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Supplier collaboration and speed-to-market of new products: the mediating and moderating effects

Ying Zhang · Lihua Wang · Jie Gao

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Abstract In a turbulent market economy, the role of suppliers in manufacturer's new product development has received great attention from both practitioners and researchers. Substantial empirical evidence on the contribution of suppliers in addressing challenges in terms of shorter product life, more immediate response, and faster information flows has been presented. This study aims to investigate which of the supplier collaboration (SC) practices are directly or indirectly related to the speed-to-market (STM) of new products across different firm sizes. The results confirm the direct and positive effect of information sharing on STM. Furthermore, information sharing may partially mediate the effect of strategic purchasing on STM, and completely mediate the effect of supplier involvement on STM. It is also shown that firm size significantly affects the relationship between strategic purchasing and information sharing and that between information sharing and STM. The implications on improving STM via SC for future research and managerial practices are also discussed.

Keywords Supplier collaboration · Speed-to-market · Information sharing · Strategic purchasing · Supplier involvement

Y. Zhang · J. Gao (✉)
School of Management, Xi'an Jiaotong University, Xi'an 710049, China
e-mail: gaoj@mail.xjtu.edu.cn

Y. Zhang
e-mail: zhangying.som@stu.xjtu.edu.cn

L. Wang
School of Economics and Finance, Xi'an Jiaotong University, Xi'an 710061, China
e-mail: wanglh@mail.xjtu.edu.cn

Y. Zhang · J. Gao
The State Key Laboratory for Manufacturing Systems Engineering, Xi'an Jiaotong University, Xi'an 710049, China

Introduction

The speed-to-market (STM) of new products is extremely important in today's marketplace, which is characterized by short product life, rapid response, and fast information flows (Sorescu and Spanjol 2008). STM significantly influences the long-term competitiveness of firms. The reason for this condition is the actuality that the firms, which introduce new products more rapidly than their competitors, may enjoy more advantages, such as maintaining technology leadership and keeping a closer relationship with customers (Stalk 1988). However, improving STM involves numerous challenges owing to the growing product complexity and turbulent economic environment. Over the last two decades, supplier collaboration (SC) in new product development (NPD) has caught the attention of both researchers and practitioners (Clark 1989; Handfield et al. 1999; Li et al. 2012; Mentzer et al. 2000; Luo et al. 2010; Ragatz et al. 1997; Song and Di Benedetto 2008). The supplier plays a key role in the manufacturers' NPD by providing unique resources and expertise. SC practices contribute to the NPD performance of manufactures in terms of accuracy and timeliness, thus allowing a firm to generate competitive advantages.

Researchers have extensively explored the relationship between SC and STM. However, some shortcomings have also been observed. First, although some researchers confirmed that SC has a positive effect on NPD, the effects of SC may be neutral or even negative (Hartley et al. 1997; King and Penleskey 1992; Petersen et al. 2005; Yan and Dooley 2013). Hence, it is necessary to identify whether the

implementation of SC practices is positively related to STM. Second, prior research assessed only the SC practices that are directly related to STM, whereas rarely involved those that are indirectly related. Third, the benefits of suppliers to manufacturers in NPD projects depend on several contingency factors, such as firm size (Sousa and Voss 2008; Frohlich and Westbrook 2001). This particular subject has not been well assessed so far.

This study explores the following issues: (a) How do SC practices relate with STM? And (b) Will these relationships hold across different firm sizes? Information processing theory is adopted in this study to develop the conceptual framework. This theory indicates that the effectiveness of an organization depends on the fit between the amount of uncertainty it encounters and the information processing capacity it has (Galbraith 1973; Williams et al. 2013). Uncertainties exist when accurate information on the system cannot be efficiently acquired (Yu et al. 2001). Information processing capacity includes the capacities of a firm to gather, transform, communicate, and store information (Egelhoff 1991). When a firm has to deal with a task with greater uncertainties, it must process greater amount of information. STM is highly sensitive to uncertainties from both internal and external environments. Hence, SC practices can help manufacturers to reduce such uncertainties. Specifically, this study focuses on the three categories of SC practices, namely, information sharing, strategic purchasing and supplier involvement.

Overall, this study has three contributions to literature. First, this work enriches information processing and contingency theories on business strategy by providing a fine-grained analysis of SC in NPD. This study represents a systematic attempt to organize a set of SC practices for leveraging the resources of suppliers and to identify firm size as an important contingency factor. Second, this study sheds light on the intermediate processes by empirically clarifying the direct and indirect links between SC practices and STM as well as the feasibility of these links across firms of different sizes. Finally, by conducting a survey among 176 manufacturers in China, this study extends the geographic reach of empirical research on emerging economies. China has emerged as a key player in the global landscape. Moreover, the dynamic and competitive environment and countless *guanxi* networks provide fertile ground for gaining insights into SC and its effects on STM.

Theoretical framework and hypotheses development

Supplier collaboration and speed-to-market of new products

STM assesses the extent to which an organization introduces new products faster than the industry average. At present, the rapidly changing market environment has made it impossible for a single firm to respond to the opportunity that remains open for increasingly short durations. Manufacturing firms have become more aware that suppliers play a fundamental role in the industry. Some of these firms have rapidly launched their products in the market by leveraging the resources and skills of their suppliers. SC denotes that manufacturers and their suppliers collectively work to plan and execute operations, thereby attaining greater success than acting in isolation (Mahapatra et al. 2012). Apart from designing the products/services by themselves or buying them from the market, manufacturers may collaborate with suppliers for a third alternative (Kaufman et al. 2000).

