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Linking business models with technological innovation performance through organizational learning

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ABSTRACT

This study examines how business models affect technological innovation performance through the mediating role of organizational learning. Using hierarchical regression analysis with data from 173 Chinese manufacturing firms embedded in global manufacturing networks, this study shows that both efficiency-centered and novelty-centered business models affect organizational learning. The results also demonstrate that organizational learning fully mediates the relationship between efficiency-centered business models and technological innovation performance and partially mediates the relationship between novelty-centered business models and technological innovation performance. This study provides new insights into the influence of business models on technological innovation performance by showing the indirect influence of business models. This study may help managers better understand the influence of business models on technological innovation performance.

Introduction

Business models have received increasing attention from scholars in the research fields of strategy, competition, and technological innovation (e.g., Lee, Shin, & Park, 2012; Mitchell & Coles, 2003; Teece, 2010). This study focuses on the influence of business models on technological innovation performance because a great amount of previous research has highlighted the crucial effects of business models on the improvement of technological innovation performance. On the one hand, an appropriate business model design is necessary for the successful commercialization of innovative technology (Teece, 2010; Zott, Amit, & Massa, 2011). On the other hand, the lack of an appropriate business model design reduces the profit gained from technological innovation and even forces a firm to cancel the application of a new technology (Chesbrough & Rosenbloom, 2002).

Although prior studies are important for understanding the influence of business models on technological innovation performance, they are limited in two respects. First, prior studies do not take business model design themes into consideration. Business model design themes describe "the holistic gestalt of a firm's business model, and they facilitate its conceptualization and measurement" (Zott & Amit, 2008, p. 4). The literature indicates great interest in efficiency-centered and novelty-centered business model design themes (e.g., Brettel, Strese, & Flatten, 2012; Zott & Amit, 2007, 2008). For example, Zott and Amit (2007) examine the relationship between these two themes and the performance of entrepreneurial firms. An efficiency-centered business model design aims at "reducing transaction costs for all transaction participants" (Zott & Amit, 2008, p. 9). A novelty-centered business model design refers to "the conceptualization and adoption of new ways of conducting economic exchanges among transaction participants" (Zott & Amit, 2008, p. 8). From the perspective of practice, efficiency and novelty are the themes corresponding to product market strategy (Zott & Amit, 2008), and they allow a firm to reach its strategic goals (Casadesus-Masanell & Ricart, 2010). These two design themes are not mutually exclusive: they may coexist in a specific business model (Zott & Amit, 2008). Given the importance of these two design themes, it is surprising that few studies explore how these two themes affect technological innovation performance. Therefore, it is necessary to take these two business model design themes into account when trying to understand how business models affect technological innovation performance.

Second, prior studies have not yet examined the indirect influence of business models on technological innovation performance. As mentioned previously, these studies have primarily concentrated on the value of business models in terms of the commercialization of technological innovation, a concept that essentially belongs to studies of direct influence (Björkdahl, 2009; Chesbrough & Rosenbloom, 2002; Teece, 2010). However, practice (as demonstrated by Wanji and Geely) shows that the influence of business models can be indirect. Specifically, business models can affect technological innovation performance through organizational learning. Consider Wanji, a manufacturer of power

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components in China. Wanji's business model is efficiency-centered. The transactions the firm offers are simple and fast. For example, Wanji provides online transactions for customers. Moreover, Wanji enables transparent transactions (e.g., the disclosure of information regarding technical parameters) and reduces customer search costs by search engine marketing. Relying on the efficiency-centered business model, Wanji has built long-term cooperation with several top enterprises in their respective industries worldwide. These efforts have enabled Wanji not only to acquire market information and product knowledge from these customers but also to co-develop new products with these customers. Geely is one of the top ten automobile manufacturers in China. Compared with Wanji's business model, Geely's business model is novelty-centered because it focuses on connecting previously unconnected parties rather than reducing transaction costs (Zott & Amit, 2007, 2008). For example, Geely took over the global luxury car brand Volvo in 2010. Learning from Volvo was one of purposes of the takeover, as verified by cooperation in a new R&D center in Gothenburg, Sweden. The center aims to develop a new modular architecture and a set of components for future C-segment cars, addressing the needs of both Volvo and Geely. Do business models influence technological innovation performance indirectly through organizational learning? The answer to this question will help us better understand the influence of business models on technological innovation performance.

This study aims to address the gaps mentioned above. It focuses on two business model design themes, efficiency-centered and novelty-centered business model designs (Amit & Zott, 2001; Zott & Amit, 2007, 2008), and examines the influence of these two themes on technological innovation performance through the mediating role of organizational learning. The rest of the paper is organized as follows. In Section 2, the paper presents the theoretical foundation of this study and proposes hypotheses. Section 3 introduces the research methods used. Section 4 presents the results of this study, which were obtained by empirical analysis. Section 5 discusses the findings, theoretical contributions, practical implications, limitations, and further research.

