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ENABLING SUPPLY CHAIN AGILITY THROUGH IOS INTEGRATION AND SUPPLY CHAIN FLEXIBILITY

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Abstract

In today's turbulent environment, competitive pressures and market unpredictability have dramatically lashed business profits. Agility is an essential ability for firms facing such an environment. However, coping with the hostile business environment requires not only the agility from individual firms but also the collaboration from their supply chain partners. Supply chain agility (SCA) therefore is vital to the competitiveness and performance of a firm and its supply chain partners. Exploring how to effectively enable SCA is significant for both practice and theory development. Recently, firms are increasingly relying on integrated information systems and analytical tools, such as business intelligent systems, and close collaboration with their supplier chain partners to enhance their responsiveness. This paper seeks to broaden the understanding about the enabling roles of IOS integration, analytical ability of inter-organizational information systems (IOS), and supply chain flexibility on SCA based on the dynamic capabilities view and real options theory. With a sample of 147 matched-pair data gathered from the top 2000 Taiwanese manufacturing firms, our results support the effect of IOS integration on supply chain flexibility, including offering and sourcing flexibilities, which in turn facilitate SCA. We also propose and show the moderating effect of analytical ability of IOS on the process of enabling SCA. These results contribute to a better understanding of how SCA may be achieved in theory and in practice. The model and findings of this study should be able to serve as a basis for future research for studying SCA.

Keywords: supply chain agility, supply chain flexibility, inter-organizational system integration, and business intelligent.

1 INTRODUCTION

Globalization has resulted in a hyper-competitive business environment over the last two decades (Baramichai et al., 2007). Constant changes in demands and technologies have limited market visibility and heightened environmental uncertainty drastically (Swafford et al., 2006). In such an environment, firms have to possess various capabilities to achieve and maintain their competitiveness. Agility is the ability of a firm to cope with unexpected market opportunities and threats and has emerged as a key business imperative for seizing market opportunities for competitive advantages (Swafford et al., 2008; Tallon & Pinsonneault, 2011). However, seizing opportunities and coping with threats requires not only an individual firm's agility but also its trading partners' coordination and collaboration, motivating researchers and practitioners to extend the agility concept into the supply chain context (van Oosterhout et al., 2006). In this paper, supply chain agility (SCA) is proposed and defined as the capability of a firm, in conjunction with its key supply chain partners, to adapt or respond to unexpected market changes in a speedy manner (Braunscheidel & Suresh, 2009). SCA allows a firm together with its supply chain partners to react more efficiently and effectively to market dynamics, thereby allowing them to seize market opportunities and establish a superior competitive position (Braunscheidel & Suresh, 2009; Setia et al., 2008; Swafford et al., 2006). Consequently, SCA should be one of the essential ingredients for helping a firm and its supply chain partners survive in turbulent environments(Braunscheidel & Suresh, 2009; Ngai et al., 2011; Swafford et al., 2006). Thus, understanding how to achieve SCA is both theoretically significant and practically important.

To achieve SCA inevitably requires firms to link and collaborate closely with its upstream trading partners (Agarwal et al., 2007; Power et al., 2001) because agile responses to market dynamics involves collaborative mechanisms to cope with unexpected order changes (Young-Ybarra & Wiersema, 1999). Rigidity in collaboration and relationships is likely to misguide upstream trading partners in their decisions regarding production, inventory, and delivery, thereby causing unfulfilled orders (Lee et al., 1997). This would reduce the supply chain's ability to respond to market changes speedily. However, without the support of information technology (IT), achieving SCA is not easy because interactions for greater interfirm flexibility involve timely synchronization of information, decision-making and operations between firms,(Christopher & Towill, 2000; Holmqvist & Pessi, 2006). In fact, SCA is all about speed, including the time to sense relevant events, the time to interpret what is happening and assess the consequences, the time to explore options and decide on which actions to take, and time to implement appropriate responses (Haeckel, 1999; Mathiassen & Pries-Heje, 2006). To compress these times requires integrated and possibly intelligent information systems to support rapid information sharing, data analysis, and operational adjustments. Thus, for achieving SCA, supply chain flexibility (SCF) (Gosling et al., 2010; Vickery et al., 1999), interorganizational information system (IOS) integration and analytical tools of IOS (Grover & Saeed, 2007; Overby et al., 2006; Rai & Tang, 2010; Saeed et al., 2011) should all play an important enabling role.

Research on the relationships among these factors should therefore be critical to our understanding of SCA. Although flexibility and IT have been proposed as key enablers of SCA (Braunscheidel & Suresh, 2009; Ngai et al., 2011; Swafford et al., 2006, 2008), prior studies have neglected to deeply understand what capabilities and characterises of IT can enable SCA (Trinh-Phuong et al., 2012). Most studies in information systems still focus on the relationship between IT and organizational agility rather than SCA (Lu & Ramamurthy, 2011). Extant research on SCA focuses mainly on conceptual development without empirical investigation (Agarwal et al., 2007; Yusuf et al., 2004; Yusuf et al., 1999); most empirical studies emphasize on internal supply (value) chain and its immediate entities due to the difficulties of extending unit of analysis from the firm level to the interfirm or network level (Swafford et al., 2006, 2008). Thus, with the emerging business value of SCA and insufficient research on it, this study seeks to better understand how SCF facilitates SCA and how IOS integration and analytical tools of IOS can support SCF by facilitating information sharing, process efficiency, and decision-making in a dyadic relationship.