In the context of NPD, product complexity, technological novelty and task interdependence are considered elements that induce uncertainties (Yan and Dooley 2013). These uncertainties in the outside environment may be reduced with SC, as suppliers could employ expertise to manage uncertainties related to raw materials, components, and the latest development in specific technology fields. SC practices refer to the critical activities that are expected to enhance the collaborative relationship between the manufacturer and the supplier and make such a relationship more sensitive to market demands.

This study particularly addresses the SC practices that can enhance the information processing capacity of firms in the context of manufacturer-supplier NPD, including strategic purchasing, supplier involvement, and information sharing. Strategic purchasing pertains to the planning process that is part of the strategic management processes, including setting goals, establishing strategies, analyzing the environment, and evaluating, implementing, and controlling strategies (Carr and Smeltzer 1997). Strategic purchasing emphasizes the strategically managed buyer-supplier relationships and long-term focus (Cousins 1999; Paulraj et al. 2006). Supplier involvement refers to the dependence of manufactures on suppliers for engineering work to reduce the former's internal engineering efforts (Clark 1989). This practice requires the direct participation of suppliers - from providing minor design suggestions to completely developing a specific part of the assembly (Chen and Paulraj 2004; Wynstra and Pierick 2000). Information sharing focuses on the content and quality of information flow between manufacturers and suppliers (Li and Lin 2006). Extensive information sharing helps manufacturers improve manufacturability, reduce total cost and cycle time, and improve order fulfillment rate (Takeishi 2001).

Figure 1 depicts the conceptual model, with an emphasis on the effect of SC practices on STM. The intermediate processes and contingency factors are further explored by analyzing the relationships between various SC practices and STM across different firm sizes.

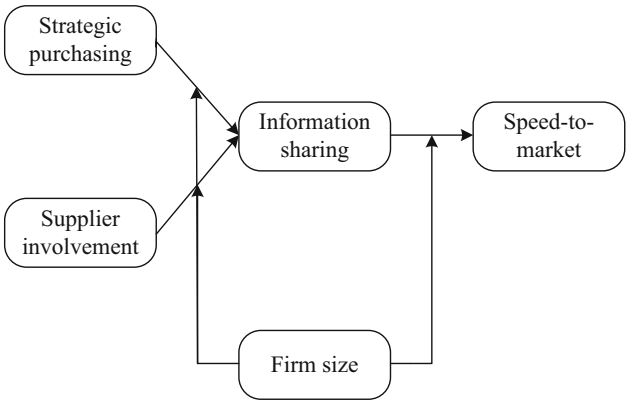

Fig. 1 Conceptual model

Direct effects of information sharing

Manufacturers collaborate with suppliers to obtain benefits, such as improved economic return, reduced risk, and superior new products. However, significant barriers (e.g., technical, cultural, and management uncertainties) may arise with the implementation of SC. Information sharing help organizations improve their information processing capability and overcome these barriers (Yu et al. 2001). Uncertainties emerge for a specific collaborative relationship between the manufacturer and its suppliers due to the insufficient amount of accurate information about each other. Each member has more information about itself than its partners. So if these members willingly share information, they will acquire more information about each others, eventually improving the performance of the entire system. The substantial information sharing between the manufacturers and its suppliers can remarkably benefit the formation of knowledge resources and the improvement of operational efficiency, quality, flexibility as well as customer responsiveness (Paulraj et al. 2008).

Information sharing with suppliers consists of two information flows. The first pertains to the information the manufacturer receives from its suppliers, and the other refers to the flow of information provided by a manufacturer to its suppliers (Baihaqi and Sohal 2013). Information sharing is a direct means for exchanging critical and proprietary information (Li and Lin 2006). Weak information sharing may serve as a huge obstacle for NPD activities. The dramatic increase in current knowledge prompts firms to keep pace with the latest development in all fields. Suppliers may seize cutting-edge expertise, which complements the disciplinary expertise of manufacturers. NPD activities begin with the perception of opportunities, and information sharing with suppliers may help manufacturers easily recognize and access new opportunities.

Information sharing links are necessary to enhance the coordination between manufacturers and their suppliers, resulting in increased performance (Lee 2000). Firstly, information sharing can improve the supply chain efficiency by polishing the production. With information sharing, manufacturers can inform suppliers about what information and materials they require, allowing the latter to better understand their roles in the articulated development process. Information sharing also provides linkages to coordinate interactive behavior and synchronize concurrent engineering efforts between manufacturers and suppliers, which enables the manufacturers more responsive and flexible to market demands (Baihaqi and Sohal 2013). In particular, frequent and meaningful information sharing can strengthen the ties and trust among the supply chain partners (Morgan and Hunt 1994; Uzzi 1997). By contrast, insufficient information sharing may induce conflicts and misunderstandings. These complications are recognized as the reasons for many collaboration failures. Based on the above arguments, this study proposes its first hypothesis.

H1 Information sharing with suppliers is positively associated with STM.

Indirect effects of strategic purchasing

Strategic purchasing is considered as a strategic weapon in establishing cooperative supplier relationships to enhance the competitiveness of firms (Carr and Smeltzer 1997). The traditional purchasing function in a firm usually takes a supportive role, and its responsibilities are limited to ensuring that supplier quality satisfies the required standards for production (Ellram and Carr 1994). Strategic purchasing, however, requires firms to regard purchasing function as strategically important in addition to conforming to physical and price specifications. Ignoring the important role of purchasing in today's consumer-oriented and pragmatic society may introduce disadvantages to firms by acquiring ordinary inputs, which are available to all competitors and of no use in generating premium profit (Barney 1986). Strategic purchasing serves as an important antecedent of STM (Atuahene-Gima 1995) and helps perform the following tasks in NPD: (a) monitoring the market for new technologies from novel or existing suppliers; and (b) selecting suppliers that are expected to ensure the continuous supply of required materials and components (Nijssen et al. 2002).