Literature review and hypotheses

Business models

It is generally accepted that value creation is the core of the business model (Teece, 2010; Zott & Amit, 2010). Based on value-creation mechanisms, existing business model definitions can be divided into two types. The first type is built from the perspective of an internal value chain, which considers the offer of products or services, the arrangement of internal value activities, and the allocation of internal resources to be the main mechanisms of value creation (Morris, Schindehutte, & Allen, 2005; Timmers, 1998). For example, Morris et al. (2005, p. 727) define the business model as "a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets".

The second type is built from the perspective of an external value network. This type emphasizes the arrangement of a value network, the integration of boundary-spanning activities, and cooperation between firms as the primary mechanisms of value creation (Amit & Zott, 2001; Hienerth, Keinz, & Lettl, 2011; Zott & Amit, 2010). For example, Amit and Zott (2001, p. 511) define the business model as "depicting the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities". Zott and Amit (2007, p. 181) further state, "a business model elucidates how an organization is linked to external stakeholders, and how it engages in economic exchanges with them to create value for all exchange partners".

This study adopts the definition of Amit and Zott (2001) for two major reasons. First, this definition, grounded in strategic network theory, reflects the characteristics of the business model as a network concept. Recent studies on open business models (Chesbrough, 2006), dynamic business models (Mason & Leek, 2008), and collaborative business models (Chen & Cheng, 2010) all indicate that the business model is a concept based on network structure. Second, although this definition is derived from the study of e-business, it has broad applicability. For example, Brettel et al. (2012) show that this definition is valid for both manufacturing and service firms.

The business model is an abstract concept but can be easily understood when interpreted in terms of design themes. Design themes depict the primary value creation sources, drivers, and effects constituting the essential elements of business models (Amit & Zott, 2001; Zott & Amit, 2008, 2010). Amit and Zott (2001) propose four design themes, namely, efficiency-centered, complementarities-centered, lock-in-centered, and novelty-centered. As mentioned previously, this study focuses on efficiency-centered and novelty-centered design themes. The efficiency-centered design, which builds on transaction cost theory (Williamson, 1975, 1979), focuses on improving the transaction efficiency and reducing the transaction costs of business model participants (Zott & Amit, 2007, 2008). The novelty-centered design, which is rooted in Schumpeterian innovation theory (Schumpeter, 1934), focuses on introducing new ways of making transactions or connecting with new partners (Zott & Amit, 2007, 2008). Similarly, Sorescu, Frambach, Singh, Rangaswamy, and Bridges (2011) propose that efficiency and effectiveness are the primary design themes of the retail business model. In their work, efficiency refers to making transactions faster, cheaper, and easier; effectiveness refers to achieving the goals of retail firms and consumers in innovative ways (e.g., customer co-creation) (Sorescu et al., 2011). Hamel (2000) also emphasizes that it is important to create an efficient and unique business model because efficiency and uniqueness determine the profit potential of a business model.

Organizational learning

Although organizational learning has many definitions, at the most fundamental level, it is "the development of new knowledge or insights that have the potential to influence behavior" (Slater & Narver, 1995, p. 63). Organizational learning is an important and basic organizational process through which information and knowledge can be processed and the attributes, behaviors, capabilities, and performance of an organization can be changed (Cohen & Levinthal, 1990; Huber, 1991). Organizational learning consists of a series of subprocesses, such as knowledge acquisition, knowledge sharing, and knowledge utilization (Nevis, DiBella, & Gould, 1995).

Organizations, where internal learning happens, also learn within interorganizational networks (Knight, 2002; Lane & Lubatkin, 1998). Networks gather the information and knowledge of different node firms to ensure that firms meet diverse information and knowledge needs (Uzzi, 1997). In addition, networks boost cooperation and communication among firms, leading to information flow and knowledge transfer (Dyer & Singh, 1998). Learning in networks suggests that organizations learn through interaction with other organizations to improve their structures, processes, strategies, and performance (Knight, 2002).

This study examines how business models affect technological innovation performance through organizational learning in networks consisting of business model participants. Therefore, organizational learning in this study refers to organizational learning in

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networks. Prior studies of organizational learning in networks focus on acquiring and using knowledge from networks (Knight, 2002; Schildt, Keil, & Maula, 2012). Following these studies, organizational learning in this study includes two subprocesses. One subprocess is knowledge acquisition, which is the process of acquiring knowledge from other business model participants. The other is knowledge utilization, which is the process of using the knowledge gathered from other business model participants.

Business models and organizational learning

Efficiency-centered business model design is realized mainly by reducing transaction uncertainty, information asymmetry, and transaction complexity among business model participants (Zott & Amit, 2007). This design theme affects organizational learning for the following three reasons.

First, efficiency-centered business model design improves the level of information sharing. Reducing transaction uncertainty among business model participants means that all participants are required to enhance information sharing because uncertainty imposes organizational information needs (Li & Lin, 2006). Information sharing is defined as "the degree to which each party discloses information that may facilitate the other party's activities" (Heide & Miner, 1992, p. 275). Because information sharing helps firms acquire, understand, integrate, accumulate, and store knowledge gathered from outside or from networks, organizational learning can be enhanced by information sharing (Fang, Fang, Chou, Yang, & Tsai, 2011; Liu, Xu, & Hu, 2010).