Specifically, this study aims to answer the following research questions: (1) Why and how does SCF enable SCA? (2) Why and how does IOS integration leverage SCF and SCA? (3) Why and how does analytical ability of IOS enhance the firm's ability to achieve SCA by augmenting the effects of SCF and IOS integration? This study focuses on dyadic relationships from the buyer perspective and treats dyadic firms as supply chain systems responding to downstream unexpected changes. We address these issues by adopting the dynamic capabilities view (Teece, 2007; Teece et al., 1997) and the real option theory (Kogut & Kulatilaka, 2001). This study, involving a sample of 147 matched-pair data collected from Taiwanese manufacturing firms, contributes to the literature by demonstrating the effects of SCF and IOS integration on SCA and the moderating role of analytical ability of IOS in the processes of enabling SCA.

2 CONCEPTUAL FRAMEWORK

Prior studies on SCA appear lack of a substantive theoretical foundation; most studies adopt the resource-based view and develop the flexibility-agility association as a competence-capability relationship (Braunscheidel & Suresh, 2009; Swafford et al., 2006, 2008). In this study, several preliminary theoretical works from strategic management provide us with new insights into how to achieve SCA, particularly the dynamic capabilities view, which elaborates on how firms can seize emergent opportunities (Kogut & Kulatilaka, 1994, 2001) and shares many of the same concepts with agility (Overby et al., 2006; Teece, 2007; Teece et al., 1997) and the real options theory. Based on these two theoretical perspectives, we propose the conceptual framework as depicted in Figure 1.

According to the dynamic capabilities view (Teece et al., 1997), winners in today's competitive environment have been firms that can demonstrate timely responsiveness and rapid and flexible product innovation. Firms must be able to integrate, build, and reconfigure internal and external competences to address rapid environmental changes and seize the opportunities (Teece et al., 1997). These higher-level capabilities are reflected more specifically as SCA in the supply chain context (Winter, 2003; Zollo & Winter, 2002), i.e., the ability of a firm together with its key supplier to respond to a changing marketplace by adapting their operations and linkages to the new situation. Based on the dynamic capabilities view (Teece, 2007), we propose a conceptual framework that incorporate seizing and sensing capabilities for studying SCA, as shown in Figure 1.

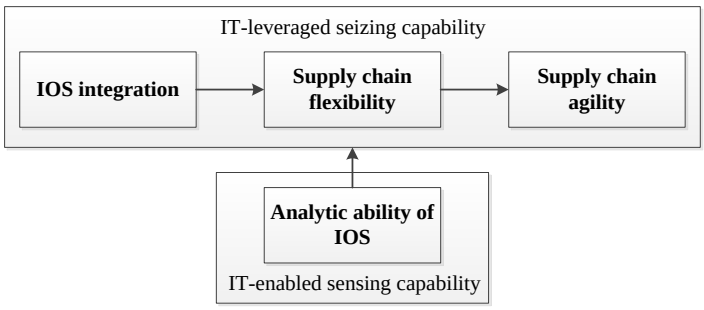

Figure 1. Conceptual framework

2.1 IT-leveraged seizing capability

To seize opportunities, firms have to strategize around investment decisions, getting the timing right and leveraging products and services from one application to another efficiently (Teece, 2007). These activities involve efficient transformation from one state to another, which requires a basket of capabilities as the fundamental platform for supporting related complementary activities. The platform offers an organizing logic or managerial rationale for creating flexible arrangements of capabilities and relationships that allow a firm with its key supplier to respond to challenges and exploit opportunities (Gallagher & Worrell, 2008). In recent digital economy, a firm with its key supplier are likely to depend on their IOS competence to achieve SCA. The competence has been considered a

critical antecedent for firms to generate more competitive actions and greater action repertoire complexity (Overby et al., 2006; Sambamurthy et al., 2003). Integrated IOS (or called IOS integration) enables consistent and real-time transfer of information between applications and functions of trading partners (Rai et al., 2006). Blending IOS with inter-firm processes permits firms to adapt to changing requirements rapidly (Sambamurthy et al., 2003) and to develop higher-order capabilities for operations and workflow coordination (Rai et al., 2006). These capabilities expand the available collaboration and linkage options, thus enhancing the range and mobility of the capacity of SCF (Upton, 1994). These capabilities of variety are options held by a firm with its key supplier for seizing future opportunities. IOS integration therefore as an options generator provides the firm and its key supplier with a stock of options that creates a solid capability platform from which agile moves can be launched (Kogut & Kulatilaka, 2001; Overby et al., 2006; Sambamurthy et al., 2003). Striking the options at appropriate time provides the appropriate flexibility for a stochastically changing environment. Thus, it is held that IOS integration can provide the flexibility to seize and to respond to opportunities (Kogut & Kulatilaka, 2001), and thereby is helpful in achieving SCA.

2.2 IT-enabled sensing capability

According to the microfoundations of dynamic capabilities (Teece, 2007), to identify and seize the opportunities when they emerge, firms must constantly scan, search, and explore markets. These activities involve the probing and re-probing of market trends and customer needs, which involve an understanding of latent demand, the structural evolution of industries and markets, and likely supplier and competitor responses. However, seizing a market opportunity inevitably will incur certain cost for transition from one state to another. The ability to calibrate the required transition and effectuate the needed adjustments with minimum cost is important for firms. Such an ability then depends on whether the firm can scan the environment, evaluate markets and competitors, and accomplish reconfiguration and transformation ahead of competition (Teece et al., 1997). These requirements emerge the critical role of sensing capability. Recently, most transaction and customer data are stored in large databases or data warehouses. These data must be filtered to become sensible to management (Teece, 2007). Potentially useful information and knowledge, such as customer needs, market demands, and trends, are hidden within the data and must be discovered by analytical tools, such as time series analysis, optimization techniques, scenario-based planning, or other business intelligent tools (Saeed et al., 2011). Such tools can extract market opportunities from the databases by applying specific decision models to a particular situation and therefore support seizing capability. Consequently, three antecedent constructs are pinpointed to analyze their effects on SCA as the research model shown in Figure 2.