Strategic purchasing promotes information sharing among the supply chain partners (Chen and Paulraj 2004). Strategic purchasing fosters close interactions among a limited number of suppliers and enables the firm to achieve more superior operational performance (Cousins 1999; Mohr and Spekman 1994). This practice is more likely to be associated with long-term relationship orientation and reflects the strategic mindset. That is, supply chain partners must cultivate the norms of mutuality, flexibility and information sharing in line with relational contracting (Heide and John 1992). Accordingly,

firms are more willing to focus on developing knowledge and exchanging information to enhance relationship-specific assets (Madhok and Tallman 1998).

Strategic purchasing requires different mindsets on the roles of both the supplier and the purchasing function. Many firms have successfully developed the technical aspects of the SC practice, but encounter difficulties in implementing these aspects in softer conditions, such as changing the management. The focus of strategic purchasing is to seek long-term opportunities to extend support and expertise to pursue the firm's strategic objectives, which involves risks and uncertainties (Paulraj et al. 2006). Information sharing has been cited as one of the major means to capture the environmental dynamics and thus reduce uncertainties. Strategic purchasing also emphasizes strategic relationships and trust between manufacturers and suppliers. Both the two elements can be developed by conducting adequate information sharing programs. Accordingly, this study posits the second hypothesis.

H2 The relationship between strategic purchasing and STM is mediated by information sharing.

Indirect effects of supplier involvement

Supplier involvement reduces the internal engineering efforts of manufacturers in NPD projects (Clark 1989). Nowadays, the designing and manufacturing of components are regarded as responsibilities of suppliers, who employ appropriate technology and experience (Vonderembse and Tracey 1999). Suppliers are encouraged to participate in NPD activities to enable manufacturers to access the information and expertise of the former (Valk and Wynstra 2005). Among the previous literature, supplier involvement is generally perceived as a determinant that extensively affects the manufacturers' NPD activities (Johnsen 2009). Supplier involvement can expedite the speed and quality of developing new products (Ragatz et al. 2002). Suppliers possess specialized products and process capabilities, which are important for NPD as products are becoming increasingly complex. Supplier involvement can also help manufacturers adapt their products and upgrade their technologies. The findings of several studies in automotive industry clarify that supplier involvement is a key explanatory factor in superior Japanese NPD performance (Clark 1989; Cusumano and Takeishi 1991; Kamath and Liker 1994).

Supplier involvement facilitates information sharing and knowledge learning between manufacturers and their suppliers. In the product design process, suppliers can provide information about the specification of components downstream (Hilletofth and Eriksson 2011). If suppliers are involved in testing new products, they are expected to gain better understating of how technical features work and which parts should be improved (Song and Di Benedetto 2008). In particular, increased supplier involvement may enable suppliers to gain better information about the market strategies and the manufacturer's plans to implement adjustments.

Information sharing between manufacturers and suppliers improves mutual understanding, and thus is crucial in ensuring effective supplier involvement. Suppliers can achieve effective supplier involvement by providing manufacturers with suggestions for the component design. For example, suppliers may share their views on contradictory specifications and unrealistic design when they are involved at the early stage of the NPD process (Wheelwright and Clark 1992), which helps to improve STM. Meanwhile, manufacturers are required to provide the clear goals, truthful feedback regarding the suppliers' efforts and knowledge in solving the problems. Information sharing emphasizes communication and exchange and is deemed necessary for the successful implementation of supplier involvement (Kessler 2000; Gupta and Wilemon 1990). Based on the above discussions, the third hypothesis is presented.

H3 The relationship between supplier involvement and STM is mediated by information sharing.

Moderating effects of firm size

Contingency theory explores organizational issues from a contextual perspective, and maintains that the strategy initiatives of firms must be aligned with the factors of organizational design (Hoffer 1975; Jayaram et al. 2011). Firms have various strategic objectives and capabilities, and thus differ in their approaches toward the supplier base and SC practices. The heterogeneity in deploying supplier resources can help some manufacturers obtain above-normal benefits over the others (Peteraf 1993). Furthermore, identifying the contingency factors can significantly encourage the use of SC practices to improve STM.

Firm size is an important contingency factor, and hence should be analyzed to determine how SC practices influences STM. The distinction between small and large firms seems to capture many effects of other explanatory variables (Koski et al. 2012). However, previous studies have specified the controversial relationships between firm size and innovation performance (see meta-analysis by Damanpour 1992; Camisón-Zornoza et al. 2004), indicating that the applicability and feasibility of the effects posited in H1, H2 and H3 for firms of different sizes have yet to be explored. In this study, firm size is measured by the number of employees in the corporation as in Deveraj et al. (2007). In particular, small, medium, and large firms refer to those businesses with employees <300, from 300 to 2,000 and $>2{,}000$, respectively.

We argue that firm size is a key contextual variable for two reasons. Firstly, the fitness of the SC practices depends on the resources of the manufacturers. A larger firm usually has greater underlying resources, including financial slack,

research and development capabilities, and product development experience (Damanpour 1992; Frohlich and Westbrook 2001; Sousa and Voss 2008). Secondly, the attitude of suppliers may affect the SC practices' effects. Suppliers are more willing to collaborate with large manufacturers, because the latter generally accounts for a considerable portion of the former's sales volume. Based on information processing and contingency theories, the relationships posited in the research model may be more applicable to larger firms. Therefore, we speculate that firm size may moderate the relationships specified in H1, H2, and H3.