Second, efficiency-centered business model design strengthens mutual trust between firms. Reducing information asymmetry reduces opportunistic behavior (Williamson, 1975) and, in turn, increases mutual trust between firms (Morgan & Hunt, 1994). Trust refers to "a willingness to rely on an exchange partner in whom one has confidence" (Morgan & Hunt, 1994, p. 23). Trust plays a critical role in organizational learning. For example, the work of Levin and Cross (2004) shows that trust leads to the receipt of useful knowledge. In addition, Norman (2004) shows that trust reduces the probability that partners exhibit knowledge protection.

Third, efficiency-centered business model design promotes joint problem solving. Opportunistic behavior negatively affects cooperation (Morgan & Hunt, 1994), which indicates that reducing opportunistic behavior promotes joint problem solving among firms. Joint problem solving is defined as "the degree to which the parties share the responsibility for maintaining the relationship itself and for problems that arise as time goes on" (Heide & Miner, 1992, p. 275). Joint problem solving is important to organizational learning. For example, McEvily and Marcus (2005) argue that joint problem solving facilitates the transfer of situation-specific knowledge. Liu et al. (2010) show that joint problem solving promotes the acquisition and application of new knowledge.

As stated above, efficiency-centered business model design positively affects organizational learning through information sharing, trust, and joint problem solving, leading to the following hypothesis:

H1: Efficiency-centered business model design is positively related to organizational learning.

Novelty-centered business model design is achieved by "connecting previously unconnected parties, linking transaction participants in new ways, or designing new transaction mechanisms" (Zott & Amit, 2007, p. 184). The reasons novelty-centered business model design affects organizational learning are summarized as follows.

First, novelty-centered business model design increases the learning intent of firms. This design is one type of innovation behavior (e.g., offering new combinations of products, services, and information or designing new transaction mechanisms) (Zott & Amit, 2007). To achieve innovation, external knowledge search and utilization are required (Laursen & Salter, 2006). Thus, this design enhances the intent of firms to learn. Learning intent refers to "a determination to learn certain skills possessed by the other partner" (Tsang, 2002, p. 843). Learning intent affects organizational learning because it is one of the significant determinants of knowledge transfer (Simonin, 2004). Park, Giroud, and Glaister (2009) also show that learning intent facilitates information exchange and knowledge acquisition.

Second, novelty-centered business model design improves network centrality. Connecting previously unconnected parties enhances the direct ties linking the firm with other business model participants as well as the probability that other business model participants are linked to each other through the firm. Therefore, network centrality is enhanced. Network centrality refers to "an individual actor's position in the network, relative to others" (Pillai, 2006, p. 138). It represents a firm's potential capability to acquire and use external knowledge (Tsai, 2001) because it is easy for a firm occupying the central position in a network to identify, acquire, integrate, and use diverse and novel knowledge (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008). In addition, network centrality enhances a firm's absorptive capacity through high-frequency and high-strength interactions with other partners, which enables the firm to acquire and use knowledge successfully (Pillai, 2006).

As suggested above, novelty-centered business model design positively affects organizational learning through learning intent and network centrality, leading to the following hypothesis:

H2: Novelty-centered business model design is positively related to organizational learning.

Organizational learning and technological innovation performance

Because the knowledge that contributes to technological innovation exists not only inside firms but also outside firms, external knowledge is also the basis of technological innovation. In addition, Chesbrough (2006) suggests that external knowledge acquisition and utilization are particularly important to open innovation, which has become the dominant paradigm of technological innovation. Similarly, Chen, Chen, and Vanhaverbeke (2011) argue that open innovation is more dependent on external innovation resources, especially external knowledge, than closed innovation.

Moreover, external knowledge acquisition and utilization are complementary to internal R&D. Freeman (1991) shows that the combination of external technical expertise and internal basic research contributes to the success of innovation efforts. Cassiman and Veugelers (2006) prove that external knowledge acquisition and utilization and internal R&D are complementary innovation activities, and when integrated into the innovation process, these activities help firms achieve greater rewards. Cohen and Levinthal (1990) indicate that building absorptive capability requires both the technological knowledge gathered from internal R&D and outside expertise.

Furthermore, external knowledge acquisition and utilization increase the probability of more novel innovation because they increase a firm's breadth and depth of knowledge and enhance the firm's technological distinctiveness (Yli-Renko, Autio, & Sapienza, 2001). Studies of knowledge search also indicate that searching, acquiring, and using diverse and novel external knowledge not only promotes the implementation of multiple solutions (Hargadon & Sutton, 1997) but also encourages the combination of novel knowledge (Fleming, 2001), thus leading to more novel innovation (Ahuja & Lampert, 2001).