3 RESEARCH MODEL

3.1 Supply chain agility

SCA, extended from general agility concept, provides a more practical orientation for assessing agility in the supply chain context (van Hoek et al., 2001). Recently, researchers tend to conceptualize SCA as a multi-dimensional construct. In this study, we adopt the definition proposed by Braunscheidel and Suresh (2009) and define SCA as the extent to which the capability of a firm, internally and in conjunction with its key supplier (a dyadic perspective), to adapt or respond to a changing marketplace in a speedy manner. Different from the original definition of Braunscheidel and Suresh (2009), we focus on the perspective of dyadic relationship as a system to reflect SCA and model SCA as a second-order construct reflected on customer responsiveness, product responsiveness, and demand response.

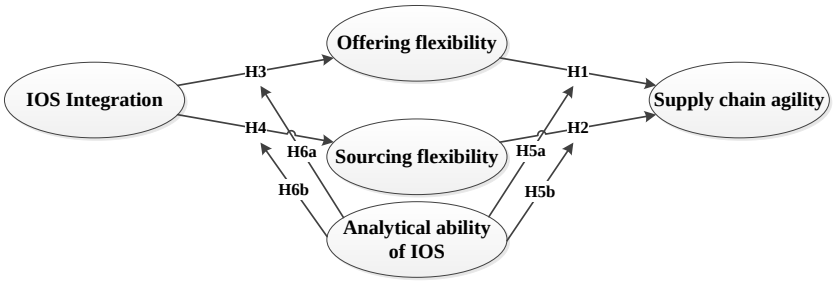

Figure 2. Research model

3.2 Effect of Supply chain flexibility

In this study, flexibility refers to the ability of dyadic firms to change with little penalty in time, effort, cost or performance, as holding a stock of options (Upton, 1994). Such conceptualization of flexibility seems similar to agility, but in fact, they are different in nature. Flexibility is the ability to change status within a pre-established and limited range and mobility. The range is the number of different states that can be achieved. The mobility is the transition cost and time to move from one state to another within the established range (Bernardes & Hanna, 2009; Upton, 1994). Thus, flexibility is to generate variety so that options are held and available to do things differently (Bernardes & Hanna, 2009). However, agility is the ability to change states to accommodate possibly unforeseen environmental circumstances speedily (Bernardes & Hanna, 2009). It is the ability to exercise or sometimes reconfigure available options rapidly when uncertainty or opportunities have materialized, whereby the end state or situation needing change is unknown beforehand. Although these concepts highlight the essential differences between flexibility and agility, flexibility can be the repertory that supports agility (Bernardes & Hanna, 2009). Consequently, this study holds that agility can be supported by tapping the synergies among different forms of flexibility (Agarwal et al., 2007; Bernardes & Hanna, 2009; Braunscheidel & Suresh, 2009; Swafford et al., 2006, 2008).

In the supply chain setting, flexibility usually incorporates different flexibilities to form a higher order flexibility construct (Gosain et al., 2004; Gosling et al., 2010; Moon et al., 2012; Vickery et al., 1999). However, such as construct can become huge, ambiguous, and thereby difficult to identify and elaborate. Gosain et al. (2004) provide a definition of SCF that refers to the extent to which supply chain linkages are able to adapt within a range rather than being forced into committed adaptation. We follow their definition and conceptualization plus the works of Vickery et al. (1999) and Gosling et al. (2010) to identify offering flexibility and sourcing flexibility as the two key elements of SCF. The two elements reflect the typical functionality of the supply chain that is to fulfill the demands from downstream and to settle the reliable inputs from upstream (Lummus et al., 2003; Swafford et al., 2006). For a dyadic relationship, offering flexibility meets the former function and reflects how flexible a firm with its supplier can fulfill the demands from downstream; sourcing flexibility meets the latter function and reflects how flexible a firm can manage its relationship with the supplier. We nevertheless do not aggregate these two flexibilities into a second-order construct or a product construct (Gosain et al., 2004) because an aggregated construct may eliminate the nuances of each flexibility.

Offering flexibility refers to the ability of a firm to support changes in product or service offerings produced in conjunction with its key supplier (Gosain et al., 2004). Specifically, offering flexibility represents the abilities of the dyadic firms to accommodate change in production volumes, delivery dates, products being produced, as well as the production of new products (Gosain et al., 2004; Gosling et al., 2010). The variety of these offerings is a set of available options that provides the dyadic firms a platform for responding to unpredictable market demands and customer needs (Braunscheidel & Suresh, 2009; Upton, 1994). More available options provide the dyadic firms with greater flexibility to exercise or to reconfigure the combination of the options rapidly, increasing the probability of meeting unpredictable demands and needs (Teece, 2007). By further tapping the

synergy of the options, the dyad firms may also be able to find some undiscovered offering solutions for resolving unpredicted demands and needs in a short time (Agarwal et al., 2007; Swafford et al., 2008; Yusuf et al., 1999), thus satisfying customers and markets more rapidly. Consequently, greater offering flexibility should facilitate the dyadic firms' market responsiveness and thereby lead to greater SCA. Accordingly, we propose the following hypothesis:

Hypothesis 1: Offering flexibility is positively associated with supply chain agility.

