

Technological innovation of firms in China: Past, present, and future

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Abstract What do we know about technological innovation of firms in China? What are the directions for future research on this topic? This paper summarizes and discusses some of the newest literature on technological innovation of firms in China in the following three ways: (1) the influence of firms' external factors, (2) the influence of firms' internal factors, and (3) interfirm cooperation factors. Based on the analysis of these articles, we propose a framework which highlights these influencing factors, decision-making and implementation of technological innovation and innovation performance, in the context of China's emerging economy. This framework sheds lights on future innovation research.

Keywords Technological innovation strategy · Influencing factors · Innovation performance · Future · Framework · China

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China has been playing an important role in the development of the world economy. During the rapid development of China's economy, the technological innovation of Chinese firms has become one of the critical engines driving this development (Brockhoff & Guan, 1996; Li, Li, Liu, & Wang, 2005; Ni & Wu, 2000). Over the past two decades, the Chinese economic system has transformed from a central plan-based economy to a market-based economy. This has exerted a great impact on and brought a great deal of changes to the Chinese innovation system (Chiesa, Coughlan, & Voss, 1996). The financial crises in the late 1990s and in 2008 have made it clear to the Chinese government that the nation's sustainable growth in the global economy will depend on the further development of the science and technology system and on the competence of its technological innovation (Lu & Lazonick, 2001).

However, the extant research focusing on firms' technological innovation in transition economies such as China has been largely neglected since most research on firms' innovation has been conducted in the context of market economies (Deshpande & Farley, 2000). Moreover, the contents and features of Chinese firms' technological innovation strategies have been distinguished from others for the specific transitional context of China's economy (Bhagat et al., 2010; Ahlstrom, Chen, & Yeh, 2010). For example, accompanied with the transition toward a market economy, indigenous firms need flexible and multiple innovation strategies rather than only depending on the strategy of introduction, imitation, and absorption in order to adapt to the changes of the external environment.

This article summarizes the main viewpoints of the latest literature on technological innovation strategies of Chinese firms. We focus on two questions: (1) What do we know about the technological innovation of firms in China? (2) What are the directions for future research on this topic? This article can help scholars and managers to better understand the technological innovation strategies of Chinese firms. Further, this paper proposes promising directions for future research through building a new theoretical framework of technological innovation strategy in China.

Journals and articles on technological innovation of Chinese firms

The database for this article consists of 175 published articles culled from major journals which have published articles about innovation strategy in the recent decade (1996–2006). The selection and processing of these 175 articles have undergone three steps: (1) selecting journals; (2) finding relevant articles through keyword searches in several main research databases, such as EBSCOhost, Elsevier, Springer Link, and university libraries; and (3) classifying, reading, and discussing the articles.

We identify 20 journals which publish relevant articles by using two journal lists. One list of famous international journals is used by the School of Management at Xi'an Jiaotong University: the 20 journals are approximately distributed in four types, namely, Management Science, Engineering Management, Marketing, and Operations Management. The other list is developed by the Wirtschaftsuniversität Wien (Vienna University of Economics and Business Administration). This journal list contains more than 1,700 entries and has five categories, namely, A+, A, B, C, and D. We have made the selections through our rigorous review process as follows:

searching for relevant keywords, valuing quality of articles, and considering the levels of the journals and their international impact factors.

In detail, we have conducted advanced keyword searches using such phrases as “innovation strategy and China,” “technological innovation and China,” “technological innovation and strategy and China,” and so forth. Through this process, we find a database with 175 articles. Table 1 presents the search results and distributions of journals. Through carefully comparing the content of these papers with the demands of our study, we finally end up with 122 articles.

The characteristics of the articles we include are as follows: (1) All the articles are from top international journals. Articles in these journals have a high reputation for quality. In addition, starting with these journals could accelerate identification of relevant articles. (2) The articles nearly cover all present research about technological innovation strategies of Chinese firms both at home and abroad.

Basic influencing factors from extant literature

We have summarized the basic perspectives from the influences of firms’ external factors, internal factors, and interfirm cooperation on Chinese firms’ technological innovation strategies.

Table 1 Final distribution of gathered articles.

Journals	Number of articles
<i>Journal of Management Studies</i>	33
<i>Strategic Management Journal</i>	26
<i>R&D Management</i>	18
<i>Journal of Management</i>	16
<i>Journal of International Business Studies</i>	9
<i>Journal of Product Innovation Management</i>	9
<i>Industrial Marketing Management</i>	8
<i>Asia Pacific Journal of Management</i>	9
<i>IEEE Transactions on Engineering Management</i>	7
<i>Academy of Management Journal</i>	6
<i>Organizational Science</i>	6
<i>Research Policy</i>	7
<i>Journal of Business Venturing</i>	4
<i>Journal of Operations Management</i>	4
<i>International Journal of Technology Management</i>	3
<i>International Journal of Production Research</i>	3
<i>Journal of Business Research</i>	2
<i>Journal of Marketing</i>	2
<i>Management Science</i>	2
<i>Journal of High Technology Management Research</i>	1
Total	175

Influence of firms' external factors

The external environment is viewed as one of the key factors influencing firm strategy (Porter, 1998). Different from Western societies, Chinese society is transitioning from a traditionally central-planned economy to a market-oriented one, and Chinese firms have to compete in this incomplete market (Peng, 2002). On the one hand, profound institutional pressures have been identified for Chinese firms conducting their innovation activities in a transition economy context (Peng et al., 2008). In China, the government has pushed and controlled the transition from a planned economy to a market economy (Tan & Tan, 2005). Therefore, rather than competition, government control has become an important external factor for Chinese firms' technological innovation. On the other hand, Chinese firms have had to adapt their technological innovation strategies to the changing business environment and the interplay between external and internal environmental complexity and dynamism (Li et al., 2005). Overall, the market environment and government policies have been important factors which exert significant influence on the innovation of Chinese firms (Li, Liu, & Zhao, 2006a; Li, Sun, & Liu, 2006b). Some main viewpoints are shown in Table 2.