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As stated previously, organizational learning, which includes knowledge acquisition and knowledge utilization, positively affects technological innovation performance, leading to the following hypothesis:

H3: Organizational learning is positively related to technological innovation performance.

Mediating effect of organizational learning

Within the domain of networks and technological innovation, researchers generally believe that the networks in which firms are embedded have positive effects on technological innovation performance. However, the effects of networks can be direct or indirect. By reviewing studies of indirect effects of networks on technological innovation performance, this study finds that a theoretical framework of network embeddedness-organizational learning-technological innovation performance has been developed (e.g., Salman & Saives, 2005; Tsai, 2001). Embeddedness is defined as "the degree to which commercial transactions take place through social relations and networks of relations that use exchange protocols associated with social, noncommercial attachments to govern business dealings" (Uzzi, 1999, p. 482). Network embeddedness includes relational embeddedness (e.g., trust) and structural embeddedness (e.g., network centrality) (Gnyawali & Madhavan, 2001; Gulati, 1998; McEvily & Marcus, 2005). The framework of network embeddedness-organizational learning-technological innovation performance indicates that organizational learning plays a mediating role. For example, from the perspective of network relationships, Liu et al. (2010) show that relational embeddedness (i.e., information sharing, trust, joint problem solving) affects technological innovation performance through exploratory learning. From the perspective of network structure, Salman and Saives (2005) show that network centrality enhances technological innovation performance through access to knowledge. In fact, many studies of the direct influence of network embeddedness on technological innovation performance also focus on the mediating role of organizational learning (e.g., Tsai, 2001).

As mentioned previously, this study proposes that efficiency-centered design affects organizational learning through relational embeddedness (i.e., information sharing, trust, joint problem solving), which indicates that efficiency-centered design is one of the antecedents of relational embeddedness. This study also proposes that novelty-centered design affects organizational learning through network centrality, which indicates that novelty-centered design is one of the antecedents of network centrality. Combining these results and the framework of network embeddedness-organizational learning-technological innovation performance, this study expects that organizational learning mediates the relationship between these business model designs and technological innovation performance. Thus, this study proposes the following hypotheses:

H4: Organizational learning mediates the relationship between efficiency-centered business model design and technological innovation performance.

H5: Organizational learning mediates the relationship between novelty-centered business model design and technological innovation performance.

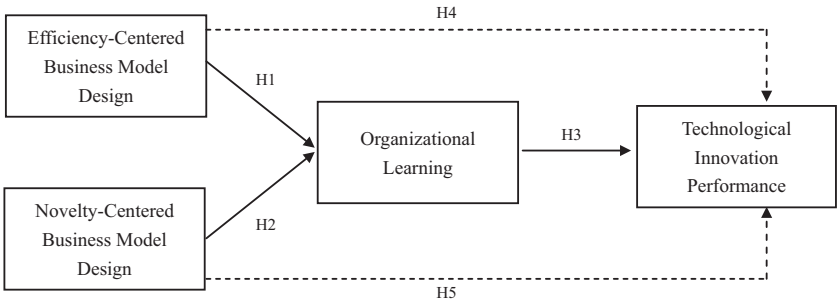
The five hypotheses formulated herein constitute a model (see Fig. 1) linking business model designs, organizational learning, and technological innovation performance.

Data and methods

Sample and data collection

This study is based on a sample of Chinese manufacturing firms embedded in global manufacturing networks. The sample was selected for several reasons. First, because these firms undertake manufacturing or assembly functions while transacting with other partners in networks, the business model designs of these firms are open, less complex, and are easily identified. Second, these firms exhibit the distinct features of organizational learning because acquiring and using knowledge from networks for growth are important reasons for these firms joining global manufacturing networks. Third, the acquisition of competitive capabilities through technological innovation is one of the strategic requirements of these firms. Because most manufacturing firms in the Zhengjiang, Jiangsu, and Guangdong Provinces exhibit the distinct features of global manufacturing network embeddedness, data were collected in those areas. A diverse sample was used to ensure sample representativeness and, in turn, increase the generalizability of our results. For example, the sample covered a wide range of sales revenues. Specifically, 22.0% of the sample firms showed sales revenues below 30 million RMB, 53.2% in the range of 30–300 million RMB, and 24.9% over 300 million RMB. It can be concluded that this sample distribution is consistent with the characteristics of firm size in China. The characteristics of the participating firms are summarized in Table 1.

Data collection involved a questionnaire administered in 2011. This study chose general managers, marketing managers, R&D managers, and directors of the office of the general manager as respondents. These middle and senior managers acquire large amounts of information from different departments and therefore possess sufficient knowledge to evaluate the different variables of



Note: Dotted lines indicate the hypotheses regarding mediation effects.

Fig. 1. Conceptual model.

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Table 1
Characteristics of participating firms.

