deeper exploration for the impact of supply chain flexibility mechanisms (Singh and Acharya 2013; Wan and Wang 2010). Secondly, this study doesn't divide the samples according to type of business and life cycle features, and future research directions can combine some industries' characteristics. Thirdly, although we regard the number of years of business, firm size and use time of IT as control variables, there are many other factors that can affect supply chain flexibility, so future studies should further consider the impact of these factors such as type of business, areas of enterprises and so on.

5. CONCLUSIONS

Flexibility is essential for supply chains competing in today's high turbulent global market. This research indicated that IOS use for exploration has positive effects on supply chain flexibility and collaborative knowledge creation plays a partially mediated role between them. IOS will play a more important role when the environment uncertainty is high. We suggest when supply chain enterprises face market uncertainty, they need to improve the level of IOS use for exploration to facilitate understanding of the market, which will improve the supply chain flexibility.

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Appendix Constructs and related literature

Construct	items	Measurement	Related literature
IOS use for exploration	IOSE1	Understanding trends in sales and customer preferences with <SC partner company>.	(Boynton et al. 1994)
	IOSE2	Leveraging company's and <SC partner company>'s expertise to create opportunities.	
	IOSE3	Exploring new opportunities to improve supply chain with <SC partner company>.	
Market uncertainty	MU1	In our kind of business, customers' product preferences change a lot over time.	(Pavlou and sawy 2006)
	MU2	Marketing practices in our product area are constantly changing.	
	MU3	There are many competitors in this market.	

Collaborative knowledge creation	CKC1	Working with <SC partner company> has helped company better understand the market	(Malhotra et al. 2005)
	CKC2	Working with <SC partner company> has helped company better understand the needs of customers	
	CKC3	Working with <SC partner company> has helped company better understand competitors.	
	CKC4	Working with <SC partner company> has helped company find better ways of distributing/selling	
	CKC5	Working with <SC partner company> has helped company develop strategies to compete in the market	
supply chain flexibility	SCF1	Company can offer more products and services efficiently in comparison with industry norms	(Cao and Zhang 2011)
	SCF2	Company can offer more customized products and services with different features	
	SCF3	Company can meet different customer requirements efficiently in comparison with industry norms	
Control variable	CV1	Firm size	
	CV2	Ownership	
	CV3	Firm age	

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