Large firms can effectively adopt their superior resources to execute SC practices, whereas small firms may not execute these practices smoothly owing to their inadequate resources. Meanwhile, suppliers are more willing to adopt collaborative posture and provide positive feedback to large manufacturers on account of their leverage in the relationship. Moreover, compared with their smaller counterparts, large firms may have less difficulty in attracting first-class suppliers. Hence, the fourth hypothesis is presented.

H4 Firm size moderates the relationship between information sharing and STM.

Firm size also moderates the links between SC practices. When a strategic purchasing relationship is established, large manufacturers are more likely to develop long-term relationship and mutual trust with their respective suppliers, thereby increasing their collaborative information sharing. With regards to supplier involvement, the collaborative position of first-class suppliers may provide large firms the access to high-quality information on account of the latter's leverage in the relationship. Moreover, larger firms invest more resources in supporting technologies and systems to enhance information sharing. Therefore, the following two hypotheses are proposed.

H5 Firm size moderates the relationship between strategic purchasing and information sharing.

H6 Firm size moderates the relationship between supplier involvement and information sharing.

Research method

Questionnaire design

A survey instrument was designed to measure the relationship between SC and STM. Based on the scale developing procedure proposed by Churchill (1979), an extensive literature review was conducted to gain a comprehensive understanding of existing measures for the constructs. The items that were validated in previous studies were adopted in this study. When there was no available item for a subject, new items were developed based on the conducted interviews and discussions with practitioners. The questionnaire also includes the demographic profile of the companies, including information about the industry, ownership, size, and location.

Strategic purchasing and supplier involvement were measured with the items used by Chen and Paulraj (2004). The items of information sharing were adapted from Li and Lin (2006); a subset of their information quality items was employed, and those related to the effectiveness of information sharing between suppliers and manufacturers were also selected. STM was measured with three items based on the existing scales (Beamon 1999; Vickery et al. 2003). For each item, the informants were instructed to select a description representing a certain level ranging from 1 to 7, where "1" represented strongly disagree and "7" represented strongly agree. 'Appendix 2 ' demonstrates and summarizes the survey items.

The items were drawn from the English literature, translated into Chinese by three PhD candidates, and then back-translated into English by three other PhD candidates with extensive research experience. Necessary improvements were applied to the initial Chinese version to avoid cultural bias. Afterwards, a pilot test was conducted among 10 randomly selected companies. Subsequently, the questionnaire was modified based on the results of the pilot test, thus resulting in the final Chinese questionnaire.

Sampling and data collection

The survey was conducted from 2008 to 2009 in China. Only the typical representative regions were selected as target samples considering the country's large geographical size and the imbalanced economic development between its coastal and interior provinces. The majority of the data were collected in four typical provinces, namely, Guangdong, Shandong, Shaanxi, and Henan. Guangdong is located in the southern coastal areas of China and enjoys a higher degree of economic reform and well-developed business structure (Zhao et al. 2011). Shandong is a major industrial province in northern China and lies in the Bo Sea Economic Area, which reflects the average level of economic development in the country (Feng et al. 2010). Shaanxi and Henan are located in the western and central parts of China, respectively, representing regions with a relatively low level of economic development and early stage of industrialization. These four provinces reflect the profiles of regions undergoing various stages of economic and manufacturing developments in China.

In the provinces mentioned above, 500 firms were randomly selected from a list provided by the local governments and universities. These firms belong to a range of manufacturing industries, including food and beverage, textile, chemical and related products, pharmaceutical and medical, rubber and plastics, and electrical machinery and equipment. By the end of 2009, a total of 202 survey questionnaires were collected, among which 26 were excluded from the analysis because of

missing significant data or incompleteness. Consequently, a usable response rate of 35.2 % was achieved.

As opposed to multiple informants, one key informant from each firm who is knowledgeable in product development and familiar with supplier relationship management seems more reasonable (Zhao et al. 2011). These key informants were among product managers, supply chain managers, vice presidents, or other senior executives. The selected companies were contacted via phone call to identify the most suitable informants. The representatives where then introduced to the purpose of this study. Afterwards, questionnaires were sent to the informants along with a cover letter, which underlined the importance of the study and guaranteed that they would receive a copy of the report on the survey results. Phone calls were once again made to remind the informants of their responsibility and to clarify issues if they had any.

Respondent profile

Table 1 shows the industry profile of the surveyed companies. In particular, about 27 % of these companies come from communication and computer-related equipment industry, and nearly 18 % produce machinery products. Guangdong and Shandong have the most number of firms included in this investigation at 68 and 52 firms, respectively, and the remaining 56 companies come from the other provinces.

The company sizes vary widely. Over 7 % of the firms have <50 employees, whereas 17 % have over 5,000 employees. The median annual sales of the firms are about 100 million RMB. Regarding ownership, 41 firms are State-owned, 63 are privately-owned, 47 are foreign-owned, and the other 25 responding firms are either collectively-owned or foreign-invested. Table 2 illustrates the detailed information on the sample demographics.