	Frequency	Percent		Frequency	Percent
Sales revenue (RMB million)			Manufacturing sectors		
30 or lower	38	22.0	Electronic connectors	33	19.1
30–300	92	53.2	Textile and clothing	53	30.6
Over 300	43	24.9	Small household appliances	32	18.5
Firm ages (years)			Medicine and chemical	15	8.7
10 or younger	62	35.8	Auto and motorbike parts	17	9.8
11–20	95	54.9	Others (e.g., plastic)	23	13.3
Over 20	16	9.2			

their organizations (Lloréns Montes, Ruiz Moreno, & García Morales, 2005). Sample firms were contacted through three channels. First, an electronic version of the questionnaire was sent to officials in four government agencies (e.g., Zhejiang Province Economic and Information Commission) by email. Then, the officials printed the questionnaires and mailed them to the managers of local firms, with a total of 112 questionnaires distributed. Of the 91 questionnaires returned, 4 were excluded due to the respondents being unmatched; 5 were excluded due to the data being incomplete; and 6 were excluded due to the data being exceedingly regular (e.g., the respondent evaluated most items with the same score). Second, 19 personal contacts of the author received the electronic version of the questionnaire and emailed it to the managers of suppliers, partners, customers, and their own managers. One hundred thirteen questionnaires were distributed in this manner. Of the 98 questionnaires returned, 5 were excluded due to unmatched respondents; 3 were excluded due to incomplete data; and 4 were excluded due to exceedingly regular data. Third, this study conducted personal interviews with the managers of 12 firms (e.g., Zhejiang Yueli Electrical Co., Ltd), resulting in the collection of data from 12 firms; however, the data from 1 firm were excluded due to an incomplete interview. In total, this study used 173 of 237 questionnaires for the final analysis. The response rates are summarized in Table 2.

Measures

All constructs were measured using a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree), except for firm age and firm size. Table 3 shows the constructs and their corresponding measures used in this study.

Dependent variable

Technological innovation performance is the dependent variable of this study. It was measured by four items: the number of new products, adapted from Tsai (2001); the novelty of new products, adapted from Wang and Ahmed (2004); the percentage of sales from new products, adapted from Atuahene-Gima and Ko (2001); and the value-added rate of new products, adapted from Jiao, Ma, and Tseng (2003) (see Table 3). Although the number of patents is an important indicator of technological innovation performance (Brouwer & Kleinknecht, 1999), it is typically suitable for the measurement of technology-intensive firms' technological innovation performance (Salman & Saives, 2005). Because most firms in the sample are non-technology-intensive, the number of patents was not used to measure technological innovation performance.

Table 2
Summary of response rates by contact method.

Contact method	Distributed	Response (rate)	Valid (rate)
Government departments	112	91 (81.3%)	76 (67.9%)
Personal contacts	113	98 (86.7%)	86 (76.1%)
Interviews	12	12 (100.0%)	11 (91.7%)
Total	237	201 (84.8%)	173 (73.0%)

Table 3
Reliability and validity.

Constructs and items	Loading
Technological innovation performance (Alpha = 0.81)	
1. Compared with that of our key competitors, the number of new products we introduced was greater in the past 2 years	0.82
2. Compared with those of our key competitors, our new products were often perceived as more novel in the past 2 years	0.90
3. Compared with that of our key competitors, the percentage of sales from new products was higher in the past 2 years	0.86
4. Compared with that of our key competitors, the value-added rate of our new products was higher in the past 2 years	0.61
Efficiency-centered business model design (Alpha = 0.85)	
1. The business model enables fast transactions	0.86
2. Transactions are transparent: Flows and use of information, services, goods can be verified	0.90
3. Costs for participants in the business model are reduced (e.g., inventory, marketing and sales, transaction-processing, communication costs)	0.68
Novelty-centered business model design (Alpha = 0.88)	
1. Incentives offered to participants in transactions are novel	0.88
2. The business model links participants to transactions in novel ways	0.81
3. The business model brings together new participants	0.81
Organizational learning (Alpha = 0.94)	
1. We acquired lots of product development knowledge from other business model participants in the past 2 years	0.86
2. We acquired lots of manufacturing process knowledge from other business model participants in the past 2 years	0.82
3. We acquired lots of market knowledge from other business model participants in the past 2 years	0.85
4. We used lots of product development knowledge from other business model participants in the past 2 years	0.91
5. We used lots of manufacturing process knowledge from other business model participants in the past 2 years	0.89
6. We used lots of market knowledge from other business model participants in the past 2 years	0.90

Independent variables

Efficiency-centered and novelty-centered business model designs are the independent variables of this study. Except for Zott and Amit (2007), there are few studies on the measurement of business model designs. Zott and Amit (2007) develop items to measure business model designs and prove that these items exhibit good reliability and validity. Efficiency-centered business model design was measured with a three-item scale adapted from Zott and Amit (2007) that includes the following items: fast transactions, transparent transactions, and reduced costs (see Table 3). To measure novelty-centered business model design, this study also used a three-item scale. The scale includes the following items: novel incentives offered to participants, novel ways of linking participants, and new participants (Zott & Amit, 2007) (see Table 3).