Uncertainties from market competition In China's transition economy, the uncertain environment has an extensive influence on firms' technological innovation. The direct influence of the uncertainty of market, competition, and technology on technological innovation has been examined (Li et al., 2006a, b; Zhou, Yim, & Tse,

Table 2 Main viewpoints for firms' external factors.

Category	Author and Year	Viewpoints and Findings
Uncertain environment	Li et al. (2006b); Zhou et al. (2005b)	Direct influence of uncertainty on technological innovation
	Li et al. (2005); Tan and Litschert (1994); Tan and Tan (2005)	Indirect influence of uncertainty on relationship between NPD and firm performance
	Tan and Litschert (1994); Tan and Tan (2005)	Firms in Chinese context will prefer a more defense-oriented strategy when environment uncertainty is increasing
	Zhou et al. (2005b)	Most of the market forces will positively influence breakthrough innovation
	Tan and Litschert (1994); Tan and Tan (2005)	Classify environment uncertainty into three kinds: complexity, dynamism, and hostility
	Li (2001)	Environment factors can mediate the relationship between product innovation strategy and new technology venture performance
Influence of government	Huang et al. (2004)	There are five important components in the framework of innovation policy
	Liu and White (2001)	Chinese NIS has three levels: primary actors, secondary actors, and institutions
	Huang et al. (1999)	In steel industry, many government departments have the right to intervene in the firm's R&D process

2005b). Researchers have also explored the indirect influence of these factors on the relationship between new product development (NPD) and firm performance (Li et al., 2005; Tan & Litschert, 1994; Tan & Tan, 2005). Further, some scholars find a moderating effect on the relationship between product innovation strategy and new technology venture performance (Li & Gima, 2001).

Compared with studies in developed economies, the Chinese studies report some different results. For example, Tan and Litschert (1994) and Tan and Tan (2005) noted that, during the transition from a planned to a market economy, firms in China have preferred a more defense-oriented strategy when environmental uncertainty is high. Furthermore, they concluded that an increase in environmental uncertainty will negatively impact proactive, future orientation and risk-taking strategies, which is inconsistent with the study of Miller and Friesen (1983).

As far as the direct effect is concerned, Zhou et al. (2005b) found that most of the market forces, such as demand uncertainty, technological turbulence, and competitive intensity, will positively influence breakthrough innovation. Whether the indirect effect of environmental factors on innovation will be positive or negative partially depends on the classification of environmental factors and the kinds of mediating factors they choose. Tan and Litschert (1994) and Tan and Tan (2005) classified environmental uncertainty into three kinds: complexity, dynamism, and hostility, and argued that these will influence firm performance differently through various strategic orientations. Other scholars find that environmental factors such as institutional support, environmental turbulence, and inefficient competition can mediate the relationship between product innovation strategy and new technology venture performance (Li, 2001). Different results from existing studies challenge us to inquire into the following questions: Do these environmental factors have different influences on different kinds of innovation? How do these environmental factors affect the technological innovation of different firms in China? How do the interactions of these factors influence the technological innovation of Chinese firms?

Influence of government In China, the government still plays an important role in firms' innovation processes by establishing supportive policies, making institutional arrangements, and even directly intervening. The Chinese government has made great efforts in building the national capability of science and technology (S&T) since the 1978 reforms (Fischer & Zedtwitz, 2004). Huang, Amorim, Spinoglio, Gouveia, and Medina (2004) noted that there are five important components in the innovation policy framework: reform in the public S&T institutions, financial policy, business innovation support structure, human resources policy, and legislative action. Within these five aspects, there are two specific areas where China has fallen behind other countries: (1) education and human resources; and (2) protection of intellectual and industrial property (Huang et al., 2004).

In the area of China's innovation policy, it is necessary to define a long-term institutional strategy to strengthen the regimes for innovation issues (Huang et al., 2004). From the macro view, China's national innovation system (NIS) has gained widespread attention and has played a key role in Chinese firms' innovation activities. According to Liu and White (2001), the Chinese NIS is divided into three levels: primary actors, secondary actors, and institutions. The primary actors are the organizations which play education, R&D, implementation, end-use, and linkage

roles in the NIS. The secondary actors are organizations that affect the behavior of or interaction between primary actors. Institutions are the sets of practices, rules, and norms that guide or constrain an actor's behavior.

In some industries, the Chinese government directly participates and guides firms' innovation process. For example, Huang, Schroder, and Steffens (1999) noted that, in the Chinese steel industry, many government departments have the right to influence firms' R&D process, which often guides innovation. In addition, the government participates in and organizes technological innovation affairs by related government organizations, including the State Steering Committee of Science and Technology and Education, the Ministry of Science and Technology—which is a principal participant in China's technological endeavors—and the Chinese Academy of Science, which has been an essential part of China's S&T system in the planned economy and still offers the largest body of S&T research (Huang et al., 2004).

Influence of firms' internal organizational factors

The choice of technological innovation strategies depends not only on the external environment but also on the internal environment that relates to organizational factors, which include structure, process, governance, and so forth. The extant literature emphasizes research on the following internal influencing factors: strategic orientation of firms, top management teams (TMTs), organizational control, and organizational learning. Some main viewpoints are depicted in Table 3.

