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How does intellectual capital affect product innovation performance? Evidence from China and India

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Abstract

Purpose – Intellectual capital reflects the sum of existing knowledge a manufacturer is able to leverage and plays a critical role in new product development. The purpose of this paper is to empirically investigate the mechanisms through which intellectual capital enhances product innovation performance and how economic and institutional environments affect the mechanisms.

Design/methodology/approach – Using a knowledge-based view and institutional theory, this study proposes a model on the relationships among intellectual capital, supplier knowledge integration, supply chain adaptability, and product innovation performance. The hypotheses are empirically tested using multiple group structural equation modelling and data collected from 300 Chinese and 200 Indian manufacturers.

Findings – The authors find that intellectual capital improves product innovation performance both directly and indirectly through supplier knowledge integration. However, the effects are different in China and India. In particular, the direct effect of intellectual capital on product innovation performance is significantly higher in China than that in India, and intellectual capital improves product innovation performance indirectly through supplier knowledge integration only in India. The authors also find that supplier knowledge integration improves product innovation performance indirectly through supply chain adaptability in both China and India.

Originality/value – Using a moderated mediation model, this study provides insights into the joint effects of intellectual capital, supplier knowledge integration, and supply chain adaptability on product innovation performance. The findings enhance current understandings of how supply chain management helps a manufacturer develop new products using existing knowledge and the influences of economic and institutional environments on knowledge and supply chain management.

Keywords China, India, Intellectual capital, Supply chain adaptability, Product innovation performance, Supplier knowledge integration

Paper type Research paper



1. Introduction

Intellectual capital refers to the knowledge stock embedded in a firm (Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005). Empirical evidence exists that intellectual capital positively affects innovation (Lee *et al.*, 2011; Menor *et al.*, 2007; Subramaniam and Youndt, 2005) and firm performance (Hsu and Wang, 2012; Youndt *et al.*, 2004). Knowledge sourced from suppliers can stimulate creativity and effectively address the interdependence among product, process, and supply chain designs (Cousins *et al.*, 2011; Petersen *et al.*, 2003). Intellectual capital and supplier knowledge integration thus enable a manufacturer to implement and exploit the existing knowledge resided internally and externally in supply networks for product innovation (Youndt *et al.*, 2004; Hult *et al.*, 2006). Although researchers argue that existing knowledge enables a manufacturer to acquire and integrate external knowledge (Cohen and Levinthal, 1990; Szulanski, 1996), the majority of empirical studies take an internal perspective and focus on intellectual capital's direct effects on performance outcomes (e.g. Lee *et al.*, 2011; Subramaniam and Youndt, 2005). By exploring the effect of intellectual capital on supplier knowledge integration and how they jointly influence product innovation performance, this study enhances current understandings on how existing knowledge contributes to new product development.

Although researchers argue that knowledge acquired from suppliers enhances new product development (Cousins *et al.*, 2011; Petersen *et al.*, 2003; Un *et al.*, 2010), some empirical studies fail to support a direct and positive relationship between learning from suppliers and product innovation performance (Tavani *et al.*, 2013; Jean *et al.*, 2014). Integrating the knowledge sourced from suppliers, such as technical know-how, changes in factor markets, and suggestions for process improvement, can assist manufacturers in adapting supply chain designs and reconfiguring supply chain resources to deal with unexpected and unpredicted changes and events (Braunscheidel and Suresh, 2009; Lee, 2004). Supply chain adaptability helps manufacturers identify shifts in environments which facilitates the manufacturers to develop new or adjust existing products in a timely and cost-effective manner (Swafford *et al.*, 2006; Blome *et al.*, 2013). Therefore, exploring how supplier knowledge integration and supply chain adaptability jointly influence product innovation performance can provide insights into the mixed findings about the roles of suppliers in new product development (Wang *et al.*, 2011; Gao *et al.*, 2015; Jean *et al.*, 2014) and the mechanisms through which supply chain learning contributes to product innovation performance.

China and India have experienced high-speed economic growth, demonstrated rising levels of innovation performance, and have diversified domestic markets with large low income population (Altenburg *et al.*, 2008; Bruche, 2009; Fan, 2011). Manufacturers in China and India tend to develop new products that are affordable to local customers (Breznitz and Murphree, 2011; Ernst *et al.*, 2015). To benefit from latecomer's advantage, they innovate by adapting and exploiting existing technologies and products creatively (Parayil and D'Costa, 2009; Ernst *et al.*, 2015; Radjou *et al.*, 2012). Intellectual capital and supplier knowledge integration enable a manufacturer to apply existing knowledge innovatively which reduces new product development costs and lead-times (Pralhad and Mashelkar, 2010; Radjou *et al.*, 2012). In addition, product innovations may be copied by competitors because of the lack of sufficient market-supporting institutions and may become out of date quickly because of high market uncertainties in China and India (Parayil and D'Costa, 2009; Fan, 2011). The speed for commercialisation, which is dependent on a manufacturer's capability to adapt and adjust supply chains quickly, is critical for a manufacturer to profit from product innovation (Blome *et al.*, 2013). Hence, China and India provide interesting contexts to investigate the combined effects of intellectual capital, supplier knowledge integration, and supply chain adaptability on product innovation performance. Moreover, the economic development paths and institutional environments are different in China and India (Parayil and D'Costa, 2009;

Saran and Guo, 2005), which may affect a manufacturer's supply chain management and new product development decisions (Marquis and Tilcsik, 2013; Simsek *et al.*, 2015). Conducting the survey in the two countries and comparing the results can not only improve the generalisability of the findings but also provide insights into the impacts of economic and institutional environments on how intellectual capital affects product innovation performance. By combining a knowledge-based view (KBV) of the firm and institutional theory, this study links a manufacturer's existing knowledge with supply chain management and external environments. The findings enhance current understandings on the complex relationships among intellectual capital, supply chain learning and adaptability, product innovation, and environmental conditions, and how to develop new products by exploiting existing knowledge and collaborating with suppliers.

The objective of this study is to empirically investigate how intellectual capital influences product innovation performance. This study addresses two research questions:

RQ1. How do intellectual capital, supplier knowledge integration, and supply chain adaptability jointly influence product innovation performance?

RQ2. How do economic and institutional environments affect such influences?

2. Theoretical background and research hypotheses

2.1 KBV

KBV considers knowledge as an important strategic resource of a manufacturer (Kogut and Zander, 1992; Grant, 1996; Szulanski, 2000). Scholars further argue that a manufacturer's knowledge comes not only from within its boundary but also from a wider network of supply chain relationships (Hult *et al.*, 2006; Zhang *et al.*, 2015). This study focusses on intellectual capital and supplier knowledge integration because they represent the internal and external sources of knowledge a manufacturer can leverage.