Table 1 Industry profile ($N = 176$)

Industry type	Frequency	Percentage
Food and beverage	4	2.27
Textile	2	1.14
Chemical and related products	4	2.27
Pharmaceutical and medical	2	1.14
Rubber and plastics	13	7.39
Non-metallic mineral products	2	1.14
Smelting and pressing	3	1.70
Metal products	4	2.27
Machinery	32	18.18
Transport equipment	13	7.39
Electrical machinery and equipment	20	11.36
Communication and computers related equipment	48	27.27
Instruments and related products	4	2.27
Others	25	14.20

Table 2 Number of employee, annual sales and type of firm ownership($N = 176$)

Characteristics of firms	Frequency	Percentage
Number of employees		
<50	13	7.39
50–99	9	5.11
100–299	35	19.89
300–999	29	16.48
1,000–1,999	29	16.48
2,000–4,999	31	17.61
5,000 or more	30	17.05
Annual sales (million RMB)		
<5	5	2.84
5–9	8	4.55
10–19	9	5.11
20–49	14	7.95
50–99	17	9.66
100 or more	118	67.05
Unmarked	5	2.84
Type of ownership		
State-owned	41	23.30
Collective-owned	7	3.98
Privately-owned	63	35.80
Foreign invested	18	10.23
Foreign-owned	47	26.70

Non-response bias and common method bias

Non-response bias was examined by conducting t test analysis. At a 5 % significance level, the results did not indicate the statistical differences between the early and late respondents on the number of employees ($t = 0.389$, $p = 0.698$), annual sales ($t = 1.186$, $p = 0.237$), or total assets ($t = 0.230$, $p = 0.818$). Accordingly, the non-response bias was not considered a major concern regarding the data collected.

Because we were limited to collect responses from a single informant, the potential common method bias had to be verified. Hereof, Harman's single-factor test of common method bias was performed on the variables of SC by executing confirmatory factor analysis (CFA). The complete depiction of this test is that, if common method bias is the inherent factor causing distinct scales, the fit indices of the single-factor model are expected to be as good as those of the measurement model (Korsgaard and Roberson 1995). The fit indices of the model are unacceptable [χ^2 (77) = 700.35, normed fit

Table 3 Reliability analysis

Construct	Number of items	Cronbach's alpha	CITC range of the underlying items
Strategic purchasing (SP)	3	0.857	0.657–0.811
Supplier involvement (SI)	4	0.891	0.705–0.812
Information sharing (IS)	3	0.869	0.711–0.791
STM	4	0.881	0.650–0.792

index (NFI) = 0.77, non-normed fit index (NNFI) = 0.76, root mean square error of approximation (RMSEA) = 0.24, and standardized root mean square residual (RMR) = 0.14], and significantly worse than those of the measurement model [χ^2 (71) = 120.13, NFI = 0.96, NNFI = 0.98, RMSEA = 0.055, and standardized RMR = 0.058]. These findings suggest that the common method bias is small and may not appear as a significant problem.

Reliability

Reliability was estimated via Cronbach's alpha value. As is shown in Table 3, the values of all constructs are larger than 0.60, which is the widely accepted lower limit for Cronbach's alpha value (Flynn et al. 1990). In addition, the corrected item-total correlation (CITC) values are all greater than the minimum acceptable value of 0.30 (Zhao et al. 2011). Therefore, the scales are reliable.

CFA was used to further test the unidimensionality and reliability of the constructs. The result of the test reveals that the model fit indices are acceptable [RMSEA = 0.055, 90 % confidence interval for RMSEA = (0.033, 0.075), NNFI = 0.98, incremental fit index (IFI) = 0.98, CFI = 0.98, standardized RMR = 0.058]. Other fit indices (Bentler and Bonett 1980), such as χ^2 = 120.13 with degree of freedom (*df*) = 71, NFI = 0.96, relative fit index (RFI) = 0.95, parsimony normed fit index (PNFI) = 0.75, goodness of fit index (GFI) = 0.92, adjusted goodness of fit index (AGFI) = 0.88 and parsimony goodness of fit index (PGFI) = 0.62, are also acceptable. These results indicate that the model is acceptable, further confirming the unidimensionality and reliability of the constructs.

Validity

Convergent validity reflects whether multiple measurements of a variable provide identical results, which can be ascertained with CFA (O'Leary-Kelly and Vokurka 1998). As mentioned above, the CFA model is acceptable. Moreover, 'Appendix 2 ' shows that all factor loadings are larger than 0.50 with significant t values ($t > 2.0$). Therefore, convergent validity is achieved.

Discriminant validity was determined using the pairwise comparison of χ^2 values between the constrained and unconstrained CFA models (Anderson and Gerbring 1988). Each correlation of a pair of constructs was set as 1 in the constrained model, which was then compared with the original unconstrained model with freely estimated correlations. A significant difference of the χ^2 statistics between the two models indicates high discriminant validity (Fornell and Larcker 1981). In this study, all the χ^2 differences between the fixed and unconstrained models are significant at the 0.05 significance level (Table 4). Discriminant validity was further confirmed by determining the average extracted variance (AVE), following the procedure recommended by Fornell and Larcker (1981). An AVE value higher than 0.50 guarantees that over 50 % of the factor variance is due to its indicators. 'Appendix 2' shows that all AVE values are greater than the minimum required value. Hence, the discriminant validity is established.

Results and analysis

In this study, the measurement error problems of regression approaches were avoided by adopting the structural equation modeling (SEM) to test the hypothesized relationships (Hopwood 2007). The direct and indirect effects of SC practices on STM were evaluated, and then the moderating effects of firm size were examined by performing multi-group analysis.