Sourcing flexibility, defined as the ability of a firm to change and modify the relationship with its key supplier (Gosling et al., 2010; Stevenson & Spring, 2007; Young-Ybarra & Wiersema, 1999), can provide dyadic firms greater ability to adapt to changes. SCA is the capability of the dyadic firms to do unplanned activities in response to unforeseen market demands and customer needs (Bernardes & Hanna, 2009; Narasimhan et al., 2006). These activities may be out of the boundaries of the dyadic firms' extant agreement or contract, especially as the nature of agility encompassing the exploration of opportunities for market arbitrage (Sambamurthy et al., 2003). Thus, the variety of the relationship, as a set of relational options, allows the dyadic firms to rapidly reconfigure their relationship and the form of collaboration (Volberda, 1996, 1997), allowing them to perform certain activities without being pre-specified in the extant agreement or contract. Such a flexible relationship helps the dyad access each other's assets, competencies, or knowledge and synergize these resources for rapid mastering the demands and needs (Sherehiy et al., 2007). Thus, we propose the following hypothesis:

Hypothesis 2: Sourcing flexibility is positively associated with supply chain agility.

3.3 Effect of IOS integration

IOS integration reflects the extent to which a focal firm's information systems are closely linked with those of its supplier as a unified whole to facilitate bidirectional information access (Grover & Saeed, 2007; Rai & Tang, 2010; Saraf et al., 2007). This will help the dyadic firms achieve offering flexibility by two approaches. On the one hand, IOS integration as a process-oriented information system is designed to help two firms conduct business processes, connect their stakeholders, and facilitate boundary-spanning activities (Overby et al., 2006) as IOS integration can provide timely inter-firm information sharing and coordination. Its proper applications also give the dyadic firms greater ability to manage and control their supply chain operations and coordinate with each other (Wang et al., 2006). An integrated IOS also allow the dyad to track each other's variations in production schedules, product qualities, inventory levels, and delivery capability (Rai et al., 2006; Wang et al., 2006). Through bidirectional information sharing, IOS integration therefore facilitates process integration and enhance visibility, which, in turn, help the firms plan and adjust their own operations more rapidly, facilitating the adaptability of their linked activities and processes (Overby et al., 2006; Rai et al., 2006; Rai & Tang, 2010; Saraf et al., 2007). These abilities thereby expand the range of offering options for the dyadic firms. On the other hand, IOS integration provides the firms with integrated data, applications, and processes (Rai et al., 2006). Those information channels reduce communication and collaboration costs and help the firms transit from one state to another more easily, resulting in greater mobility (Upton, 1994), and thus have the potential to reduce the transition penalties for adjusting output levels. Teece et al. (1997) also suggest that integration of external activities and virtual corporation are critical enablers of seizing capabilities. Similarly, Sambamurthy et al. (2003) and Overby et al. (2006) propose that an integrated IOS platform can promote process reach and richness and create the digital options for achieving flexibility. Thus, we propose:

Hypothesis 3: IOS integration is positively associated with offering flexibility.

Building IOS integration usually involves dyadic firms making a series of linked strategic decisions and moving related resources to support the building process (Rai et al., 2006). These activities enable the dyad to understand each other's requirements, constraints and weaknesses (Kogut & Zander, 1992). Such understandings may influence their attitudes of adapting the linkage toward positive outcomes. Intense and real-time operational information sharing enabled by IOS integration further helps managers of the dyad identify their operational problems that may subvert the responding capability

and competitive advantages. Modifying their linkage to fix the problems in order to meet business environment changes is indispensable. Further, IOS integration may force the dyad to expand the range of the linkage. According to the relational view (Dyer & Singh, 1998), IOS integration is a type of relational-specific asset because its development evolves a series of mutual adjustments on information system configurations, personnel skills, and organizational structures. These relational-specific tangible and intangible assets, though facilitating information sharing and process efficiency, may also lead to lock-in effect on the linkage (Young-Ybarra & Wiersema, 1999). Therefore, in order to protect these assets, the firms may be more willing to remain flexible in terms of modifying their agreement and relationship so as not to cause the relationship to fail (Young-Ybarra & Wiersema, 1999). Consequently, their available options can be expanded, leading to greater sourcing flexibility. Thus, we propose the following hypothesis:

Hypothesis 4: IOS integration is positively associated with sourcing flexibility.

3.4 Effect of Analytical ability of IOS

Analytic ability of IOS is defined as the extent to which the IOS provides analytical tools to support decision making with respect to the supply chain functions (Saeed et al., 2011). It can help a firm develop rich knowledge through real-time data monitoring, pattern recognition, and strategic scenario modelling (Overby et al., 2006; Saeed et al., 2011), providing the managers with greater ability to identify emerging opportunities and unforeseen customer needs and decide when to exercise particular offering option, which enables agility. As Overby et al. (2006) argue, analytical ability of IOS as knowledge-oriented IT supports a firm's sensing capability more directly. Analytical ability help the firm not only identify patterns and extract knowledge from data or databases but also rule out overloaded or garbage data (Overby et al., 2006). High-quality knowledge helps the firm's managers sense the opportunities so they can allocate appropriate resources and output levels more rapidly than other firms without such knowledge. Teece (2007) also suggests that the ability to sense opportunities is clearly not uniformly distributed among firms; opportunity discovery by individual firms require both access to information and the ability to recognize, sense, and shape development; those depend on the capabilities and knowledge that can help seizing the opportunities. Thus, if two firms with their suppliers, respectively, had the same initial level of offering flexibility, the one dyad with greater analytical ability should have more information and knowledge to activate appropriate offering options so as to attain a higher level of SCA. Accordingly, we propose the following hypothesis:

Hypothesis 5a: The impact of offering flexibility on supply chain agility is positively moderated by analytical ability of IOS.