Intellectual capital reflects the intangible assets held by individuals, stored within organisational processes and structures, and resided in social relationships (Youndt *et al.*, 2004). Intellectual capital can be conceptualised as three complementary dimensions: human (i.e. employees' knowledge and skills), structural (i.e. operating procedures and systems), and social capital (i.e. social relationships and interactions among employees) (Lee *et al.*, 2011; Youndt *et al.*, 2004). Empirical evidence exists that the three components are complementary and their interactions are positively associated with performance outcomes (Subramaniam and Youndt, 2005; Youndt *et al.*, 2004). Hence, we conceptualise intellectual capital as a second-order construct to capture the combined effects of human, structural, and social capital (Hsu and Sabherwal, 2012; Menor *et al.*, 2007). Supplier knowledge integration refers to a manufacturer's ability to acquire knowledge from suppliers and apply the knowledge into operations (Hult *et al.*, 2004; Song *et al.*, 2005). The information and know-how obtained from suppliers can enlarge a manufacturer's knowledge base and enable the manufacturer to develop new applications for existing knowledge and to create new product designs (Zhang *et al.*, 2015).

KBV argues that manufacturers can develop capabilities and gain superior performance by acquiring and implementing knowledge (Grant, 1996; Hult *et al.*, 2004). This study focusses on supply chain adaptability and product innovation performance. Supply chain adaptability refers to a manufacturer's ability to quickly and efficiently adapt product and supply chain designs in response to market changes (Engelhardt-Nowitzki, 2012; Swafford *et al.*, 2006). An adaptable supply chain enables manufacturers to gain competitive advantages by quickly adapting existing products and technologies (e.g. implementing engineering changes), identifying new resources (e.g. acquiring raw materials for new products), and solving problems (e.g. in commercialisation and launch) (Blome *et al.*, 2013; Lee, 2004). Product innovation performance refers to how well a manufacturer develops new products (Chandy and Tellis, 1998). Customer preferences change very quickly in China and

India due to globalisation and fast economic growth (Fan, 2011). Manufacturers need to develop more new products with fewer resources for more people, and make adaptations, refinements, and improvements to existing products quickly (Pralhad and Mashelkar, 2010; Breznitz and Murphree, 2011; Radjou *et al.*, 2012). Hence, the number of new products developed and the speed and frequency of new product introduction are critical for the success of product innovation (Parayil and D'Costa, 2009).

KBV also indicates that a manufacturer's capability to integrate and utilise external knowledge is largely influenced by its prior knowledge base (Cohen and Levinthal, 1990; Szulanski, 1996). Hence, we argue that intellectual capital helps a manufacturer integrate knowledge from suppliers which then improves product innovation performance (Cousins *et al.*, 2011; Szulanski, 2000). In this way, this study proposes that intellectual capital can improve product innovation performance both directly and indirectly through supplier knowledge integration. In addition, a manufacturer can acquire different kinds of knowledge from suppliers, such as inventory levels, production planning, new applications of raw materials or components, process improvement suggestions, and new product ideas (Kogut and Zander, 1992; Zhang *et al.*, 2015). Some of the knowledge can be applied in new product development and hence supplier knowledge integration can improve product innovation performance directly. Others allows the manufacturer to adapt supply chain processes according to new product designs (Braunscheidel and Suresh, 2009; Atuahene-Gima, 2005). Therefore, we argue that supplier knowledge integration also improves product innovation performance indirectly through supply chain adaptability.

2.2 Institutional theory

Institutional theory argues that manufacturers' practices and strategies are substantially influenced and shaped by the broader social institutional settings in which they operate (DiMaggio and Powell, 1983; Marquis and Tilcsik, 2013; Peng *et al.*, 2008). Institutions set legitimate requirements on manufacturers which lead to isomorphism among them (DiMaggio and Powell, 1983). Manufacturers' strategic choices are made within environmental conditions and constraints (Peng *et al.*, 2008). Hence, the institutional theory indicates that manufacturers' behaviour and decisions, including product innovation and supply chain management practices, are influenced by the prominent features of a country's economic and institutional environments (Marquis and Tilcsik, 2013; Simsek *et al.*, 2015). Scholars further argue that the evolution of a country's economic and institutional environments affects manufacturers' operations (Boeker, 1989). Manufacturers preserve previously adopted structures and capabilities which persist in the long run due to inertia or institutionalisation (Marquis and Tilcsik, 2013; Simsek *et al.*, 2015). They tend to follow the strategies or practices that are rewarded or encouraged by environmental conditions to ensure survival and growth (Boeker, 1989; Peng *et al.*, 2008). China and India have different political and legal institutions and patterns of economic development (Parayil and D'Costa, 2009; Saran and Guo, 2005). Therefore, we propose that the mechanisms through which intellectual capital influences product innovation performance are different in China and India. The conceptual model and all proposed hypotheses are provided in Figure 1.

2.3 Research hypotheses

Intellectual capital enables manufacturers to find new applications for existing technologies and to synthesise existing capabilities in a fresh way, both of which are critical for designing affordable products (Ernst *et al.*, 2015; Radjou *et al.*, 2012). In particular, employees' knowledge and skills allow manufacturers to quickly reverse engineer and adapt existing products and technologies based on local customers' preferences (Pralhad and Mashelkar, 2010). Operating procedures and systems can keep the knowledge created by employees and hence manufacturers can use the knowledge even when the employees leave the manufacturers