Table 4 Pairwise comparison of χ^2 values

Construct	STM			SP			SI		
	Free	Cons.	Diff.	Free	Cons.	Diff.	Free	Cons.	Diff.
SP	14.28	63.03	48.75						
SI	32.35	67.75	35.70	28.67	54.65	25.98			
IS	22.74	60.41	37.67	14.99	43.10	28.11	24.44	34.26	9.82

All Chi square differences are significant at the 0.01 level

Table 5 SEM estimates of direct and indirect effects

	Standardized coefficient	t value
Information sharing → STM	0.57	6.44***
Strategic purchasing → information sharing	0.39	5.90***
Supplier involvement → information sharing	0.52	6.19***

*** Significance at the 0.01 level

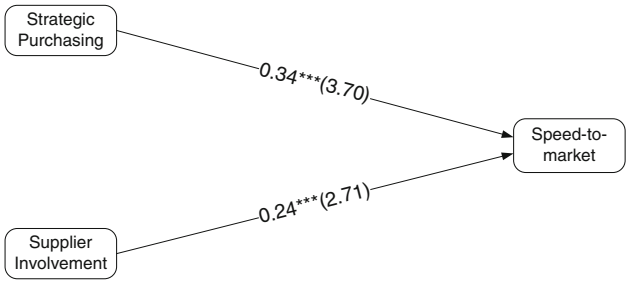

Fig. 2 Structural equation model for the direct relationships among strategic purchasing, supplier involvement and STM (*** $p < 0.01$)

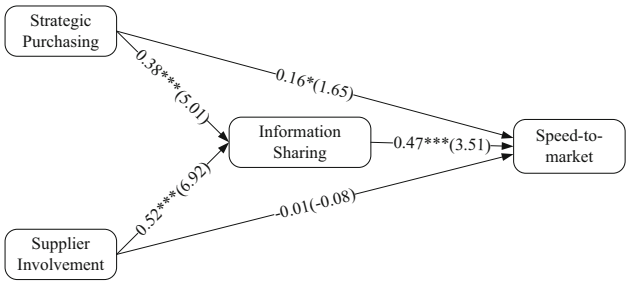

Fig. 3 Structural equation model with information sharing variable as mediator (* $p < 0.1$; *** $p < 0.01$)

SEM of direct and indirect effects

The SEM estimates of the direct and indirect effects were generated with LISREL 8.70. The results are shown in Table 5. The goodness of fit indices are $\chi^2 = 122.87$ with $df = 73$, RMSEA = 0.054, 90 % confidence interval for RMSEA = (0.032, 0.074), NNFI = 0.98, IFI = 0.98, CFI = 0.98, and standardized RMR = 0.060. All the above indices are better than the generally agreed values (Hu and Bentler 1999; Shah and Goldstein 2006). Given the satisfactory fit indices, the proposed research model is acceptable and deserves future discussion.

H1 posits that information sharing directly contributes to STM. Table 5 specifies that H1 is evidently supported. Information sharing is significantly and positively related to STM. For H2 and H3, further SEM estimation was required. Evaluating the mediation required an examination of the three sets of relationships (Baron and Kenny 1986), including the relationships between the (1) independent (strategic purchasing and supplier involvement) and dependent variables (STM) (Fig. 2); (2) independent variables and mediator, referring to the influences of strategic purchasing and supplier involvement on information sharing (Table 5; Fig. 3); and (3) independent and dependent variables with mediator as an independent variable (Fig. 3).

In Fig. 2, the direct effect relationships among strategic purchasing, supplier involvement and STM are all significant. Similarly, Table 5 and Fig. 3 both show that the relationships among strategic purchasing, supplier involvement and information sharing (the mediator) are significant. Figure 3 also demonstrates that information sharing is strongly related to the dependent variable STM of new products. Meanwhile, with the existence of information sharing, the original direct relationship between strategic purchasing and STM is still significant, but with a lower path coefficient. Therefore, H2 is supported, thus affirming that the relationship between strategic purchasing and STM is partially mediated by information sharing between suppliers and manufacturers. For H3, the original direct relationship between supplier involvement and STM is statistically insignificant with the existence of information sharing. In particular, information sharing completely mediates the relationship between supplier involvement and STM. Thus, H3 is strongly supported.

Multi-group analysis of the moderating effects of firm size

The multi-group analysis was conducted in LISREL to examine whether the above relationships are maintained across small, medium, and large firms. Firms with employees of <300, between 300 and 2,000, and >2,000 were classified as small (n = 57), medium (n = 58) and large (n = 61) firms, respectively. First, for the baseline model (Model 1 in Table 6), $\chi^2 = 357.94$ with $df = 237$, RMSEA = 0.079, CFI = 0.98, and NNFI = 0.95 are all accepted. In Model 2, each factor loading was forced to be equal across the three groups. The χ^2 difference between Model 2 and the baseline model is 13.61 with a df difference of 20. The significance level of $p = 0.850$ shows that the factor loadings are invariant across the three groups. Similarly, the insignificant result ($p = 0.519$) of the difference between Models 2 and 3 demonstrates that the factor loadings and measurement errors are invariant across the three groups.

The results of the invariance tests reveal that the differences between Models 4a and 3 are significant ($\chi^2 = 6.94$ with $df = 2$; $p = 0.031$), and H4 is supported. Thus, firm size moderates the relationship between information sharing and STM. With regards, the differences between Models 4b and 3 are significant, indicating that the levels of relationship between strategic purchasing and information sharing are different across the three groups ($\chi^2 = 4.76$ with $df = 2$;

Table 6 Results of the SEM analysis for moderating effect of firm size

Models	χ^2	*df*	χ^2 /*df*	CFI	NNFI	RMSEA	Nested models	$\Delta\chi^2$	Δdf	Significance level
1. Equal pattern	364.65	243	1.501	0.96	0.95	0.076				
2. Equal factor loadings	378.13	263	1.438	0.96	0.96	0.07	2-1	13.48	20	0.856
3. Equal factor loadings, measurement errors	391.31	277	1.413	0.96	0.96	0.067	3-2	13.18	14	0.512
4a. IS → STM	398.25	279	1.427	0.96	0.96	0.07	4c-3	6.94	2	0.031**
4b. SP → IS	396.07	279	1.420	0.96	0.96	0.069	4a-3	4.76	2	0.093*
4c. SI → IS	395.22	279	1.417	0.96	0.96	0.068	4b-3	3.91	2	0.142