As discussed above, when the firm has greater analytical ability of IOS, its managers should have a better understanding of potential opportunities and trends in a changing market. Such knowledge should provide them the opportunity to exercise sourcing flexibility more proactively with its supplier to tackle market changes. Although sourcing flexibility provides the dyad greater range and mobility of linkage modification, modifying the linkage still requires a period of preparation and adaptation. By sensing the market opportunities and trends, a firm with greater analytical ability should give itself more time to modify its linkage with its supplier than the others without such ability. Thus, with a more clear direction to change, the firm should be better prepared for achieving agility than the others without a direction. Accordingly, we propose the following hypothesis:

Hypothesis 5b: The impact of sourcing flexibility on supply chain agility is positively moderated by analytical ability of IOS.

Analytical ability of IOS can complement IOS integration to support a firm to expand offering options with its supplier so as to create a solid platform for enhancing offering flexibility (Overby et al., 2006). IOS integration is designed to support inter-firm business processes and product offerings. It can generate the raw data needed for the analytical tools of IOS. Market trends and patterns identified by the analytical tools can be transformed into various parameters, which can then be imported into the functions of IOS integration for adjusting the automatized business processes and transactions quickly

(Saeed et al., 2011). This will enhance the range and mobility of product offerings. Thus, IOS integration and analytical ability of IOS are complementary, as seizing capability requires the support of sensing capability to be useful (Teece, 2007). Accordingly, we propose the following hypothesis:

Hypothesis 6a: The impact of IOS integration on offering flexibility is positively moderated by analytical ability of IOS.

Analytical ability of IOS can help dyadic firms understand not only market trends and patterns but also monitor and analyze the performance of their collaboration and linkage (Saeed et al., 2011). This knowledge allows their managers to better decide whether and when to modify their linkage in order to meet a changing market. As discussed above, although IOS integration may lead to lock-in effect on the linkage, it may also motivate and enable the dyadic firm to expand the range of their linked activities. Under such circumstances, the dyadic firms with greater analytical ability should have more intelligence and capability to explore the potential options within their relationship. This would benefit the firms when they elaborate on how to modify their linkage for tackling market changes. Thus, we propose the following hypothesis:

Hypothesis 6b: The impact of IOS integration on sourcing flexibility is positively moderated by analytical ability of IOS.

4 RESEARCH METHODOLOGY

4.1 Measurement

Our research data were collected using a carefully developed self-report survey instrument. We developed and validated our measures using the guidelines in the IS literature (Straub, 1989). We first reviewed prior studies to develop measures that were suitable for the current study, had face validity, and had a minimal overlap between constructs. In order to establish content validity of the constructs, items were independently evaluated by each of the researchers. Then, the researchers jointly discussed each construct and its items until they had an agreement. After compiling an English version of the questionnaire, the survey items were first translated into Chinese by a bilingual researcher. The survey items were verified and refined for translation accuracy by an MIS professor and a PhD candidate. The Chinese version of the draft was then pretested with 6 senior managers (including CEO, senior business manager, procurement manager, and IS executive) for verifying face and content validity again, resulting in modification of the wording of some survey items. We operationalized all constructs using multi-item reflective measures with a seven-point scale that ranged from "strongly disagree" to "strongly agree," with its midpoint anchored as "neither agree nor disagree." Appendix A shows the instrument and the supporting literature.

4.2 Sample and data collection

A cross-sectional and matched-pair mail survey of purchasing managers and IS executives was administrated for collecting data from the top 2000 manufacturing firms based on the Year 2012 Directory of the Top 5000 Largest Firms in Taiwan, published by China Credit Information Services Ltd. After accounting for undelivered and invalid mails, the effective mailing was 1950 surveys. Survey packages were mailed to the purchasing managers of each target firm with a request that the recipient completed Part A related to SCA and SCF. The recipient needs to select an important supplier of the recipient's firm and write down the supplier name before distributing Part B to the suitable IS executive for providing the information about IOS integration and analytical ability of IOS. Part A and B must refer to a same supplier because all of our constructs focus on the dyadic relationship. Totally, 172 surveys were returned, with 147 having completed the data in both Parts A and B and available for subsequent analysis, yielding an effective response rate of 7.5%. Tables 1 and 2 exhibit the characteristics of the sample.

Non-response bias was assessed using the procedure recommended by Armstrong and Overton (Armstrong & Overton, 1977). Considering the last group of respondents as most likely to be similar to non-respondents, a comparison of the first and last quartile of respondents provides a test of response bias. No significant differences between the first and last quartile of the respondents were found on the key research variables.