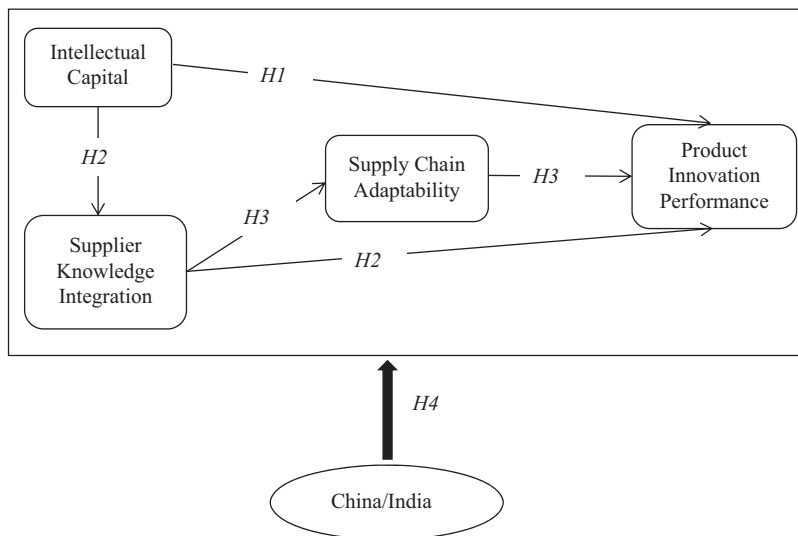
Intellectual
capital

Figure 1.
Conceptual framework

(Lee *et al.*, 2011). They can also standardise the development of new products, and reduce the variety in and improve the efficiency of product innovation (Ernst *et al.*, 2015). Technical manuals and databases help employees reuse existing modules and components in product innovation to satisfy price-sensitive customers (Radjou *et al.*, 2012). Social relationships facilitate collaboration and cooperation among employees (Nahapiet and Ghoshal, 1998). They are critical for the employees to access each other's private and personal knowledge (Szulanski, 1996). Interactions between employees also allow manufacturers to implement cross-functional teams on new product development, solve conflict among different departments, and make joint decisions on the price, quality, and functionality of new products which are important for adapting products quickly (Szulanski, 2000; Zhang *et al.*, 2014). Hence, manufacturers with higher levels of intellectual capital are more capable of responding to varying and unpredictable market environments by introducing new products quickly and frequently (Atuahene-Gima, 2005). Therefore, we propose the following hypothesis:

H1. Intellectual capital directly improves product innovation performance.

Intellectual capital retains a manufacturer's past experiences on supplier collaboration within employees' knowledge and organisational procedures (Lee *et al.*, 2011). Manufacturers thus can rely on intellectual capital to identify suppliers' valuable knowledge and integrate such knowledge (Szulanski, 1996; Menor *et al.*, 2007). Product innovation requires manufacturers to develop fresh insights into supply chain operations, technology trends, and local markets (Radjou *et al.*, 2012). Such knowledge can be sourced from suppliers (Gao *et al.*, 2015; Zhang *et al.*, 2015). For example, suppliers can provide knowledge on new applications of existing materials, information about the components and modules used in competitors' products, and new product ideas (Zhang *et al.*, 2014, 2015). The knowledge enables a manufacturer to imitate competitors' products and to adapt existing products by designing new components or reconfiguring modules innovatively, thereby increasing the speed and frequency of new product introduction (Chandy and Tellis, 1998; Jean *et al.*, 2014). In addition, supplier knowledge integration supplements internal research and development (R&D) efforts and enables a manufacturer to exploit suppliers' knowledge for new product development (Cousins *et al.*, 2011). The manufacturer can thus develop more products with fewer R&D investments (Radjou *et al.*, 2012).

Integrating knowledge acquired from suppliers also enhances a manufacturer's ability to generate new ideas on how to extend functionality or improve specifications when customising and localising products, and assists the manufacturer in developing products concurrently with suppliers (Un *et al.*, 2010; Wang *et al.*, 2011). Moreover, incorporating suppliers' new ideas and designs when adapting products helps a manufacturer enhance product quality and manufacturability and make better decisions on product features (Jean *et al.*, 2014; Tavani *et al.*, 2013), improving product innovation performance. Therefore, we propose the following hypothesis:

H2. Intellectual capital improves product innovation performance indirectly through supplier knowledge integration.

Knowledge acquired from suppliers, such as inventory levels and production planning, can improve a manufacturer's procurement and manufacturing processes (Tavani *et al.*, 2013), and help the manufacturer reduce delivery lead-times and improve supply chain responsiveness and flexibility (Un *et al.*, 2010). In addition, supplier knowledge integration allows manufacturers to capture the latest information and to develop a better understanding about their supply chains (Nahapiet and Ghoshal, 1998; Petersen *et al.*, 2003) which help the manufacturers rapidly adapt to changing environments (Lee, 2004). Hence, knowledge acquired from suppliers can be implemented to adjust and adapt supply chain processes with reduced reaction times, enhancing supply chain adaptability (Braunscheidel and Suresh, 2009; Tavani *et al.*, 2013).

An adaptive supply chain is able to leverage supply chain resources to adjust operations swiftly and nimbly and to profit from rapidly changing environments (Blome *et al.*, 2013). This capability enables manufacturers to innovate by localising and customising existing products and technologies (Ernst *et al.*, 2015). Supply chain adaptability also enables a manufacturer to adjust supply chain processes quickly according to new product designs which can speed up the commercialisation of product innovations (Braunscheidel and Suresh, 2009; Engelhardt-Nowitzki, 2012). An adaptable supply chain can deal with the negative effects of late engineering or specification changes by enabling a manufacturer to launch products into markets as basic platforms and then to improve designs based on user feedback (Swafford *et al.*, 2006). Hence, supply chain adaptability enables a manufacturer to introduce more new products quickly. Therefore, we propose the following hypothesis:

H3. Supplier knowledge integration improves product innovation performance indirectly through supply chain adaptability.

China and India liberalised their markets in 1978 and 1991, respectively. Since then, both countries have experienced rapid economic growth (Bruche, 2009). However, they have followed different growth paths (Fan, 2011; Parayil and D'Costa, 2009). Compared to India, China reformed its economic systems much earlier. China also developed at a faster pace and received larger inflows of foreign direct investment (Table I). In addition, exports of goods and services and high-technology exports play more important roles in Chinese economic development (Table I). The Chinese Government has practiced the "swap market

	1990		2000		2005	
	China	India	China	India	China	India
GDP (current US\$, billion)	359	327	1,205	477	2,269	834
GDP growth (annual %)	3.93	5.53	8.43	3.84	11.35	9.28
Foreign direct investment, net inflows (current US\$, billion)	3.49	0.23	38	3.58	111	7
Exports of goods and services (% of GDP)	15.90	6.93	20.68	12.77	33.70	19.28
High-technology exports (% of manufactured exports)	n/a	3.94	18.98	6.26	30.84	5.80

Table I.
Economic growth in
China and India

Source: World Development Indicators, the World Bank

for technology” strategy that encouraged Chinese manufacturers to form joint-ventures with western firms seeking access to China’s large and growing markets, enabling Chinese manufacturers to learn advanced technologies, production techniques, and management skills (Altenburg *et al.*, 2008; Breznitz and Murphree, 2011). As an important part of global production network and with the help of intensive capital investment, Chinese manufacturers can and must build extensive intellectual capital to catch up with domestic and foreign customers’ changing and novel demands. Moreover, the Chinese Government has provided supportive policies to motivate Chinese manufacturers to implement the “self-dependent innovation” strategy that emphasised endogenous innovation using internal resources and capabilities (Parayil and D’Costa, 2009). Manufacturers that answer such institutional arrangements are rewarded by the government. Thus, Chinese manufacturers are encouraged by the environment to rely on internal knowledge and resources, such as intellectual capital, to develop new products. In contrast, India has followed an import substitution policy and relied on domestic resource mobilisation with much lower foreign capital participation (Fan, 2011). Hence, Indian manufacturers may accumulate fewer technological capabilities and successful new product development experiences by exporting and supplying western customers and thus may depend less on intellectual capital for product innovation compared to Chinese manufacturers. We argue that the differences in economic growth paths and institutional environments in China and India moderate the direct effect of intellectual capital on product innovation performance.