* Significance at the 0.1 level.
** Significance at the 0.05 level

Table 7 Path coefficients and *t* values by firm size

Firm size	H4 (IS→STM)		H5 (SP→IS)		H6 (SI→IS)	
	Path coefficient	*t* value	Path coefficient	*t* value	Path coefficient	*t* value
Small ($N = 57$)	0.33	2.52	0.24	2.08	0.64	4.91
Medium ($N = 58$)	0.64	4.42	0.56	4.21	0.43	3.53
Large ($N = 61$)	0.81	5.13	0.45	3.82	0.45	3.92

All path coefficients are significant at the 0.01 level

$p = 0.093$, which is statistically significant). For H6, the level of relationship between supplier involvement and information sharing holds across small, medium, and large firms ($\chi^2 = 3.91$ with $df = 2$; $p = 0.142$, which is statistically insignificant). H6 is not supported.

The moderating effect of firm size was further analyzed by examining the standardized structural path coefficients across the three groups, as depicted in Table 7. In terms of the relationship between information sharing and STM (H4), all the three path coefficients are significant and increase with the increase of firm size (path coefficients are 0.33, 0.64, and 0.81 for the small, medium and large firms, respectively). The moderating effect of firm size on the association of information sharing with STM is significant, suggesting that large firms enjoy more benefits than small and medium firms in improving STM by enhancing information sharing.

For the relationship between strategic purchasing and information sharing (H5), the path coefficient for small firms (path coefficient = 0.24, $t = 2.08$) is lower than those for medium (path coefficient = 0.56, $t = 4.21$) and large firms (path coefficient = 0.45, $t = 3.82$). The discrepancy is adequately large and significant, implying that medium and large firms enjoy more benefits than small firms in promoting information sharing by enhancing strategic purchasing.

For the relationship between supplier involvement and information sharing (H6), all standardized coefficients are significant for the three groups. Meanwhile, insignificant moderating effects of firm size for H6 is observed, indicating that the three kinds of firms enjoy the same benefit in promoting information sharing by encouraging supplier involvement.

Discussion and contributions

Discussion

This study examined the effect of SC on STM by clarifying the mediating effect of information sharing and the moderating effect firm size. Several interesting findings are obtained. First, the result that H1 is supported demonstrates the importance of information sharing for expediting NPD. Moreover, the findings that H1, H2 and H3 are supported indicate that information sharing represents a strong link between the other two SC practices and STM. Information sharing emphasizes the investments from both manufacturer and supplier aiming at establishing communication channel, unifying systems, and matching processes. With these interactive activities, information sharing combines the resources of the manufacturer and supplier in a manner that can lead to superior performance over the competitors.

Second, the findings that H2 and H3 are supported provide compelling evidence regarding the role of strategic purchasing and supplier involvement for fostering information sharing and accelerating STM. By easing information flow and emphasizing relationship-specific assets, strategic purchasing and supplier involvement may lead to accelerated NPD activities. In addition, strategic purchasing may both directly

influence STM and indirectly through information sharing, whereas supplier involvement may only influence STM via information sharing.

Third, the examination shows that firm size significantly moderates the relationship between information sharing and STM, thus supporting H4. The links between information sharing and STM vary across small, medium, and large firms. In particular, the coefficient values increase with firm size and are significant for all the three groups of firms. Large firms are better able to develop the required flexibility and autonomy to innovate because they have greater variety of specialists and more differentiated units (Damanpour 1992). Consequently, large firms can enhance their information processing capabilities based on their diversified businesses and large operational scope (Cao and Zhang 2011).

As for the effect of strategic purchasing on information sharing, the results show that strategic purchasing of large-sized firms significantly influences the promotion of information sharing. Strategic purchasing implies that firms regard the purchasing functions as strategically important, and that these firms are willing to maximize the necessary resources and skills to implement joint activities. Hence, information sharing is more likely to be effective in large firms because these firms have more financial and technical resources to manage facilities and hire skilled workers. Meanwhile, given that H6 is not supported, this study posits that supplier involvement positively affects information sharing across small, medium, and large firms. All the firms basically promote information sharing by adopting supplier involvement.

Theoretical contributions

In this study, three theoretical contributions emerge. First, information processing theory and contingency theory of supply chain strategy are enhanced by extensively analyzing the effect of SC in manufacturer-supplier NPD. Based on the information processing theory, a set of interconnecting SC practices (including strategic purchasing, supplier involvement, and information sharing), are organized to investigate their effect on the manufacturers' STM, in response to the need to consider SC from a multi-dimensional perspective (Koufteros et al. 2012; Zhao et al. 2014). Based on the contingency theory, firm size is proposed as a contextual factor. By conducting an empirical study in China, this study provides a nuanced understanding of the direct and indirect effects of SC practices on STM in relation to the moderating effect of firm size. In particular, the results underline the explanatory and predictive power of both theories in interpreting the collaboration between the supplier and the manufacturer.