Strategic orientations of firms Strategic orientation reflects a firm's focus in terms of creating behaviors that help it achieve superior performance (Gatignon & Xuereb, 1997). Market and innovation orientations are the two most important strategic orientations for Chinese firms, both of which have important effects on technological innovation (Deshpande, Farley, & Webster, 1993; Hurley & Hult, 1998; Li et al., 2006a; Noble, Sinha, & Kumar, 2002; Zhou, Gao, Yang, & Zhou, 2005a, Zhou et al., 2005b).

Market orientation is defined as a firm's orientation toward the promotion and support for the selection, dissemination, and responsiveness to market intelligence to serve customer needs (Kohli & Jaworski, 1990). By driving a continuous and proactive disposition toward meeting customer needs and emphasizing greater information use, Atuahene-Gima (1996) noted that market orientation can enhance an organization's innovativeness and new product performance in Chinese firms. Moreover, many researchers have further emphasized the mediating role of innovation between market orientation and firm performance (Han, Kim, & Srivastava, 1998; Hurley & Hult, 1998). However, some have argued that an overemphasis on customers will make market-oriented firms pursue incremental innovations and myopic R&D (Christensen & Bower, 1996). They argue that customers are inherently shortsighted and do not necessarily know what they really want, so market orientation may not provide a firm with true insights into product innovation, which will hurt a firm's competitive advantage. To address this controversy, Zhou et al. (2005b) divided breakthrough innovation into technology-based innovation and market-based innovation, and found that market orientation facilitates innovation that uses advanced technology and offers greater benefits to mainstream customers, but inhibits innovation that targets emerging

Table 3 Main viewpoints for firms' internal factors.

Category	Author and Year	Viewpoints and Findings
Market orientations	Deshpande et al. (1993); Hurley and Hult (1998); Li et al. (2006a); Noble et al. (2002); Zhou et al. (2005a, b); Zhou & Li (2007)	Market orientation and innovation orientation are the two kinds of most important strategic orientations for Chinese firms
	Atuahene-Gima (1996)	Market orientation can enhance an organization's innovativeness and new product performance
	Christensen and Bower (1996)	Overemphasis on customers will make market-oriented firms pursue incremental innovations and myopic R&D
Entrepreneurship orientation	Zhou et al. (2005b)	Entrepreneurial orientation facilitates both types of breakthrough innovations
	Jeong et al. (2006); Li et al. (2006b)	Entrepreneurship orientation has a positive effect on the improvement of NPD
Top management team (TMT)	Chen et al. (2006)	TMTs are valuable for helping organizations overcome obstacles and innovate effectively
	Chen et al. (2005)	Effective conflict management and cooperation between members of TMT will lead to its effectiveness; can also promote organizational innovation
	Tan (2006a)	Entrepreneurs in POEs, rather than in SOEs, are more likely to make innovative and risk-taking decisions
Organizational control	Cardinal (2001); Hitt et al. (1996); Li et al. (2006a, b);	Process control and output control have had much attention in innovation literatures
	Li et al. (2006a)	Process control is positively related to the degree of improvement in NPD and output control is negatively related to the degree of improvement in NPD
Organizational learning	Bell and Pavitt (1992); Dodgson (2000); Lall and Teubal (1998); Xie and Wu (2003)	Technological learning enables firms to acquire technology and to accumulate technological capability
	Lall and Teubal (1998)	Learning is an incremental process and its locus changes over time
	Xie and Wu (2003)	Chinese firms' learning process takes a form of incremental learning

market segments. Therefore, from existing research, we can see that the relationship between market orientation and innovation is very complicated and needs further study.

Entrepreneurial orientation is described as a learning and selection mechanism that engenders exploratory, risk-seeking behaviors in the product innovation process (Lumpkin & Dess, 1996). Compared with market orientation, entrepreneurial orientation is distinguished by three characteristics: a high degree of innovativeness,

risk-taking, and proactiveness (Covin & Slevin, 1989). Entrepreneurially-oriented firms are more prone to radical innovation since innovation initiatives usually involve the creation of new resource combinations and more experimentation. Gatignon and Xuereb (1997) also argue that entrepreneurial orientation is akin to technological orientation because it increases firms' abilities to build new technical solutions to meet customers' latent needs. In brief, most studies suggest that entrepreneurial orientation will promote technological innovation. For instance, Zhou et al. (2005b) indicated that entrepreneurial orientation facilitates both types of breakthrough innovation, and both Jeong, Pae, and Zhou (2006) and Li et al. (2006a) found that entrepreneurship orientation has a positive effect on the improvement of NPD.

Top management teams TMTs often play a central role in the organization and implementation stages of innovation (Leonard & Straus, 1997; Nonaka, 1990). The important role of TMTs in firms' innovation has been extensively recognized (Boeker, 1997; Kilduff, Angelmar, & Mehra, 2000; Pegels, Song, & Yang, 2000; Weinzimmer, 1997). TMTs are valuable for helping organizations overcome obstacles and innovate effectively (Chen, Tjosvold, & Liu, 2006).

Interestingly, some researchers in China, traditionally viewed as a collectivistic country, still pay attention to conflict management and cooperation between members of TMTs (Chen, Liu, & Tjosvold, 2005; Chen et al., 2006; De Boer, Gan, & Shan, 1998). For example, Chen et al. (2005) propose that effective conflict management and cooperation among TMT members will lead to a high level of TMT effectiveness and thus promote organizational innovation. De Boer et al. (1998) argue that the most crucial issue for Chinese firms in the conflict management of TMTs is to make sure that objectives are clearly translated and recognized by directors at different levels, rather than communicated deeply only between top management members.