Although both China and India are experiencing transition to market economies (Altenburg *et al.*, 2008; Fan, 2011), they have different legal and political environments (Rajagopalan and Zhang, 2008; Saran and Guo, 2005). India maintains a legal system inherited from the colonial era. Various legislations first introduced by the British are still in effect and laws also incorporate important US court decisions. For example, the Indian Contract Act was passed by British India and is based on the principles of British Common Law. India also adopts the Westminster style of democracy with a multi-party system. The legislature, the executive, and the judiciary are independent of each other. Laws in China are influenced by traditional Chinese approaches and philosophies (Saran and Guo, 2005). Moreover, the Communist Party of China is the sole governing party and has ultimate authority throughout the economic system. Officials can undermine the rule of law and the execution of law is largely subject to local authorities’ discretion (Zhou and Poppo, 2010). Inadequacy and enforcement inefficiency characterise China’s legal environment and manufacturers may suffer from unlawful or unfair competitive behaviour, such as contract violation, copyright piracy, and counterfeiting, when involving suppliers directly in product innovation (Wang *et al.*, 2011). Hence, legal institutions cannot provide sufficient protection for Chinese manufacturers’ business interests during collaborative innovation with suppliers. In comparison to China, India’s legal framework is relatively more developed and more effective. Indian manufacturers can follow formal legal processes and depend on contracts for settling disputes, resolving conflict, and gaining protection when developing new products collaboratively with suppliers. We argue that the differences in institutional environments in China and India moderate the roles played by suppliers in product innovation and hence the indirect effect of intellectual capital on product innovation performance. Therefore, we propose the following hypothesis:

H4. The mechanisms through which intellectual capital influences product innovation performance are different in China and India.

3. Methodology

3.1 Questionnaire design

Based on the relevant literature, a survey instrument was designed to measure a manufacturer’s intellectual capital, supplier knowledge integration, supply chain adaptability,

and product innovation performance. In addition, the questionnaire included the demographic profile of the manufacturer (e.g. industry, age, size, R&D investment, and training budget). A multiple-item, seven-point Likert-type scale (1 = “strongly disagree”; 7 = “strongly agree”) was employed for all constructs. The questionnaire was developed in English. We organised a panel of academics to review the English version of the questionnaire and to translate it into Chinese. The Chinese version was then translated back into English and checked against the original to verify the reliability of the survey instrument. The English and Chinese versions were used in India and China for data collection, respectively. The scales, which consist of 21 measurement items, are listed in Table AI.

Intellectual capital was measured by three first-order constructs adapted from Subramaniam and Youndt (2005). In particular, three items regarding employees’ skills and expertise were used to measure human capital; structural capital was operationalized as a firm’s manuals, procedures, rules, databases, and systems using three items; and social capital was measured by the interactions and relationships among employees using another three items (Subramaniam and Youndt, 2005). Supplier knowledge integration was operationalized as acquiring and applying knowledge from suppliers using four items that were adapted from Hult *et al.* (2004) and Song *et al.* (2005). Supply chain adaptability was gauged by four items examining the capabilities for problem solving and changing product and supply chain designs quickly. They were adapted from Swafford *et al.* (2006) and Blome *et al.* (2013). Product innovation performance was measured by four items gauging the number, speed, and frequency of new product introduction (Atuahene-Gima, 2005; Chandy and Tellis, 1998).

We included R&D investment as a control variable in the analysis as manufacturers who have invested more in R&D tend to have better product innovation performance (Un *et al.*, 2010). It was measured by the percentage of annual sales invested in R&D. We also controlled for firm size and age which were measured by the number of employees and years of operation, respectively. Larger manufacturers may have higher capabilities and more resources for product innovation, and elder manufacturers may have accumulated more expertise and experiences for new product development (Un *et al.*, 2010). Moreover, we controlled for training budget as task-related training can upgrade employees’ skills which may improve product innovation performance. This was measured by the percentage of annual sales spent on training.

3.2 Data collection

We interviewed 15 manufacturers in China to pilot test the questionnaire. We then decided to use one key informant per manufacturer who is knowledgeable about supply chain management and product innovation and is familiar with knowledge management practices. Such key informants can be general managers or directors, senior R&D managers, operations/manufacturing managers, and supply chain managers.

In China, manufacturers were selected from three special economic zones (i.e. Pearl River Delta, Yangtze River Delta, and Circum-Bohai Economic Zone). We randomly selected 2,379 manufacturers from the target industries (Table II) in the three regions using the directory provided by the National Bureau of Statistics of the People’s Republic of China. A professional market research firm was hired to conduct the data collection. The firm contacted the target manufacturers by telephone to identify and verify the informant who was able to answer the survey questions and to solicit his/her participation in the survey. Of the selected sample, 2,061 could not be contacted due to incorrect contact information or they did not wish to participate in the survey. The market research firm sent representatives to visit the respondents from the remaining 318 manufacturers on site. Finally, 300 completed questionnaires were returned for a response rate of 12.6 per cent (300/2,379).