Second, this study empirically provides preliminary evidence on the importance of highlighting the positive effects of SC on STM and clarifies the intermediate processes. Moreover, concerning the debate on the effects of STM (positive, non-significant, or negative), the results confirm the positive effects of SC. The findings on the direct and indirect relationships between SC practices and STM may be of particular interest for other researchers. This study documents not only the direct influence of information sharing and strategic purchasing on STM, but also the function of information sharing as a vital link among strategic purchasing, supplier involvement, and STM. The NPD performances of manufacturers are regularly associated with information and knowledge handled by suppliers.

Third, how firm size works to predict SC strategies is investigated. The positive moderating effect of firm size on the relationship between information sharing and STM is significant. That is, SC is of greater importance for large firms than small or medium firms. Strategic purchasing improves information sharing for all the three kinds of firms, and has stronger impact for large firms. Meanwhile, the positive effect of supplier involvement on information sharing is strong and consistent across different firm sizes. These findings signify that large firms are more likely to collaborate with supply chain partners and enjoy the advantages of accelerated NPD activities.

Managerial implications

Three small managerial implications for managers of manufacturing firms can be drawn. First, the SC model is a powerful tool that helps managers develop SC patterns and establish collaborative relationships with their partners to achieve better performance. The intermediate effects indicate that SC practices are interrelated with one another and influence STM directly or indirectly. That is, the significance of an individual SC practice may tie to other practices. The result informs managers to devote attention to a set of SC practices instead of individual techniques or tools.

Second, the finding regarding the moderating role of firm size suggests that managers should conduct their actions in accordance with the specific context. Compared with small firms with limited businesses and small operational scope, it is easier for large firms to internalize and transfer information from suppliers. On the other hand, small firms need to expand the scope of their operations to enhance inter-firm knowledge and information sharing from SC.

Third, this study contributes to the understanding of whether and under what conditions SC can improve STM in the context of China, especially for managers of firms interested in penetrating the Chinese manufacturing sector. *Guanxi* is viewed as more reliable than a written contract in China due to the unreliable legal system (Leung et al. 2005). Manufacturers may encounter preferential terms on contracts due to *guanxi* (Tsang 1998). This study also provides insights into conducting SC in the business environment of China.

Limitations and future research directions

This study has some limitations that provide opportunities for future research. First, the dataset relies on a single respondent, and hence the data collection and analysis may be embedded with common method bias. Although the result of Harman's single-factor test is sufficiently good, the potential bias threatening validity cannot be completely ruled out. Second, the single-country limitation specifies the need to check the generality of the model using data from multiple countries. Third, only the NPD performance in terms of STM is focused on, and thus other benefits of SC may have been ignored.

Future research may resolve the above mentioned discrepancies by constructing and testing models that address how SC affects other NPD performances. This study provides an attempt to identify a multi-dimensional framework to explore the role of suppliers in NPD. Three practices are considered highly important in NPD, but not exclusive. Broader SC issues, including supplier selection, supplier development and other potential aspects, may exist within the operations of a firm. SC represents a critical resource that can generate competitive advantages for supply chain partners.

Conclusions

Along with other substantial evidence on the implications of suppliers, the proposed SC model offers a groundwork, through which the role of suppliers in accelerating STM can be understood. Not only three interconnecting SC practices are identified, but also the direct and indirect effects of these SC practices along with the contextual condition of firms of different sizes are determined. In conclusion, the validity of the information processing theory and contingency theory are highlighted to explain a diverse range of debates and topics in SC strategy.

Appendix 1

See Table 8.

Table 8 Survey questions

Survey question
Please indicate the degree to which the following are a current concern to your company, as compared to industry average: [1 = strongly disagree, 4 = about the same, 7 = strongly agree]
Strategic purchasing
SP1 Purchasing is included in the firm's strategic planning process
SP2 The purchasing function has a good knowledge of the firm's strategic goals[a]
SP3 Purchasing performance is measured in terms of its contributions to the firm's success
SP4 Purchasing professionals' development focuses on elements of the competitive strategy
Supplier involvement
SI1 We involve key suppliers in the product design and development stage
SI2 Our key suppliers have major influence on the design of new products
SI3 There is a strong consensus in our firm that supplier involvement is needed in product design/development
SI4 We have continuous improvement programs that include our key suppliers
Information sharing with suppliers
IS1 Information exchange between our trading partners and us is timely
IS2 Information exchange between our trading partners and us is accurate
IS3 Information exchange between our trading partners and us is complete
Speed-to-market of new products
STM1 Our company can quickly modify products to meet our major customer's requirements
STM2 Our company can quickly introduce new products into the market
STM3 Our company has an outstanding on-time delivery record to our major customer
STM4 The lead time for fulfilling customers' orders (the time which elapses between the receipt of customer's order and the delivery of the goods) is short

[a] Items dropped after CFA

Appendix 2

See Table 9.

Table 9 Construct measurement

Factors and scale items	Mean	SD	Factor loading	*t* value
Strategic purchasing (AVE = 0.687)				
Item1	5.325	1.134	0.78	–
Item2	4.917	0.991	0.81	10.10
Item3	4.878	1.153	0.96	10.74
Supplier involvement (AVE = 0.675)				
Item1	4.762	1.236	0.86	–
Item2	4.610	1.258	0.74	11.34
Item3	4.795	1.269	0.86	14.21
Item4	4.895	1.195	0.82	13.11
Information sharing with suppliers (AVE = 0.699)				
Item1	5.087	0.973	0.86	–
Item2	4.830	1.009	0.88	14.31
Item3	4.363	1.125	0.76	11.70
STM of new products (AVE = 0.655)				
Item1	5.183	1.020	0.70	–
Item2	4.688	1.272	0.81	9.87
Item3	4.766	1.273	0.87	10.50
Item4	4.931	1.254	0.85	10.30

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