Further, while private-owned enterprises (POEs) have grown rapidly during the transition, state-owned enterprises (SOEs) still play an important role in economic development and social stabilization. Tan (2006a, b) comparatively investigated the characteristics of Chinese managers and entrepreneurs in SOEs and POEs and their reactions to the regulatory and changing environment. He concluded that entrepreneurs in POEs, rather than their counterparts in SOEs, are more likely to make innovative and risk-taking decisions when faced with market uncertainty and technological turbulence. And the speed, stealth, and sound execution in POEs further facilitate entrepreneurs to harvest first-mover advantages and thus increase their chances for survival in a turbulent environment.

Organizational control Organizational control refers to any process by which managers direct, motivate, and encourage members to act in desirable ways to meet the firm's objectives (Eisenhardt, 1985). It is important for firms to exert effective organizational control during innovation (Atuahene-Gima, 2005; Cardinal, 2001) because it could affect managers' assessment of performance risk and innovation modes and outcomes. Organizational control has become a particularly pivotal issue for Chinese firms since they usually face higher innovation risk under the highly uncertain environment in China (Gima & Li, 2006; Li & Gima, 2001).

Research in the innovation literature has identified two forms of control, namely process control and output control, and has investigated the different impacts these have on firms' innovation (Cardinal, 2001; Hitt, Hoskisson, Johnson, & Moesel, 1996; Li et al., 2006a). Specifically, process control refers to the extent to which managers emphasize procedures and behavioral activities in monitoring, evaluating, and rewarding employees, and the means they use to achieve desired results. Therefore, the use of process control requires that managers have a deep understanding of the NPD process. Formal and informal face-to-face communications between managers and project members on subjective and long-term evaluative criteria are often necessary for process control (Barringer & Bluedorn, 1999), therefore it is expected to engender exploration and radical innovation by encouraging risk-seeking behaviors among employees (Hitt et al., 1996).

In contrast, output control refers to the extent to which managers place emphasis on results when monitoring, evaluating, and rewarding employees (Anderson & Oliver, 1987). It entails objective criteria such as financial results and annual corporate growth in the evaluation of project members' performance. Therefore output control will encourage low-risk activities and incremental innovation because those employees bear a disproportionate share of the innovation performance risk and thus develop risk-averse behaviors. By using a sample of 57 pharmaceutical firms, Cardinal (2001) found that output control is positively related to drug enhancement, the relationship between process control and drug enhancement is mixed, and both process control and output control are positively related to the likelihood of new drugs. In contrast, by using a sample of 607 Chinese firms, Li et al. (2006a) empirically indicated that process control is positively related to the degree of improvement in NPD and output control is negatively related to the degree of improvement in NPD. These mixed findings indicate that the relationship between organizational control and technological innovation is very complicated and needs further investigation.

Organization learning Organizational learning, especially technological learning, has been widely studied in emerging economies (Cardoza, 1999; Kim & Lee, 2002). Organizational learning can help firms acquire new knowledge, accumulate interfirm knowledge stock, form corporate culture, and enhance competitive capabilities. China, at present, is a technology catching-up nation, such that firms' technological learning under this context differs greatly from their Western counterparts (Lu & Lazonick, 2001; Mu & Lee, 2005; Xie & Wu, 2003).

First, it has been extensively discussed and concluded that upgrading technological capability through technological learning for economic development is important and significant for emerging economies to shorten the technological gap with developed economies. China, since the reform in the late 1970s, adopted the open-door policy and imported a lot of advanced technology and technological equipment. Because of this, Chinese firms have been able to acquire technology and accumulate technological capability through technological learning—an important element for firms' development and survival (Bell & Pavitt, 1992; Dodgson, 2000; Lall & Teubal, 1998; Xie & Wu, 2003).

Second, it is important for Chinese firms to understand the interplay between organizational learning and technological innovation capability building. Late-comers, like Chinese firms, usually start with the assimilation of production

capability, make changes to it, and gradually accumulate a stock of knowledge. Only when this has been done successfully will they try to build innovation capability to compete with multinational corporations (MNCs) at home and abroad (Xie & Wu, 2003). Organizational learning is an incremental process and its locus changes over time (Lall & Teubal, 1998). Different from firms in Western developed economies, Chinese firms have gone through a more incremental learning process.

Third, some researchers (Mu & Lee, 2005; Xie & Wu, 2003) assert that, given a huge domestic market in China, Chinese firms can access world-class knowledge and technology through spillovers from MNC subsidiaries and joint ventures (JVs), as well as segment the market into more favorable parts to sell its innovative new products. In addition, Mu and Lee (2005) found that technological stage-skipping catching-up occurs in the Chinese telephone switch-making industry given the predictability of the technological trajectory, initial levels of technological capability, and the nature of access to knowledge and transfer terms.

Interfirm cooperation

Over the past years, a consistent theme has emerged that increased collectivism leads to more cooperation, while increased individualism leads to more competition (Doney, Cannon, & Mullen, 1998). Although the level of collectivism has been decreasing since the reform and open-door policy in 1978, China is still a traditional collectivistic nation thus more cooperation is expected among Chinese firms. Some main viewpoints are depicted in Table 4.

Interfirm cooperation and/or alliance Social capital theory argues that cooperation and alliance with groups and individuals outside of the organization can be a substitute that helps to lower their dependence on critical resources in the external environment. Two of the important objectives of cooperation and alliance are knowledge transfer and reciprocal learning, which greatly improve firms' innovation.