	China	India	Intellectual capital
<i>Annual sales (USD)</i>			
Less than 50 million	62.3	78.0	
50-100 million	17.0	10.5	
100-250 million	12.0	4.5	
More than 250 million	8.7	7.0	
<i>Industry</i>			
Biology and pharmaceuticals	6.0	16.0	
Computer and telecommunication equipment	11.3	6.5	
Chemicals	17.0	9.5	
Medical equipment	9.3	3.5	
Electronics and electrical equipment	18.0	21.0	
Industrial machinery	16.3	27.5	
Transportation equipment	11.7	6.0	
New materials	10.3	4.0	
<i>Years of operation</i>			
Less than 10 years	26.7	25.0	
11-20 years	46.6	44.0	
21-30 years	11.0	19.5	
More than 30 years	16.7	11.5	
<i>Number of employees</i>			
Less than 200	22.3	64.8	
201-500	41.7	16.6	
501-1,000	17.3	9.1	
More than 1,000	18.7	9.5	
<i>R&D investment (% of annual sales)</i>			
Less than 0.5%	12.3	24.0	
0.51-1.0%	8.7	38.5	
1.1-2.0%	15.0	13.5	
2.1-4.0%	48.0	8.0	
More than 4.0%	16.0	16.0	
<i>Training budget (% of annual sales)</i>			
Less than 1.0%	68.3	27.0	
1.1-2.0%	18.0	40.5	
2.1-4.0%	13.7	19.5	
More than 4.0%	0.0	13.0	
Note: The numbers in the China and India columns are percentages of manufacturing firms			

Table II.
Firm profiles

In India, manufacturers were randomly selected from important industrial cities, including Delhi, Mumbai, Bangalore, Chennai, Kolkata, Chandigarh, and Ahmadabad and from the same industries as those in China. The manufacturers were selected from the IndiaMART business directory, the most comprehensive business directory of companies in India. A professional market research firm was also hired for data collection. Using a similar approach, the firm contacted target manufacturers by telephone to identify and verify the appropriate informants, resulting in a sample of 550 manufacturers who agreed to participate in this study. The firm sent representatives to collect data through face-to-face interviews with the appropriate respondents and finally collected 200 valid responses. The response rate is 36.4 per cent (200/550). The demographic statistics of the sample manufacturers are shown in Table II.

We conducted four statistical tests using SPSS 21.0 and AMOS 21.0 to assess common method bias. First, we performed Harman's single factor test using unrotated exploratory

factor analysis (Podsakoff *et al.*, 2003). The largest percentage of variances explained is 26.1 per cent in the Indian sample and 19.3 per cent in the Chinese sample, indicating that the magnitude of common method bias is not significant. Second, we constructed a confirmatory factor analysis (CFA) model in which the common method was treated as a single factor loading on all items (Podsakoff *et al.*, 2003). The fit indices are $\chi^2(189) = 1,514.58$, $\chi^2/\text{df} = 8.01$, comparative fit index (CFI) = 0.56, Tucker Lewis index (TLI) = 0.52, root mean square error of approximation (RMSEA) = 0.15 in the Chinese sample, and $\chi^2(189) = 702.71$, $\chi^2/\text{df} = 3.72$, CFI = 0.74, TLI = 0.71, RMSEA = 0.12 in the Indian sample, which are unacceptable (Hu and Bentler, 1999). Third, we constructed a conventional CFA model with each construct loading on its own items. Next, we added a common factor loading on all items to this CFA model. The purpose of this method is to estimate the amount of variance from each item that can be attributed to the common method (Podsakoff *et al.*, 2003). The results show that the average variance explained by the common method is only 3.3 per cent in the Chinese sample and 9.6 per cent in the Indian sample, indicating that the common method bias is minimal. Finally, we introduced a marker variable, environmental uncertainty (EU), to gauge and partial out the effect of common method (Lindell and Whitney, 2001). The smallest positive correlation between EU and other constructs is 0.02 (insignificant) and 0.12 (insignificant) in the Chinese and Indian samples, respectively. Using Lindell and Whitney's (2001) estimation method, we calculated the corrected correlations and *t*-values for all pairs of correlations between constructs in this study. The results indicate that all corrected correlations do not change much and remain significant in both Chinese and Indian samples. Therefore, we drew the conclusion that common method bias is not a serious problem in this study.

3.3 Psychometric test

We employed Cronbach's α and composite reliability for assessing construct reliability. The Cronbach's α values range from 0.72 to 0.87 and the composite reliabilities range from 0.84 to 0.91 (Table AI) which are all above the recommended threshold value of 0.70, suggesting that all constructs are reliable in both Chinese and Indian samples.

We used average variance extracted (AVE) and CFA to assess the convergent and discriminant validity. All of the AVE values range from 0.63 to 0.72, which are above the recommended value of 0.50 (Table AI), thereby demonstrating adequate convergent validity in both samples (Fornell and Larcker, 1981). We built a second-order CFA model to further assess the convergent validity. In the model, the items for intellectual capital were linked first to the three first-order constructs (i.e. social, structural, and human capital), which then loaded onto the second-order construct, and the items for supplier knowledge integration, supply chain adaptability, and product innovation performance were directly linked to corresponding constructs. The covariance among the constructs was freely estimated. The model fit indices are $\chi^2(180) = 318.49$, $\chi^2/\text{df} = 1.86$, CFI = 0.95, TLI = 0.95, RMSEA = 0.05 in the Chinese sample, and $\chi^2(180) = 310.99$, $\chi^2/\text{df} = 1.73$, CFI = 0.93, TLI = 0.92, RMSEA = 0.06 in the Indian sample, which are better than the threshold values recommended by Hu and Bentler (1999). In addition, all factor loadings are greater than 0.50 (Table AI), with all *t*-values greater than 2.0. The results indicate that convergent validity is ensured in both Chinese and Indian samples.

Discriminant validity was assessed by comparing the square roots of the AVE of each construct with the correlations between the focal and other constructs. A square root higher than the correlation with other constructs suggests discriminant validity (Fornell and Larcker, 1981). Table III shows the means and standard deviations of the constructs and their correlations. Comparisons of the correlations and square roots of the AVEs on the diagonal indicate adequate discriminant validity for all constructs in both Chinese and Indian samples. We also assessed discriminant validity by building a constrained CFA

	HC	StC	SoC	SKI	SCA	PIP	Intellectual capital
<i>China</i>							
Human capital (HC)	0.84						
Structural capital (StC)	0.44	0.84					
Social capital (SoC)	0.51	0.45	0.82				
Supplier knowledge integration (SKI)	0.33	0.31	0.38	0.84			
Supply chain adaptability (SCA)	0.51	0.49	0.44	0.47	0.82		
Product innovation performance (PIP)	0.48	0.25	0.27	0.19	0.41	0.85	
Mean	4.99	5.71	5.69	5.25	5.32	4.65	
Standard deviation	0.96	0.95	0.90	1.00	0.95	1.10	
<i>India</i>							
Human capital	0.85						
Structural capital	0.70	0.81					
Social capital	0.59	0.66	0.80				
Supplier knowledge integration	0.54	0.49	0.39	0.79			
Supply chain adaptability	0.50	0.46	0.46	0.39	0.82		
Product innovation performance	0.60	0.50	0.45	0.53	0.58	0.82	
Mean	5.76	5.56	5.70	5.58	5.39	5.45	
Standard deviation	0.83	0.87	0.76	0.86	0.83	0.80	
Notes: The square root of average variance extracted (AVE) is shown on the diagonal of each matrix in italic. Inter-construct correlation is shown off the diagonal of each matrix. All of the correlations are significant at the 0.01 level							

Table III.
Correlations, means,
and standard
deviations

model for every possible pair of latent constructs in which the correlations between the paired constructs were fixed to 1.0. This was compared with the original unconstrained model, in which the correlations among constructs were freely estimated. A significant difference in the χ^2 statistics between the constrained and unconstrained models indicates high discriminant validity (Fornell and Larcker, 1981). This method was used in both Chinese and Indian samples, and all differences are significant at the 0.001 level, indicating that discriminant validity is ensured.