Mediating variable

Organizational learning comprising knowledge acquisition and utilization is the mediating variable of this study. This study adopted the perspective of previous studies that focus on measuring knowledge acquisition and utilization from knowledge types, such as marketing knowledge acquisition/utilization (Lyles & Salk, 1996; Yli-Renko et al., 2001; Zhang, Benedetto, & Hoenig, 2009). To measure organizational learning, this study used a six-item scale adapted from Lyles and Salk (1996), Yli-Renko et al. (2001), and Zhang et al. (2009). The scale covers the following items: product development knowledge acquisition, manufacturing process

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knowledge acquisition, market knowledge acquisition, product development knowledge utilization, manufacturing process knowledge utilization, and market knowledge utilization (see Table 3). It should be noted that the knowledge acquired and used by firms refers to the knowledge gathered from other business model participants, such as key suppliers, customers, and other partners.

Control variables

Following the studies of organizational learning (Park et al., 2009; Yli-Renko et al., 2001) and technological innovation (Laursen & Salter, 2006; Salman & Saives, 2005), this study chose firm age and firm size as the control variables. Based on Lyles and Salk (1996), this study calculated firm age by subtracting the year when the firm was founded from the year when the survey was conducted (i.e., 2011). Related studies show that the logarithm of the number of employees (Park et al., 2009) and sales revenue (Song, Van der Bij, & Weggeman, 2005) can be used to measure firm size. Because the firms in the sample are labor-intensive, the error associated with measuring a firm size greater than the actual firm size would have most likely occurred if this study had used the logarithm of the number of employees to measure firm size. Therefore, the sales revenue was selected to measure firm size.

Reliability and validity

Before the survey, this study took steps to ensure reliability and validity. First, the scales used were adapted from related studies and had been proven valid. Second, all of the variables except the control variables were measured by multiple items. Third, a pre-test was carried out for 3 firms. According to the feedback of the pre-test, the expressions of some items were modified. Fourth, only the middle and senior managers who are familiar with the firms were chosen to be respondents. Fifth, although the contact methods of the survey were unable to meet the requirements of random sampling, they were able to ensure that respondents were willing to accept the survey. Sixth, a commitment was made to ensure the survey data would be used solely for academic study rather than any type of commercial activities, increasing the willingness of the respondents to accept the survey.

After the survey, the reliability and validity of the constructs were evaluated. Cronbach's alpha was used to evaluate the internal consistency reliability. Internal consistency assesses the homogeneity of a set of items (Peter, 1979). Nunnally (1978) indicates that a construct is reliable if the Cronbach's alpha of the construct is greater than 0.7. The reliability analysis results of this study show that the Cronbach's alpha of every construct is greater than 0.7 (ranging from 0.81 to 0.94), which meets the standard proposed by Nunnally (1978). Therefore, the reliability of the constructs is acceptable (see Table 3). Exploratory factor analysis (principal component analysis with varimax rotation) was used to evaluate the construct validity. Construct validity refers to "the degree to which a measure correctly measures its targeted variable" (O'Leary-Kelly and Vokurka, 1998, p. 389). Hinkin (1995) indicates that a construct is valid if the factor loading of every item is greater than 0.4. In this study, the results show that the factor loading of every item is greater than 0.6, which is above the acceptable standard proposed by Hinkin (1995), indicating that all of the constructs are valid (see Table 3). To detect common method bias (e.g., artifactual relationships produced by the use of positively worded items), Harman's single-factor test was used (Podsakoff, Mackenzie, Lee, & Podsakoff, 2003). Podsakoff et al. (2003) state that a significant common method bias emerges when a single factor emerges or one general factor explains most of the covariance among all variables. An exploratory factor analysis of all of the variables shows that 4 factors emerge from the analysis and account for 76.4% of the total variance, where the first factor accounts for 28.1% of the total variance. Compared with the standard mentioned above, these results indicate that common method bias does not reduce the validity of the research findings of this study.

After these tests, this study concluded that the measures could be accepted to test the hypotheses.

Analysis and results

This study tested the aforementioned hypotheses using hierarchical regression because it allowed for the testing of both direct relationships (Hypotheses 1, 2, and 3) and indirect relationships (Hypotheses 4 and 5). Prior to testing, the correlations of the variables were analyzed. As shown in Table 4, the correlation coefficients between the independent variables and the dependent variable, those between the independent variables and the mediating variable, and those between the mediating variable and the dependent variable all achieved statistical significance. These correlations provide preliminary empirical evidence of valid hypothesis testing.