Many scholars have investigated the effects of cooperation and alliance on innovation in China: some have examined the direct influence (Inkpen & Wang, 2006); others have found moderating effects of strategic alliance between product innovation and performance of new technology ventures (Li & Gima, 2001). In addition, marketing alliances may contradict the negative impact of environmental hostility on new venture performance (Li, 2001). Furthermore, with Chinese firms increasingly adopting long-term, flexible, relationship-oriented partnering arrangements with foreign market entry strategies, international strategic alliances have become widespread (Luo, 2003). By studying strategic alliances in international distribution channels, Mehta, Polsa, Mazur, Fan, and Dubinsky (2006) empirically verified learning orientation, relationship longevity, and relationship closeness as determinants of cooperation, which is an antecedent of performance and relationship satisfaction.

Li and Gima (2002) found that successful agency business activity is positively related to new venture performance but negatively related to product innovation efforts. Taking China's telecom equipment industry as an example, Fan (2006) pointed out that Chinese firms should prioritize building innovation capability from

Table 4 Main viewpoints for interfirm factors.

Category	Author and Year	Viewpoints and Findings
Interfirm cooperation and/or alliance	Li and Gima (2001)	Moderating effect of strategic alliance between product innovation and performance of new technology ventures
	Luo (2003)	With Chinese firms increasingly adopting features, international strategic alliances have become widespread
	Li and Gima (2002)	Successful agency business activity is positively related to new venture performance but negatively related to its product innovation efforts
Network and managerial ties	Li (2005)	Formation of managerial networks is driven by institutional factors, environmental dynamics, and organizational characteristics
	Burt (1992); Peng and Luo (2000); Wu and Leung (2005)	Social capital embedded in the managerial ties is viewed as beneficial when environmental uncertainty is high, market competition is imperfect, or when the firms transact in a transition economy
	Tsui and Farh (1997)	Most Chinese cultivate <i>guanxi</i> , which govern firm's attitudes toward social and business relationships
	Li et al. (2008)	Managerial ties may offer only conditional value. Foreign firms have a competitive disadvantage from tie utilization compared with domestic firms. Managerial ties are less effective for fostering performance when competition becomes more intense. And ties lead to higher levels of firm performance when structural uncertainty increases
Cluster cooperation	Porter (1998)	Clustering of companies leads to high productivity
	Eun et al. (2006)	Explains cooperation between university and industry from the macro and micro level
	Tan (2006b)	It is crucial to build sustainable competitive advantages that will bind clusters of entrepreneurial firms, especially the smaller ones

the very beginning to establish their competitiveness and to survive competition with both MNCs and domestic companies. Therefore, it is necessary to study to what extent and under what circumstances cooperation and alliance will build and improve firms' innovation capability.

Network and managerial ties A number of studies have shown the importance of managerial networking for doing business in emerging economies, especially in China (Farh, Tsui, Xin, & Cheng, 1998; Lovett, Simmons, & Kali, 1999; Peng & Luo, 2000). Despite the growing consensus that managerial networks matter, most studies thus far have focused on the strategic value of interpersonal networking, whereas the issue of how it develops has been less systematically examined (with a few exceptions such as Luo, 2003; Park & Luo, 2001; Peng & Zhou, 2005; Xin &

Pearce, 1996). Li (2005) suggested that the formation of managerial networks is driven by institutional factors (e.g., ownership, location), environmental dynamics (e.g., market growth, competitive intensity), and organizational characteristics (e.g., firm size). However, firms can also be heterogeneous in their philosophy on how to conduct business (Park & Luo, 2001).

The social capital embedded in managerial ties is viewed as beneficial when (1) environmental uncertainty is high, (2) market competition is imperfect (Burt, 1992), or (3) the firms transact in a transition economy (Peng & Luo, 2000; Wu & Leung, 2005). Most Chinese cultivate intricate and pervasive personal ties (*guanxi*), which govern firms' attitudes toward social and business relationships (Tsui & Farh, 1997). A growing number of literature on Chinese management and organization has contributed tremendously to our understanding of the role of *guanxi* behind firm performance (Luo, 2003; Luo & Chen, 1997; Park & Luo, 2001; Peng & Luo, 2000). Some scholars have proposed and tested a contingency perspective to specify the nature of such a micro-macro link (Peng & Luo, 2000), suggesting that the impact of managerial ties on firm performance differs among firms with different ownership types, business sectors, sizes, and industry growth rates. Therefore, it makes sense to highlight both the extent to which managerial ties are beneficial and the limits of those ties under certain circumstances.

Cluster cooperation Assuming homogeneity of clusters, Porter (1998) advocated that clustering of companies leads to high productivity because of the access to specialized inputs and employees, information, complementarities across products, and institutions and public goods. In China, science parks have been built by the central or local governments, as well as by other research institutes such as top class universities.

From the late 1970s, many universities in China have set up their own university-run enterprises, to transfer their research findings of S&T into products or services. Cooperation between university and industry has been a popular model at macro-level, university-run enterprises located in the highly entrepreneurial universities to (1) share knowledge flow, and (2) at the micro-level, to pursue economic gains, strong internal resources, and barren external environments for transferring S&T knowledge (Eun, Lee, & Wu, 2006).

MNCs also take advantage of knowledge transfer and supplier-chain cooperation in Chinese science parks. At present, the majority of MNCs' R&D centers are located in the three economically most important cities of China: Beijing, Shanghai, and Guangzhou. These cities are noted for their highly qualified human resources, well-developed infrastructure, numerous industrial sectors and high-tech parks, and mature local scientific communities including top notch universities and research institutes (Li & Zhong, 2003).