3.4 Measurement equivalence

To ensure cross-country comparability, an empirical assessment of the measurement equivalence of the constructs between the two countries was conducted. Measurement equivalence evaluates the ability of a scale to yield an accurate measurement of some contextual issues across different settings (Cheung and Rensvold, 1999). As a methodological norm in cross-country survey study, measurement equivalence guarantees that the cross-country differences are not due to the differences in measurement scales (Rungtusanatham *et al.*, 2008).

The measurement equivalence between Chinese and Indian samples was assessed with the method recommended by Rungtusanatham *et al.* (2008) using multiple group CFA. First, a stacked model was built to assess configural equivalence which refers to the extent to which Chinese and Indian samples share the same factor structure. The configural model fits well between the two samples ($\chi^2(360) = 629.59$, $\chi^2/df = 1.75$, CFI = 0.95, TLI = 0.95, RMSEA = 0.039) and all factor loadings and variances are statistically significant. These results establish configural equivalence between the two samples (Rungtusanatham *et al.*, 2008). Second, metric equivalence was assessed with a nested CFA model which determines the extent to which individual factor loadings are identical across the two samples. In this model, the factor loadings were constrained to be equal across the two samples and other parameters were freely estimated. The insignificant change ($\Delta\chi^2(17) = 24.74$, $p > 0.1$) between the unconstrained and

the constrained models shows the evidence of the metric equivalence. Third, starting with the second model, another nested model was built to assess the measurement error variance invariance (MEVI) which refers to the extent to which measurement error variances for individual items are identical across the two samples. In this model, the measurement error variances were further constrained to be equal across the two samples and other parameters were freely estimated. The significant change ($\Delta\chi^2(51) = 329.16, p < 0.01$) shows that the full MEVI cannot be established. Thus, a series of CFA models were built to assess partial MEVI. The results show that partial MEVI can be established across the two samples. As suggested by Rungtusanatham *et al.* (2008), partial MEVI is enough for further comparative analyses across two countries.

4. Analysis and results

The hypotheses are tested using structural equation modelling (SEM) with the maximum likelihood estimation method. The proposed model for each country (i.e. China and India) is stacked and tested using AMOS 21.0. The results are presented in Figure 2. The model fit indices are $\chi^2(518) = 950.54, \chi^2/df = 1.84, CFI = 0.92, TLI = 0.91, RMSEA = 0.041$, which are acceptable (Hu and Bentler, 1999). We find that in China, intellectual capital significantly enhances supplier knowledge integration ($b = 0.57, p < 0.01$) and product innovation performance ($b = 0.39, p < 0.01$). Supplier knowledge integration increases supply chain adaptability ($b = 0.56, p < 0.01$) which positively influences product innovation performance ($b = 0.29, p < 0.01$). However, the direct effect of supplier knowledge integration on product innovation performance is not significant. In India, product innovation performance is positively influenced by intellectual capital ($b = 0.32, p < 0.01$), supplier knowledge integration ($b = 0.25, p < 0.05$), and supply chain adaptability ($b = 0.36, p < 0.01$). Intellectual capital also increases supplier knowledge integration ($b = 0.71, p < 0.01$) and supplier knowledge integration enhances supply chain adaptability ($b = 0.53, p < 0.01$). The results show that the direct effect of intellectual capital on product innovation performance is significant and positive in both countries. Thus, *H1* is supported. Moreover, the effects of the four control variables on product innovation performance are not significant in both countries.

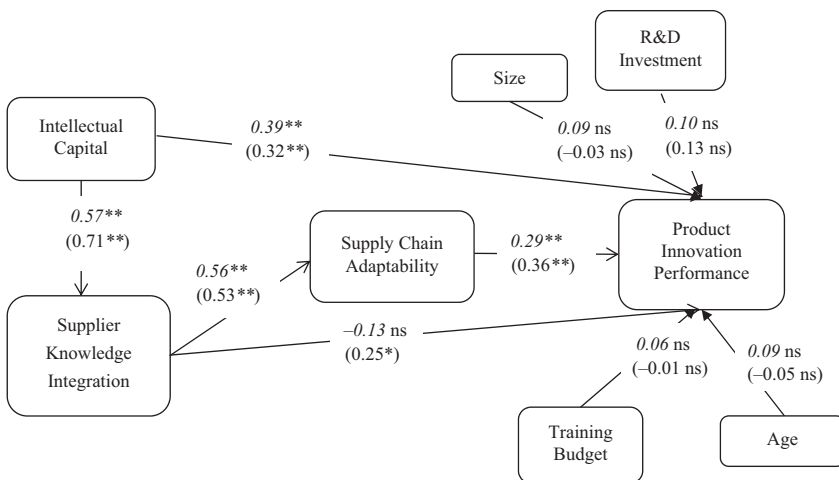


Figure 2. Results of statistical analysis

Notes: ns: not significant. The results of the Chinese sample are shown in italic font and those of the Indian sample are shown in parentheses. * $p < 0.05$; ** $p < 0.01$

As recommended by Malhotra *et al.* (2014), bootstrapping method is used to test the mediation effects in both Chinese and Indian samples. Accordingly, bias-corrected bootstrapping with 5,000 samples is conducted in each sample. The indirect effect of intellectual capital on product innovation performance through supplier knowledge integration is insignificant in China but significant in India ($b = 0.32, p < 0.05$). Therefore, $H2$ is partially supported. The indirect effect of supplier knowledge integration on product innovation performance through supply chain adaptability is significant in both China ($b = 0.16, p < 0.01$) and India ($b = 0.19, p < 0.01$). Therefore, $H3$ is supported.