Common method variance (CMV) was tackled with three strategies. First, multiple informant approach allowed us to mitigate the CMV (Podsakoff et al., 2003). Second, we used Harmon's single-factor test to assess CMV (Podsakoff et al., 2003). Six factors with eigenvalues >1 were extracted and collectively accounted for 76% of the variances in the data, with the first factor accounting for 39.26% of the variances. These findings suggest that CMV should not be a main concern with regard to our data. Third, we conducted PLS marker variable approach to diagnosing CMV (Rönkkö & Ylitalo, 2011). We compared our model including the marker variable with the baseline model. The results showed all the paths were significant in both the baseline model and the compared model. Taken together, we concluded that CMV is not significant in our data.

5 RESULTS

A partial least squares (PLS) structural equation model was constructed for validating the measures and testing the hypotheses. We used SmartPLS 2.0 M3 (Ringle et al., 2005) to estimate the parameters in the outer model with a factor weighting scheme and the inner model with a path weighting scheme (Hair et al., 2012; Henseler, 2010). We used non-parametric bootstrapping with 5,000 replications and individual changes to obtain the estimates (Hair et al., 2012). Following the guidelines for second-order construct suggested by Wetzels et al. (2009), SCA was set up through the repeated use of the manifest variables of the first-order constructs.

5.1 Outer model (measurement model)

The mean, range, and standard deviation for each construct are reported in Table 3. Path loadings of all items are significant at 0.1% level, indicating individual item reliability. The composite reliability (CR) estimates are above 0.9 for all constructs, indicating good internal consistency and reliability of our scales (Hair et al., 2012). Although the item loadings and their significance appear to demonstrate convergent validity, we also assess the convergent validity of our first-order constructs using average variance extracted (AVE) criterion. The AVE of each construct exceeds the minimum threshold value of 0.50 (Fornell & Larcker, 1981; Hair et al., 2012; Henseler et al., 2009). The combined results demonstrate convergent validity of our first-order constructs. Discriminant validity is established when the square root of the AVE by each construct is larger than the inter-construct correlations. Our results support the discriminant validity of our measures. In Table 4, we include the CR and AVE of SCA, showing the CR greater than 0.9 and the AVE greater than 0.5, which provide the evidence of reliability. The loadings of all the first-order constructs on SCA exceed 0.9 and are significant ($p < 0.01$).

Table 1. Profile of the respondents (N=147)

Purchasing title	No.	%	MIS title	No.	%
Director/Manager/Assistant Manager/Section Manager of Purchasing	60	41	Section Manager/Manager/Assistant manager/Administrator/Consultant of MIS	33	22
Management (with purchasing responsibility)	62	42	Engineer of MIS	33	22
Top management	7	5	Management (with MIS responsibility)	49	33
Others	10	7	Top management	3	2
Missing	8	5	Others	7	5

Table 2. Profile of the responding firms (N=147)

Industry	No.	%	Number of employees	No.	%
Automobile	13	9	1-250	76	52
Chemical	17	12	251-500	29	20
Computer and electronics	55	37	501-1,000	17	12
Food	6	4	1,001-2,000	11	7
Machine and tool	10	7	>2,000	14	10
Metals and materials	27	18			
Textile	7	5			
Others	12	8			

Table 3. Inter-construct correlations and reliability measures for first-order constructs (N=147)

						Correlations of among constructs						
Construct	Items	Mean	Std.	CR.	AVE	1	2	3	4	5	6	7
1. Customer responsiveness	3	5.28	1.06	0.88	0.76	**0.87**						
2. Product responsiveness	4	5.01	1.21	0.86	0.78	0.79	**0.88**					
3. Demand response	3	5.07	1.08	0.82	0.74	0.83	0.72	**0.86**				
4. Offering flexibility	4	5.20	1.12	0.90	0.69	0.70	0.64	0.64	**0.83**			
5. Sourcing flexibility	3	5.19	1.23	0.92	0.80	0.52	0.47	0.53	0.57	**0.89**		
6. IOS integration	10	3.52	1.96	0.96	0.69	0.38	0.34	0.30	0.41	0.21	**0.83**	
7. Analytic ability of IOS	3	4.30	1.66	0.96	0.88	0.30	0.18	0.29	0.33	0.14	0.40	**0.94**

Note: Square roots of average variance extracted are shown on the diagonal.

Table 4. Second-order constructs and its association with first-order constructs (N=147)

Construct	**CR.**	**AVE**	**First-order constructs**	**Loadings**	**R^2**
1. Supply chain agility	0.95	0.65	Customer responsiveness	0.94	88.0%
			Product responsiveness	0.93	85.8%
			Demand response	0.91	82.1%

5.2 Inner model (structural model)

We estimate three models. Model 1 is a baseline model that predicts SCA using control variables. Model 2 builds on model 1 by including all paths in the model, but excluding the moderating effects of analytical ability of IOS. Model 3 includes analytical ability of IOS as a moderator. The results of these three models are shown in Table 5. The full model (model 3) has an R^2 of 58.5% for SCA. R^2 for offering flexibility and sourcing flexibility are 24.2% and 14.3%, respectively. In the full mode, we create product constructs with the mean-centering approach, suggested by Chin et al. (2003), for testing the moderating effects. With omission distance equal to 5, that all the cross-validated redundancy Q^2 values of the endogenous constructs are larger than zero indicates that the exogenous constructs have predictive relevance for the endogenous constructs (Chin, 2010). Finally, the absolute GOF is 0.49.