Although many researchers have identified the clusters and science parks in China, several questions remain unclear. What are the mechanisms that motivate firms and universities to invest in these clusters and science parks? What is the strategy for smaller clusters owned by local governments or universities to develop and lure more robust corporations to join? As Tan (2006a, b) demonstrated, it is crucial to build sustainable competitive advantages that will bind clusters of entrepreneurial firms; and firms in these clusters, especially the smaller ones, can build strategic flexibility and adaptability so that they can benefit from fast second-mover advantages, quickly make the transition from imitation toward innovation,

and establish competitive positions, or leverage flexibility in order to break into the international market.

In sum, we have reviewed and concluded three dimensions of influencing factors of firms' technological innovation in China. These dimensions have evolved from different perspectives and have focused on different aspects of Chinese firms' technological innovation. Most of the leading perspectives have been broadly discussed in our article, which shows a bird's-eye view of research on firms' technological innovation strategy in China. Overall, the clear grouping of influencing factors, namely, external environmental factors, internal factors, and interfirm cooperation provides us a fertile ground to scrutinize the present findings and direct future research on firms' technological innovation in China.

A framework for future research

It is clear that previous research has made great contributions to understanding what will affect firms' technological innovation strategies. However, these papers suffer from several shortcomings. First, some studies depend on a static perspective rather than a dynamic approach. While the linear directions of relationships between variables have been studied, research on dynamic aspects of complex relationships still remains relatively rare (Peng, 2002). Second, some research results have a limited scope of application: most results from one industry can hardly be applied to other industries. Many papers give a general conclusion only based on very limited samples and data. Finally, there are many other important issues that remain unexplored, such as how external factors affect internal factors and continuously influence behaviors of technological innovation strategies. Moreover, although some papers demonstrate a positive influence of innovation strategy on the performance of companies in China's transition economy, research on the relations between innovation strategy and firm performance still needs further strengthening through extensively considering the influence path and other contextual factors which impact on the relationship.

The summary of key findings within the literature provides us a point of departure for future studies of Chinese firms' technological innovation. In this section, we rely on the above insights and views to provide the basis of an integrative model for future research. Key to developing this model is that, among the three levels of influencing factors, some factors need further research to clearly verify their impact and dynamic influence on Chinese firms' technological innovation. In addition, other influencing factors should be added and explored for systematic research on their effect on Chinese firms' technological innovation. The resulting framework is depicted in Figure 1.

Framework overview

By summarizing the literature, we can generalize the research factors—external environmental, internal organizational, and interfirm—influencing Chinese firms' technological innovation strategies. Future research should put more emphasis on studying the effects of the following factors on the innovation of firms as well as the their interactions based on our fundamental framework. The below

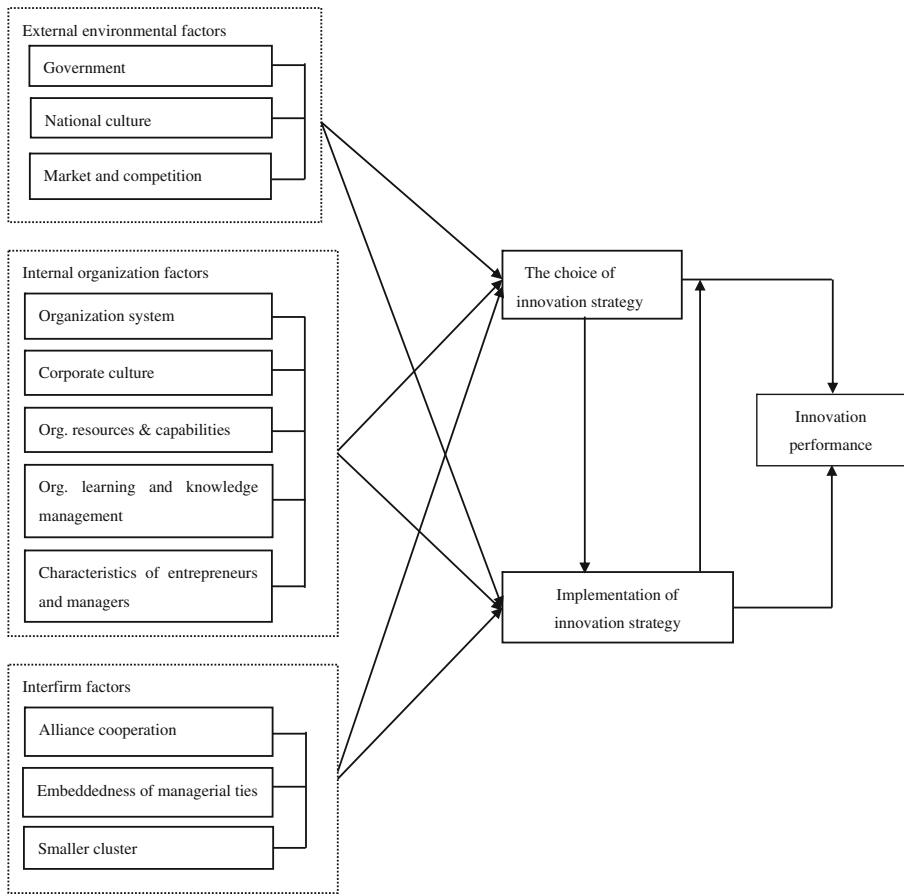


Figure 1 A framework for future research

eleven factors constitute the main contents on technological innovation strategy of firms in China.