To test Hypotheses 1 and 2, three regression models were built as shown in Table 5. Model 1 focuses on the influence of control variables on organizational learning, whereas models 2 and 3 study the influence of efficiency-centered and novelty-centered business model designs on organizational learning, respectively. Compared with model 1, model 2 suggests that efficiency-centered business model design positively affects organizational learning ($\Delta R^2 = 10.9\%$, significant at 0.001; $\beta = 0.34$, $p < 0.001$), which supports Hypothesis 1. Compared with model 1, model 3 suggests that novelty-centered business model design positively affects organizational learning ($\Delta R^2 = 2.1\%$, significant at 0.05; $\beta = 0.15$, $p < 0.05$), which supports Hypothesis 2. The results of models 2 and 3 also show that the influence of efficiency-centered design ($\beta = 0.34$, $p < 0.001$) on organizational learning is stronger than the influence of novelty-centered design ($\beta = 0.15$, $p < 0.05$).

As shown in Table 6, two regression models were built to test Hypothesis 3. Model 4 only studies the influence of control variables on technological innovation performance. Model 5 focuses on the influence of organizational learning on technological innovation performance. Adding the variable of organizational learning increases the R^2 value by 14.7% (significant at 0.001). In addition, organizational learning has a significant and positive influence on technological innovation performance ($\beta = 0.43$, $p < 0.001$). Therefore, Hypothesis 3 is supported.

Following the steps proposed by Baron and Kenny (1986), this study tested Hypotheses 4 and 5 as follows. First, the results of models 6 and 7 show that efficiency-centered (model 6;

Table 4
Descriptive statistics and correlations of variables.

	1	2	3	4	5	6
1. Firm age	1.00					
2. Firm size	.25**	1.00				
3. Efficiency-centered design	.03	.16*	1.00			
4. Novelty-centered design	.07	.10	.68***	1.00		
5. Organizational learning	.11	.46***	.41***	.31***	1.00	
6. Technological innovation performance	.13	.28***	.36***	.40***	.47***	1.00
Mean	13.01	4.42	4.97	4.85	5.65	4.97
S.D.	6.46	1.43	1.09	1.07	1.00	.90

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 5
Regression results for organizational learning.

	Dependent variable Organizational learning		
	Model 1	Model 2	Model 3
Firm age	−.01	.00	−.01
Firm size	.46***	.39***	.46***
Efficiency-centered design		.34***	
Novelty-centered design			.15*
F	22.38***	26.25***	16.79***
R^2	.21	.32	.23
Adjusted R^2	.20	.31	.22
Change in R^2		.11***	.02*

* $p < 0.05$.
*** $p < 0.001$.

Table 6
Regression results for technological innovation performance.

	Dependent variable Technological innovation performance					
	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Firm age	.07	.07	.07	.05	.07	.06
Firm size	.26**	.06	.22**	.26***	.06	.08
Efficiency-centered design			.22**		.08	
Novelty-centered design				.31***		.26***
Organizational learning		.43***			.40***	.38***
F	7.46***	16.65***	8.07***	12.27***	12.80***	17.38***
R^2	.08	.23	.13	.18	.23	.29
Adjusted R^2	.07	.21	.11	.16	.22	.28
Change in R^2		.15***	.05**	.10***	.11***	.11***

** $p < 0.01$.
*** $p < 0.001$.

$\Delta R^2 = 4.5\%$, significant at 0.01; $\beta = 0.22$, $p < 0.01$) and novelty-centered (model 7; $\Delta R^2 = 9.8\%$, significant at 0.001; $\beta = 0.31$, $p < 0.001$) business model designs both positively affect technological innovation performance (see Table 6). Second, the results of models 2 and 3 show that efficiency-centered and novelty-centered business model designs positively affect organizational learning (see Table 5). The result of model 5 shows that organizational learning positively affects technological innovation performance (see Table 6). Lastly, the influence of efficiency-centered business model design on technological innovation performance in model 6 is positive but is not significant in model 8 ($\beta = 0.08$, $p > 0.1$), indicating that organizational learning fully mediates the relationship between this design and technological innovation performance, which supports Hypothesis 4. The influence of novelty-centered business model design on technological innovation performance in model 7 is still significant ($p < 0.001$) but is weaker ($\beta = 0.31$ vs. $\beta = 0.26$) in model 9, showing that organizational learning partially mediates the relationship between this design and technological innovation performance, thus supporting Hypothesis 5.

Discussion and conclusions

The primary aim of this study was to explore how business models affect technological innovation performance through organizational learning. In doing so, a conceptual model for linking business model design themes, organizational learning, and technological innovation performance was developed. The model was tested using data collected from Chinese manufacturing firms embedded in global manufacturing networks. The results are summarized as follows.

The first primary finding of this study is that efficiency-centered business model design has an indirect influence on technological innovation performance. This result suggests that organizational learning fully mediates the relationship between this design and technological innovation performance, which is consistent with the results obtained by earlier work. For example, Ernst and Kim (2002) show that efficiency-centered business model designs foster organizational learning in global manufacturing networks, providing opportunities for innovation capability for local suppliers in developing countries. In addition, efficiency-centered design focuses on enhancing transaction efficiencies among business model participants (Zott & Amit, 2007), which makes information exchange and organizational learning more efficient and, in turn, facilitates new product development. However, with respect to new product commercialization, the influence of efficiency-centered design is limited because the commercial success of a new product requires a more novel business model design (Teece, 2010). For this reason, the direct influence of this design on technological innovation performance is limited.