In terms of the full model, we first note that offering flexibility has a strong effect on SCA (p<0.001), supporting H1. Similarly, the results also support H2 (p<0.01), indicating the effect of sourcing flexibility on SCA. Our analysis reveals that analytical ability of IOS moderates the link between offering flexibility and SCA (p<0.01; H5a is supported) but fails to moderate the link between sourcing flexibility and SCA (p>0.05; H5b is not supported). So firms should not expect greater SCA from sourcing flexibility when utilizing analytical tools with the data from IOS. IOS integration is positively related to both offering flexibility (p<0.01; H3 is supported) and sourcing flexibility (p<0.01; H4 is supported), suggesting that IOS integration can create various options for firms to increase SCF. As expected, analytical ability of IOS moderates the link between IOS integration and offering flexibility (p<0.05; H6a is supported). Perhaps most interesting of all, our analysis presents that

analytical ability of IOS has a negative and significant moderating effect on the link between IOS integration and sourcing flexibility (H6b is no supported).

Further, considering offering and sourcing flexibilities as two mediators in our model, we tested the magnitude and significance of individual mediated paths with the multiple mediator model proposed by Preacher and Hayes (2008). We performed percentile bootstrap to estimate indirect effects with 5,000 re-sampling. The results indicate that offering and sourcing flexibilities fully mediate the link between IOS integration and SCA because the direct effect of IOS integration on SCA turns from significant (t=4.74) to insignificant (t=1.63) when adding the mediators. Based on Sobel's test (Sobel, 1982) and the bootstrap results, the two indirect paths are significant (the indirect path through offering flexibility is significant at 0.05 level; through sourcing flexibility is significant at 0.1 level).

6 DISCUSSION AND CONCLUSIONS

6.1 Summary of results

Overall, our results show that IOS integration enables SCF, which, in turn, facilitates SCA. Consistent with prior studies in demonstrating the flexibility-agility relationship (Braunscheidel & Suresh, 2009; Swafford et al., 2006, 2008), we find support for the proposition that offering flexibility and sourcing flexibility, though representing different aspects of SCF, can help dyadic firms achieving greater SCA. We further compare the effects of these two flexibilities and find that the effect of offering flexibility (β=0.6) is stronger than that of sourcing flexibility (β=0.219) on SCA. This result appears reasonable because offering flexibility, which focuses on flexible product and service offerings, should allow the supply chain to meet unexpected market demands and customer needs, thereby enabling greater supply chain agility. Sourcing flexibility, on the other hand, focuses on relationship modification of dyadic firms, which may only provide a foundation for their supply chain to operate flexibly and speedily without the restriction of agreements or contracts. Thus, although both of the capabilities are significant on facilitating SCA, they engage in different dimensions of supply chain management.

This study shows that both offering and sourcing flexibilities fully mediate the effect of IOS integration on SCA. The results are consistent with the conceptual frameworks of Sambamurthy et al. (2003) and Overby et al. (2006). They propose that, through IT competence, firms can generate digital options, which in turn enable agility. In this study, we not only extend their framework but also empirically demonstrate similar relationships in the supply chain context.

More interesting results are the moderating effect of analytical ability of IOS on each direct path. We show that analytical ability of IOS significantly and positively moderates the path from IOS integration to offering flexibility, and from offering flexibility to SCA. These findings suggest that mining potential market trends and demand patterns can enhance the ability of a firm with its supplier to change product or service offerings and thus react to a changing market more rapidly. This result also demonstrates the importance of business intelligent systems. However, our findings show that analytical ability of IOS negatively moderates the relationship between IOS integration and sourcing flexibility, completely opposite to our hypothesis (H6b). One plausible reason is that analytical ability of IOS provides sufficient information and knowledge for the managers of dyadic firms to help them understand potential uncertainty in the future and then lead them to negotiate a more flexible contract prepared for future changes, thus reducing their needs to modify their relationship in the future. Another plausible reason is that firms may choose loose coupling with or de-selection of its supplier to meet future changes. Under such circumstances, they will have less need to maintain a long-term relationship and build an integrated IOS with their suppliers, for avoiding the lock-in effect and the difficulty of modifying the relationship.

Table 5. Model results

	Model 1 Controls Only	Model 2 Excluding Analytic Abi.	Model 3 Full Model
Controls	Firm size ^{NS} Sales ^{NS} Purchasing ^{NS} Association. ^{NS} Frequency ^{NS}	Firm size ^{NS} Sales ^{NS} Purchasing ^{NS} Association. ^{NS} Frequency ^{NS}	Firm size ^{NS} Sales ^{NS} Purchasing ^{NS} Association. ^{NS} Frequency ^{NS}
Offering Flex. → SCA		0.607***	0.600***
H1 (+) Supported		*0.073*	*0.083*
Analytic Abi. → SCA			0.052 ^{NS}
Main effect			*0.091*
(Offering Flex. × Analytic Abi.) → SCA			0.239**
Moderating effect: **H5a (+) Supported**			*0.144*
Sourcing Flex. → SCA		0.198*	0.219**
H2 (+) Supported		*0.086*	*0.085*
(Sourcing Flex. × Analytic Abi. → SCA			-0.083 ^{NS}
Moderating effect: **H5b (+) Not supported**			*0.087*
IOS Int.→ Offering Flex.		0.408***	0.270**
H3 (+) Supported		*0.069*	*0.087*
Analytic Abi. → Offering Flex.			0.249**
Main effect			*0.098*
(IOS Int. × Analytic Abi. → Offering Flex.			0.217*
Moderating effect: **H6a (+) Supported**			*0.235*
IOS Int.→ Sourcing Flex.		0.207*	0.238**
H4 (+) Supported		*0.084*	*0.094*
Analytic Abi. → Sourcing Flex.			-0.012 ^{NS}
Main effect			*0.103*
(IOS Int. × Analytic Abi. → Sourcing Flex.			-0.320**
Moderating effect: **H6b (+) Not supported**			*0.306*
Explained Variance: R^2			
SCA	2%	54.1%	58.5%
Offering Flex.		16.7%	24.2%
Sourcing Flex.		4.3%	14.3%