External environmental factors From the extant literature, we recognize that there are different results on the relationship between the external environment and Chinese firms’ technological innovation. For example, studies on direct influence of market uncertainty report inconsistent results (Miller & Friesen, 1983; Tan & Tan, 2005). To reconcile the conflicting findings, we have to answer the following questions: Are there any other fundamental environmental factors which affect Chinese firms’ technological innovation? How do the interactions of these factors influence Chinese firms’ technological innovation in different market situations? We propose that government and social culture are two important environmental factors in determining Chinese firms’ technological innovation strategies; meanwhile, firms face different market and competition situations, which also needs to be taken into consideration.

- (1) *Government.* Government’s effect on firms’ technological innovation should not be neglected despite some studies suggesting that the government should relax its control on innovation (Huang et al., 1999). The Chinese NIS still needs further

- improvement to adapt to global market changes. There is no doubt that the Chinese government should build a new NIS and use more encouraging policies, for example, financial and tax, investment, industry regulation, and so on.
- (2) *National culture.* National culture is a system of values and norms shared by a large number of people conditioned by similar background, education, and life experiences (Doney et al., 1998). Culture is the foundation of innovation activities. Many studies show that excellent culture is positively associated with firms' technological innovation. Lu and Peng (2008) pointed out that national culture and administrative heritage have been playing significant roles in knowledge transfer and innovation activities in Asia Pacific countries like China. Carney (2003) argued that national culture is related to what kind of technologies and innovation strategies firms will take. As a result, cultural innovation should be emphasized and developed with companies' technology and strategy (Liu & Mao, 2003).
 - (3) *Market and competition.* The market modern firms are facing is becoming more uncertain and dynamic than ever before. Diversified market environment forces such as customers, cooperative companies, and competitors have exerted crucially important influence on firms' innovation activities in China. In order to acquire a position in severe competition, strategic alliances between firms have become a new development trend. Therefore future research needs to place more attention on the coevolution of market and competition environments and Chinese firms' technological innovation strategies (i.e., how the uncertainty and dynamics of market and competition environments in China affect firms' innovation strategy; how Chinese firms adapt their technological innovation choices to the external environment and influence the environment).

Internal organizational factors Based on the review of previous literature, we find mixed conclusions about the relationships between some organizational factors and technological innovation, such as the effect of organizational control on firms' technological innovation (Cardinal, 2001; Li et al., 2006a, b). There is a shortage of research on the influences of other organizational factors, such as corporate governance and corporate culture. Therefore, we propose that it is necessary to systemically investigate how and to what extent the following five internal organizational factors will influence organizations' technological innovation in China.

- (1) *Organizational system.* The organizational system (corporate governance, organizational structure, organizational mechanism) should support corporate innovation targets and be consistent with the corporate innovation strategy and the environment, technology, and culture that corporation is facing. In addition, building a more effective incentive system to enhance motivating innovators can lead to better development of technology.
- (2) *Corporate culture.* Corporate culture such as values, norms, and beliefs play a critical role in supporting creativity and innovation through influencing individual and group behavior (Martins & Terblanche, 2003). Technological innovation will hardly develop in a satisfactory manner without an appropriate corporate culture (Claver, Llopis, Garcia, & Molina, 1998). Deshpande et al. (1993) found that Japanese companies with corporate cultures emphasizing entrepreneurship and competitiveness outperform those dominated by internal cohesiveness or hierarchies. Future

- research should focus on what kinds of corporate culture facilitates firms' technological innovation under different contexts, and which will become a key part of determining firms' technological innovation strategies (Liu & Mao, 2003).
- (3) *Organizational resources and capabilities.* Resources and capabilities are essential components for firms' technological innovation. Abundant resources can drive innovation activities rapidly and improve corporate capabilities to a particular extent. In addition, firms' choice of innovation strategies depends on the resources and capabilities they have. Veugelers and Cassiman (1999) found that large firms with sufficient resources and capabilities are more likely to combine both internal and external knowledge acquisition in their innovation strategy, while small ones usually restrict their innovation strategy to an exclusive make or buy strategy. Firms' resources and capabilities are expected to play an important role in determining firms' innovation strategies and improving technological innovation activities and performance.
 - (4) *Organizational learning and knowledge management.* Organizational learning and knowledge management are hot issues in contemporary management literature and technological innovation research, but many relevant issues still need to be explored further in the context of Chinese firms' innovation.
 - (5) *Characteristics of entrepreneurs and managers.* Factors such as senior leaders' managerial capabilities, their attitudes toward change, and unification of the management group's target have a significant influence on innovation (Zhou et al., 2005a). Moreover, the attitudes of entrepreneurs and managers toward risk and innovation vary greatly in different companies. Therefore, enhancing corporate internal management, especially the behaviors of entrepreneurs and managers, has a positive effect on corporate innovation activity.

Interfirm factors Although some researchers have identified the important roles that interfirm clusters play in Chinese firms' innovation, it is not certain whether and to what extent these factors would influence enterprises' innovation in China. Therefore, we propose that the following three key questions should be extensively explored: (1) Under what context and to what extent will alliance cooperation have a positive effect on Chinese firms' innovation capability building? (2) How the embeddedness of managerial ties will benefit the firms' technological innovation? (3) What is the role of smaller clusters in Chinese firms' innovation strategy determination and implementation (and what are the strategies for smaller clusters to develop in the future)? It is critical for enterprises' pursuit of second-mover advantage to build clusters of small entrepreneurship firms (Tan, 2006a, b). Moreover, the interaction of these interfirm factors, such as the combination of managerial ties and cluster characteristics, will determine to what extent firms take advantage of them to enhance their innovation performance (Li, Poppo, & Zhou, 2008). Thus we propose the interaction of embeddedness of managerial ties, competition relationships, and smaller cluster needs further investigation.