The second primary finding of this study is that novelty-centered business model design has a mixed influence on technological innovation performance. This result indicates that organizational learning partially mediates the relationship between this design and technological innovation performance. On the one hand, this result supports the previous finding that novelty-centered business model design meets the requirements for the commercial success of new products (Teece, 2010). Accordingly, this design has a direct influence on technological innovation performance. On the other hand, this result extends the previous finding by showing that novelty-centered business model design has an indirect influence on technological innovation performance. One possible reason for this indirect influence is that this design focuses on improving the novelty of transactions among business model participants (e.g., connecting previously unconnected parties) (Zott & Amit, 2007), which provides opportunities for firms to acquire and use diverse and novel knowledge and, in turn, makes new products more novel.

The third primary finding of this study is that the influence of efficiency-centered design on organizational learning is stronger than the influence of novelty-centered design. Due to the emphasis on cooperation among existing business model participants (Zott & Amit, 2007), efficiency-centered design promotes the acquisition and utilization of familiar and existing knowledge, which in turn makes organizational learning more efficient and more certain (March, 1991). In contrast, novelty-centered design focuses on connecting new participants (Zott & Amit, 2007), which enhances the acquisition and utilization of unfamiliar and novel knowledge and, in turn, makes organizational learning less efficient and less certain (March, 1991).

To the best of my knowledge, this study represents the first large-sample empirical study of the relationship between business models and technological innovation performance. The study makes several contributions to the literature. First, it expands the scope of studies of the influence of business models on technological innovation performance by demonstrating the indirect influence of business models. Whereas prior studies focus on the direct influence of business models on technological innovation performance and find that business models ensure the success of the commercialization of technological innovation (e.g., Chesbrough & Rosenbloom, 2002; Teece, 2010), this study introduces organizational learning as the mediating variable and studies the indirect influence of business models on technological innovation performance. The results show that both efficiency-centered and novelty-centered business model design themes

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can affect technological innovation performance through organizational learning and that the mediating role of organizational learning varies according to the business model design implemented.

Second, this study enriches studies of the influence of interorganizational networks on technological innovation performance by showing that the business model is one of the antecedents of network embeddedness. Prior studies argue that network embeddedness possesses strategic value because it affects organizational learning and, in turn, technological innovation performance (e.g., Salman & Saives, 2005; Tsai, 2001). Nevertheless, few studies demonstrate how network embeddedness is achieved. This study provides a tentative answer. More specifically, it shows that efficiency-centered design is one of the antecedents of relational embeddedness (i.e., information sharing, trust, joint problem solving) and that novelty-centered design is one of the antecedents of network centrality.

This study provides practical insights for managers as well. First, firms can choose efficiency and novelty as their business model design themes. Every firm has its own business model (Chesbrough, 2007), but not every firm knows what its business model is or how to innovate its business model. This study provides additional evidence for conclusions drawn in the previous literature suggesting that efficiency and novelty are important business model design themes (Brettel et al., 2012; Zott & Amit, 2007, 2008). These two themes provide useful dimensions for understanding business models. Firms can also conduct business model innovation according to these two themes. Second, firms should reinforce organizational learning. This study finds that both efficiency-centered and novelty-centered business model design themes have an indirect influence on technological innovation performance through the mediating role of organizational learning. Therefore, firms should take steps such as optimizing organizational structure, building appropriate organizational regulations, optimizing the processes of knowledge acquisition and utilization, and strengthening learning capabilities to enhance organizational learning. We believe that this practical insight is important not only for our sample firms but also for other firms because business models possess a boundary-spanning nature (Dahan, Doh, Oetzel, & Yaziji, 2010; Zott & Amit, 2010). Thus, business models at least provide learning objects (e.g., customers, suppliers) as well as learning channels (e.g., relationships based on repeat transactions) for firms, which indicates that firms should reinforce organizational learning.

There are also several limitations to this study that should be addressed in future research. First, due to the constraints of sampling conditions, this study does not use the random sampling method to collect data. Although the sample is representative, the biases of the results of this study may be exacerbated. Future research should conduct an empirical study based on a random sample. Second, from a functionalist perspective, organizational learning is viewed as an objective construct in this study. To offer greater theoretical contributions and practical insights, further research should adopt other perspectives, such as organizational cognition (Sinkula, 1994). Third, this study does not examine the mutually causal relationship between the business model and organizational learning. Prior studies show that organizational learning affects the business model (e.g., Teece, 2010; Wu, Guo, & Shi, 2013). This study shows that the business model affects organizational learning. This finding indicates that the business model has a mutually causal relationship with organizational learning. Future studies could investigate this mutually causal relationship using a simultaneous equation model. Lastly, this study does not analyze the contingency factors of business models affecting technological innovation performance through organizational learning. Future research can attempt to introduce moderator variables, such as environmental dynamics and competitive intensity.

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