A multiple group (i.e. China vs India) SEM analysis is further conducted to compare the relationships among intellectual capital, supplier knowledge integration, supply chain capability, and product innovation performance. As the control variables do not significantly influence the dependent variable (i.e. product innovation performance), we exclude them in the cross-country comparison analysis to keep the model parsimonious. The bias-corrected bootstrapping is also conducted to compare the indirect effects in the two countries (Malhotra *et al.*, 2014). Table IV summarises the results of cross-country comparisons for the path coefficients.

The results show that the direct effect of intellectual capital on product innovation performance in China is significantly higher than that in India ($\Delta\chi^2 = 3.18$). In addition, the path coefficient from supplier knowledge integration to product innovation performance is positive and significant in India but insignificant in China ($\Delta\chi^2 = 10.73$), and the indirect effect of intellectual capital on product innovation performance through supplier knowledge integration in China is significantly lower than that in India ($\Delta b = 0.30, p < 0.01$). Thus, the mechanisms through which intellectual capital influences product innovation performance are different in China and India. Therefore, $H4$ is supported. The path coefficients from intellectual capital to supplier knowledge integration, from supplier knowledge integration to supply chain adaptability, and from supply chain adaptability to product innovation performance are not significantly different between the two countries. The indirect effect of supplier knowledge integration on product innovation performance through supply chain adaptability in China is also not significantly different from that in India.

5. Discussion and conclusions

5.1 The direct effect of intellectual capital on product innovation performance

This study finds that intellectual capital directly improves product innovation performance. The result is consistent with existing empirical evidence (Subramaniam and Youndt, 2005; Hsu and Sabherwal, 2012; Lee *et al.*, 2011) and the argument that a firm's knowledge base helps the firm innovate (Cohen and Levinthal, 1990; Szulanski, 1996). Therefore, using existing knowledge creatively is critical for manufacturers who do not focus on developing state-of-the-art technological advances in a product category to innovate. We also find that this effect is moderated by a country's environmental conditions. Manufacturers in the countries that have introduced more policies driving endogenous innovation and accumulated more technological and managerial knowledge during economic development rely more on intellectual capital for developing new products.

Equal Paths	ΔCFI	ΔTLI	$\Delta\chi^2$
Intellectual capital → Product innovation performance	0.000	0.000	3.18*
Intellectual capital → Supplier knowledge integration	0.000	0.000	0.14
Supplier knowledge integration → Supply chain adaptability	0.000	0.000	0.01
Supplier knowledge integration → Product innovation performance	-0.002	-0.002	10.73**
Supply chain adaptability → Product innovation performance	0.000	0.00	0.05

Notes: * $p < 0.1$; ** $p < 0.05$

Table IV.
Results of
cross-country
comparison

5.2 The indirect effect of intellectual capital on product innovation performance through supplier knowledge integration

We find that the impact of intellectual capital on product innovation performance is partially mediated by supplier knowledge integration and the mediation effect is moderated by a country's institutional environment. The results are consistent with Hsu and Sabherwal's (2012) finding that knowledge management mediates the effect of intellectual capital on innovation and corroborate the existing literature on the influences of institutional environment on supply chain collaboration (Wang *et al.*, 2011; Jean *et al.*, 2014; Zhou and Poppo, 2010). It is difficult for manufacturers to perform adequate due diligence and to manage supply chain collaboration using formal control mechanisms in the countries that lack reliable public information channels, professionals (e.g. actuaries, accountants, and surveyors), and strong corporate governance (Rajagopalan and Zhang, 2008; Zhou and Poppo, 2010). Therefore, manufacturers in such countries do not directly use knowledge acquired from suppliers for innovation because this means the manufacturers must share know-how with suppliers which might be leaked to competitors as legal and political institutions may fail to protect their intellectual property rights (Rajagopalan and Zhang, 2008; Zhou and Poppo, 2010). In the countries that have well-developed contract and intellectual property laws, manufacturers are able to apply knowledge obtained from suppliers directly in innovation because their business interests can be protected by legal means. We also find that intellectual capital positively affects supplier knowledge integration, which is consistent with the argument that prior knowledge base helps a manufacturer acquire and integrate knowledge from suppliers (Tavani *et al.*, 2013; Zhang *et al.*, 2015).

5.3 The indirect effect of supplier knowledge integration on product innovation performance through supply chain adaptability

The result reveals that supply chain adaptability mediates supplier knowledge integration's effect on product innovation performance. This is consistent with the existing empirical evidence that knowledge acquired from suppliers is positively associated with new product development (Petersen *et al.*, 2003; Cousins *et al.*, 2011; Tavani *et al.*, 2013) and improves a manufacturer's supply chain capabilities (Hult *et al.*, 2004, 2006). Supplier knowledge integration enables manufacturers to acquire knowledge related to supply chain processes. The knowledge can help the manufacturers adapt and improve supply chains to commercialise new product designs quickly and efficiently which is critical for the manufacturers to enhance product innovation performance.

5.4 Theoretical contributions

This study contributes to operations management literature in three ways. First, this study provides empirical evidence that the impact of intellectual capital on production innovation performance is partially mediated by supplier knowledge integration. The finding clarifies the mechanisms through which intellectual capital enhances product innovation performance and the joint effects of internal and supplier knowledge on new product development. The majority of current studies focus on the relationships between intellectual capital and a firm's internal capabilities and operations (e.g. Hsu and Wang, 2012; Menor *et al.*, 2007; Subramaniam and Youndt, 2005). This study links intellectual capital with supply chain learning and reveals that supplier knowledge integration may carry intellectual capital's effects on product innovation performance. Therefore, we suggest scholars consider intellectual capital in a supply chain context to fully capture its effects. In addition, we find that the direct effect of intellectual capital and the mediation effect of supplier knowledge integration are moderated by the environmental conditions of a country. Hence, we suggest scholars adopt a contingent view and consider the influences of political

and legal institutions when investigating the effects of intellectual capital (Youndt *et al.*, 2004; Zhou and Poppo, 2010).

Second, this study finds that supply chain adaptability mediates the impact of supplier knowledge integration on product innovation performance. The result shows that knowledge acquired from suppliers enhances product innovation performance only indirectly through supply chain adaptability in China which provides a possible explanation for the mixed findings on the roles played by suppliers in product innovation (Gao *et al.*, 2015; Jean *et al.*, 2014). The findings also indicate that a manufacturer can acquire different kinds of knowledge from suppliers which enhance product innovation performance either directly or indirectly by improving supply chain processes and capabilities, providing insights into how suppliers contribute to new product development. Therefore, to fully reap the benefits of supplier knowledge integration on product innovation, we suggest scholars consider the effects of knowledge obtained from suppliers on both new product development and supply chain processes.