- (1) *Decision of innovation strategy.* The management of innovation strategy is guaranteed to improve corporate performance, especially in strategic decision-

- making. Therefore, how to set up an appropriate strategy on the basis of a corporate external and internal environmental analysis, and then establish a proper technological innovation strategy, is key to successful innovation (Peng, 2005).
- (2) *Implementation of innovation strategy.* The implementation of strategy will be influenced by support from the organization and uncertainty of the external environment. Thus, strong support from senior leaders and common staffs are fundamental for implementation of corporate innovation strategy. Also, the moderating effect of innovation implementation on the relationship between innovation strategy and innovation performance should be taken into consideration to clearly understand under what context certain innovation strategies will result in high innovation performance.
 - (3) *Innovation performance.* Innovation performance can be divided into result performance and potential or process performance. How to combine these two aspects and weigh innovation effect logically are very influential for building and completing innovation strategic systems.

In general, governmental behaviors, market and competition, and social culture belong to external environmental factors; corporate culture, resources and capabilities, organizational system, characteristics of entrepreneurs, and organizational learning belong to internal organization factors; interfirm factors consist of alliance cooperation, embeddedness of managerial ties, and smaller clusters. In addition, all these factors on the left side of Figure 1 influence the path and decision of innovation strategy decision and implementation. Obviously, governmental behaviors and policies are expected to have a larger influence on innovation strategy decision-making rather than innovation strategy implementation, and decision of innovation strategy decides the implementation of innovation strategy. Innovation performance represents the comprehensive results of decision of innovation and implementation of innovation strategy.

Interactions of the influencing factors

First, market environment itself interacts with government behaviors and policies. On the one hand, intense market competition and global economic integration provide a new environment for firms to conduct their technological innovation activities. In this new situation, it is necessary for Chinese firms to adopt appropriate innovation strategies, not only matching the market environment but also keeping consistent with the government policies for industry development. On the other hand, the interaction of market environment with government behaviors must also be recognized by Chinese firms to better adapt their technological innovation strategies to the external environment. Government policies can also influence the change of market and competition environments through creating concrete institutions and policies for supporting a favorable innovation environment. The development of market competition and a global economy also bring challenges and changes to current government behaviors and policies. Therefore, market, competition, and government behaviors affect each other, composing the external environment for corporate innovation activities.

Second, corporate culture should keep pace with the development of technology strategy. As a flexible technology, corporate culture can indirectly

(or directly) improve corporate technology capability and competitiveness. Besides, with the development of firms' technology and strategy, corporate culture should be changed in order to better facilitate firms' innovation (Liu & Mao, 2003).

Third, organizational system and the characteristics of entrepreneurs and managers are interplayed with each other. Entrepreneurs and managers with diversified behavioral characteristics usually choose different organizational systems because they are always related to different ways of communication and corporate internal objectives. In addition, entrepreneurial features also affect organizational learning behaviors.

Fourth, the interaction of corporate culture and organizational system is also important. On the one hand, change of culture will influence staff and organization behaviors, which further interplays with organizational structure and governance, resulting in changes of firms' innovation strategies. On the other hand, culture should adapt to innovation of the organizational structure as well, since the organizational system can also help to realize corporate culture. Therefore, a good organizational system may accelerate organizational culture innovation as well. Except direct relationships, there also exist indirect relationships between each factor.

Fifth, interfirm factors such as the interactions of cooperation alliances and contextual factors, such as institutions, industrial policies, the embeddedness of managerial ties, and smaller clusters would play a contingency role in Chinese firms' innovation activities. Under certain contexts these factors will positively relate to enterprises' high innovation performance either through appropriate innovation strategy setting and implementation, or by a proper utilization of these interfirm resources. From this view, we argue that in order to best take advantage of cooperation alliance as a promoter for firms' innovation, Chinese firms need to consider using different cooperation alliances under different situations. Also, the value of managerial ties will be conditioned with its own embeddedness, enterprises' characteristics, and capabilities. Finally, smaller clusters are expected to facilitate entrepreneurship and faster innovation development.

According to our proposed framework, future research should emphasize the following issues: First, there are few studies about path and decision of technological innovation strategy and its implementation. How to make decisions scientifically becomes the key to successful innovation strategy after understanding the corporate external and internal environments and the condition of resources. Strengthening research on this aspect can offer some beneficial references and supports for enterprise and government decisions. Second, at present, research on national culture and corporate culture is very limited. But these factors' influence on innovation cannot be neglected, especially under the context of Chinese firms' technological innovation. The impact of Chinese traditional culture on firms' technological innovation strategies should be enhanced in future research. Third, current research about market, competition, and integration is insufficient. The development of S&T parks and their impact on Chinese firms' technological innovation needs more exploration. Finally, research on the mutual influence of different factors, rather than focusing on single factors, can also provide much useful help and guidance for corporate innovation.

Conclusions

The purpose of this paper was to examine and review relevant articles so that more scholars and managers can have knowledge on the research status of technological innovation strategy of Chinese firms. One of our main contributions was proposing a framework for future research in the field of technological innovation strategy in China. In this framework, we especially emphasized the research on decision-making and implementation of innovation strategy. Meanwhile, we paid more attention to influencing factors and innovation performance analysis. In conclusion, we suggest that more researchers focus their attention on the interesting, important, but still underexplored field of technological innovation in China.

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