*Note: *** p < 0.001; ** p < 0.01; * p < 0.05; NS: not significant; standard error terms are shown in italics. We report the main effect of analytic ability of IOS on each endogenous construct for reference. These paths are added to the model in order to model analytic ability of IOS as a moderator. While not ordinarily interpreted as part of a moderation test, the main effect is still open to interpretation on its own merits.*

6.2 Implications for research and practice

For academic, we develop and examine a model that (1) deliberates the IOS integration as a key enabler of SCF, which in turn facilitates SCA; (2) proposes analytical ability of IOS as a key moderator that strengthens the effect of offering flexibility on SCA; (3) adopts the dynamic capabilities view to provide a new approach to explaining the flexibility-agility relationship. We expand the prior research on SCA to focus on the relationship with upstream trading partners. For practice, our findings suggest that SCA as a seizing capability is facilitated through offering and sourcing flexibilities. Establishing an integrated IOS with trading partners should be helpful in enabling overall seizing capability, wherein information about market trends and demand patterns provided by the analytical tools is critical in enhancing flexible and speedy product and service offerings.

6.3 Limitations

This study has several limitations. First, the response rate of the survey appears relatively low. This may be caused by our survey that requires multiple informants. The approach, however, reduces the threat of common method bias. Second, even though the possibility of non-response bias was checked and ruled out statistically, the representativeness of the sample, and thus the generalizability of our results, could still be limited. Third, the cross-sectional nature of the study only provides us with evidence for the associations among the research variables. The theoretical foundations employed to support the hypotheses nevertheless provide justification for our proposed model. Finally, the respondents were asked to select a major supplier as the target supplier for answering the survey on which our results were based. However, assuming that the choices of the relationship were randomly distributed across the sample, the choices may have minimal effects on the results.

Appendix A. Measurement Items

Scale indicators	References
Supply chain agility	Braunscheidel and Suresh (2009) Khan and Pillania (2008) Swafford et al. (2006) van Hoek et al. (2001)
Demand response	
We are able to respond to changes in demand without overstocks or lost sales in conjunction with this supplier. (DR1)	
We are capable of forecasting market demand in conjunction with this supplier. (DR2)	
We are capable of responding to real market demand in conjunction with this supplier. (DR3)	
Customer responsiveness	
We are capable of rapidly improving customer service in conjunction with this supplier. (CR1)	
We are capable of rapidly improving responsiveness to changing market needs in conjunction with this supplier. (CR2)	
We are capable of rapidly reducing order-to-delivery cycle time in conjunction with this supplier. (CR3)	
Product responsiveness	
We are capable of rapidly increasing levels of product customization in conjunction with this supplier. (PR1)	
We are capable of rapidly reducing manufacturing lead time in conjunction with this supplier. (PR2)	
We are capable of rapidly reducing product development cycle time in conjunction with this supplier. (PR3)	
We are capable of rapidly increasing frequencies of new product introductions in conjunction with this supplier. (PR4)	
Supply chain flexibility	Gosain et al. (2004) Swafford et al. (2008) Young-Ybarra and Wiersema (1999) Zhang et al. (2003)
Offering flexibility	
We are able to efficiently respond to change in demanded product volumes in conjunction with this supplier. (OF1)	
We are able to efficiently alter deliver schedules to meet customer requirement in conjunction with this supplier. (OF2)	
We are able to efficiently produce different combinations of products in conjunction with this supplier. (OF3)	
We are able to efficiently phase out old products and introduce new ones in conjunction with this supplier. (OF4)	
Sourcing flexibility	
When business environment changes, we and this supplier are able to modify the agreement rather than hold each other to the original terms. (SF1)	
Flexibility in response to requests for changes is a characteristic of the conjunction between us and this supplier. (SF2)	
Our company and this supplier expect to be make adjustments in the ongoing relationship to cope with changing circumstances. (SF3)	
IOS integration	Grover and Saeed (2007) Rai et al. (2006) Rai and Tang (2010) Saraf et al. (2007) Saeed et al.
Data are entered only once to be retrieved by this supplier's system. (IOSI1)	
Our system can access data from this supplier's system. (IOSI2)	
Our system can aggregate relevant information from this supplier's databases. (IOSI3)	
Our company shares databases with each other. (IOSI4)	
We have successfully integrated relevant applications of our system with this supplier's applications. (IOSI5)	
Our applications work seamlessly with this supplier's applications. (IOSI6)	
Our applications can share real time information with this supplier's applications. (IOSI7)	

We have synchronized data formats and standards with this supplier. (IOSI8) The data formats and standards used in the systems of our firm and this supplier are based on a common standard. (IOSI9) Definitions of key data elements (e.g., order and part numbers) are common between ours and this supplier's system. (IOSI10)	(2011)
Analytic ability of IOS Our systems offer various decision making tools (such as optimization, scenario analysis, etc.) for managing our relationship with this supplier. (AA1) Our systems offer various tools that can enable us to examine trends in the data for managing our interaction with this supplier. (AA2) Our systems offer various statistical tools for supporting our interactions with this supplier. (AA3)	Saeed et al. (2011)

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