Third, this study empirically compares the joint effects of intellectual capital, supplier knowledge integration, and supply chain adaptability on product innovation performance in China and India. The majority of empirical studies on product innovation in emerging markets focus on China (Gao *et al.*, 2015; Jean *et al.*, 2014; Wang *et al.*, 2011). This study is one of the first attempts to generalise and compare the findings in two important emerging markets. In this way, the results enhance current understandings on knowledge management and product innovation in India and the impacts of economic and institutional environments on supply chain management and new product development. We find that the economic development path and institutional environment moderate the effects of intellectual capital and supplier knowledge integration on product innovation performance. Therefore, we suggest scholars consider the influences of a country's special economic and institutional environments when exploring the effects of knowledge and supply chain management on new product development.

5.5 Managerial implications

This study also provides guidelines for managers on how to develop new products using existing knowledge and supply chain management. First, manufacturers can improve product innovation performance by developing intellectual capital and integrating knowledge acquired from suppliers. In particular, manufacturers could implement training programmes and job rotation to enhance employees' knowledge and skills. Manuals and standard operating procedures could be designed to formalize knowledge management and product development processes. Organisational procedures and rules could be created and regularly adjusted to guide cross-functional collaboration in new product development. Information systems and databases could also be used to keep knowledge automatically and systematically, and to facilitate the retrieval and implementation of knowledge in product innovation and supply chain management. In addition, lateral communication channels could be built for employees in different departments to share information and interact with each other. We suggest managers organise formal and informal social events, such as workshops, seminars, and parties, for employees to build and maintain personal relationships. Moreover, manufacturers could invest in operational processes and information technologies that enable them to obtain technical know-how on new product and process development from suppliers. For example, network-based information systems could be developed to allow real-time information sharing with suppliers. Cross-boundary teams could be formed to involve suppliers in new product development. This is especially important for Indian manufacturers because supplier knowledge integration mediates intellectual capital's effects on product innovation performance in India.

Second, we suggest manufacturers invest in improving supply chain adaptability when learning from suppliers for product innovation. Manufacturers could acquire knowledge about supply chain processes, such as inventory management, delivery scheduling, and process technologies, from suppliers. They could develop procedures and processes to apply the knowledge to solve supply chain problems and reengineer supply chains according to market changes. In this way, manufacturers are able to reap the full benefits of supplier knowledge integration on product innovation. This is especially important for Chinese manufacturers because supplier knowledge integration only enhances product innovation through supply chain adaptability in China.

Third, we find that the environmental conditions of a country moderate the impacts of intellectual capital and supplier knowledge integration on product innovation performance. Hence, we suggest managers analyse the institutional environment of a country and adjust the focus of supply chain learning accordingly. In particular, in a country that lacks market-supporting political and legal institutions, manufacturers could focus on acquiring the knowledge that can improve supply chain adaptability, such as process improvement suggestions and delivery scheduling, from suppliers. If a country has a good enough institutional environment, manufacturers could source the knowledge that can be directly applied into new product development, such as new product ideas and new applications of existing components and materials, and that can improve supply chain adaptability at the same time.

5.6 Limitations and future research directions

Although this study makes significant theoretical and practical contributions, it has limitations that open avenues for future studies. First, a manufacturer can learn from different external partners, such as suppliers, customers, universities, and competitors, who can bring different kinds of knowledge (Un *et al.*, 2010; Zhang *et al.*, 2015). Future studies could explore the joint effects of the knowledge acquired from different partners and intellectual capital on product innovation performance. Second, we conduct this study in China and India. Manufacturers in other emerging markets (e.g. Russia and Brazil) or developed economies (e.g. North America and West Europe) face different economic and institutional environments compared to Chinese and Indian manufacturers. Investigating how intellectual capital and supply chain learning affect product innovation performance in other countries and comparing the results with this study would be an interesting research topic. Third, the survey has relatively low response rates, which is a limitation of this study.

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	China	India
<i>Intellectual capital</i>		
Human capital	AVE = 0.70, CR = 0.87, $\alpha = 0.78$	AVE = 0.72, CR = 0.89, $\alpha = 0.81$
	0.857	0.943
Employees in the company are highly skilled in their respective jobs	0.781	0.777
Employees in the company are experts in their particular jobs and functions	0.700	0.733
Our employees always develop new ideas and knowledge	0.729	0.776
Structural capital	AVE = 0.71, CR = 0.88, $\alpha = 0.79$	AVE = 0.65, CR = 0.85, $\alpha = 0.73$
	0.717	0.977
Much of this company's knowledge is contained in manuals, archives, or databases	0.765	0.652
We usually follow the sequence of written procedures and rules	0.707	0.686
Our company embeds much of its knowledge and information in structures, systems, and processes	0.779	0.744
Social capital	AVE = 0.68, CR = 0.87, $\alpha = 0.76$	AVE = 0.64, CR = 0.84, $\alpha = 0.72$
	0.762	0.853
There are ample opportunities for informal conversations among employees in the company	0.633	0.589
Employees from different departments feel comfortable calling each other when the need arises	0.825	0.720
People are quite accessible to each other in the company	0.726	0.747
Supplier knowledge integration	AVE = 0.71, CR = 0.87, $\alpha = 0.87$	AVE = 0.63, CR = 0.87, $\alpha = 0.81$
We are able to obtain a tremendous amount of technical know-how from suppliers	0.820	0.803
We rapidly respond to technological changes in our industry by applying what we have learned from suppliers	0.807	0.708
As soon as we acquire new knowledge from suppliers, we try to find applications for it	0.744	0.659
Suppliers' technological knowledge has enriched the basic understanding of our innovation activities	0.778	0.692
Supply chain adaptability	AVE = 0.68, CR = 0.89, $\alpha = 0.84$	AVE = 0.68, CR = 0.89, $\alpha = 0.84$
	0.724	0.797
Our supply chain partners can help us to quickly change product designs	0.835	0.825
We can quickly solve supply chain problems	0.861	0.695
Our supply chain can adapt to market changes easily	0.631	0.725
We can quickly conduct engineering changes to adapt to customer's needs	AVE = 0.72, CR = 0.91, $\alpha = 0.87$	AVE = 0.67, CR = 0.89, $\alpha = 0.84$
Product innovation performance	0.660	0.760
Percentage of total sales stemming from new products	0.807	0.756
Number of new products	0.841	0.707
Speed of introducing new products	0.870	0.780
Frequency of new product introductions		

Table AI.

Measurement items

Notes: AVE: average variance extracted; CR: composite reliability; α : Cronbach's α **Corresponding author**Zhiqiang Wang can be contacted at: bmzqwang@scut.edu.cn

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