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Ownership and firm innovation in a transition economy: Evidence from China

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ABSTRACT

We examine innovation performance of firms in a transition economy from an ownership perspective. We focus specifically on the relationship between ownership structures and firm innovation performance. Drawing on data from 548 Chinese firms we find volume of patent registration to be most strongly influenced by foreign ownership in the firm along with firm affiliation within a business group. The influence of state and institutional ownership on innovation performance is positive but lagged. Contrary to expectations, insider ownership leads to lower innovation performance and concentrated ownership has no significant impact. Our study has two principal contributions. Firstly, we utilize a comprehensive treatment of ownership characteristics, overcoming weakness in previous studies that have used a more narrow focus on ownership type. Secondly, we contribute to understanding of how firms in transition economies build 'indigenous' capabilities for innovation by drawing attention to the interplay of foreign and domestic control of agents' innovation.

1. Introduction

The national systems of innovation (NSI) perspective highlights country-specific institutional factors in explaining national innovation performance (e.g., Freeman, 1995; Freeman and Soete, 1997; Lundvall, 1992; Nelson, 1993; Edquist, 1997). Differences in institutional context explain innovation activity and performance across countries. Furthermore, countries vary in how corporate governance and ownership structures impact firms' R&D performance (Hoskisson et al., 2002). While the Anglo-American model is characterized by dispersed ownership, equity-based financing systems, and a strong role of the market for corporate control, the German-Japanese stakeholder model features long-term and bank-based finance, concentrated ownership by large-blockholders and insider-based control mechanisms (e.g., La Porta et al., 1998; Hall and Soskice, 2001; Aguilera and Jackson, 2003).

Because of high institutional divergence, however, many countries are not easily described by these established models (Aguilera and Jackson, 2003). Chinese firms, for example, have distinctive characteristics of corporate governance, including concentrated ownership structures (Xu and Wang, 1999; Claessens and Djankov, 1999), family and insider ownership (Mak and Li, 2001; Chang, 2003; Filatotchev et al., 2007), state ownership, and an emergence of an increasing role for institutional and foreign investors (Xu and Wang, 1999; Chang, 2003; Chang et al., 2006). Studies have examined the relationship between corporate governance and innovation performance of firms in transition economies such as China (e.g., Hoskisson et al., 2002; Miozzo and Dewick, 2002; Tylecote et al., 1998; Carney, 2005; Lee and O'Neill, 2003). However, these studies have tended to take a rather narrow view of ownership, for example, with a specific focus on ownership concentration (Lee and O'Neill, 2003), institutional investors (Hoskisson et al., 2002) or foreign ownership (David et al., 2006). Others have investigated business group affiliation as a determinant of innovation performance in transition economies (Chang et al., 2006) or focused on linking innovation and the financial system at a national level, rather than firm level (Tylecote and Conesa, 1999). While some recent studies do take a slightly broader ownership view (e.g., Keister and Hodson examine differences between Chinese state-owned enterprises and collective and other non-state firms with respect to firm innovation (Keister and Hodson, 2009)), the literature is somewhat fragmented. There is lacking a comprehensive assessment of the relationship between ownership structures and innovative performance of firms in a transition economy. It is important to address this: as argued by agency theory (Berle and Means, 1932; Jensen and Mecking, 1976), effective firm response in a changing environment such as a transition economy hinges on an appropriate fit between ownership, control and monitoring mechanisms (Wright et al., 2005). Moreover, the way finance is supplied by owners to

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firms in a transition economy has a large bearing on product market development by the firm (Keister and Lu, 2004).

Our present study addresses this gap. Firstly, we undertake a more thorough treatment of ownership structure than has been apparent in the literature to date. We also compare ownership structure with business group affiliation as potential determinants of firm innovation performance. Secondly, we examine innovation performance of firms in China, a country that does not align with the Anglo-American or stakeholder models of corporate governance but which is nevertheless a major economic force in transition. China's economic transition from centralized to open form makes it a particularly interesting context to examine links between ownership and innovation. China's move away from centralized planning of its innovation system in the mid-1980s originally suffered from over-protection by the state (Cai and Tylecote, 2008). However, scholars have documented a steady trend away from protection by the state and toward an increasingly open system involving technology outsourcing (Motohashi and Yun, 2007), foreign MNC involvement (Liu and White, 2001), and a transition from technology imports and imitation to innovation (Guan et al., 2009).

Our empirical analysis consists of data from 548 Chinese firms from 2001 to 2004 inclusive, operating in a broad range of industrial sectors. The results indicate that firm innovation performance is associated with the presence of both foreign and domestic owners in the firm, as well as with the firm's affiliation to a business group. Insider owners, however, have a negative impact and concentration of owners has no significant impact. Our study has two principal contributions. Firstly, we utilize a comprehensive treatment of ownership structure, overcoming weakness in previous studies that have used a more narrow focus of one or two types of ownership. Secondly, we extend the literature, in particular agency theoretic arguments stressing hybrid structures for effective innovation in turbulent environments. By drawing attention to the interplay of foreign and domestic control of firms as agents of innovation, we provide insight into how firms in transition economies build 'indigenous' capabilities for innovation. We also highlight the danger of insider ownership on innovation in a transition economy. The findings have particular relevance to innovation strategy and policy, particularly in the context of transition countries that are in the process of developing 'indigenous' capabilities for innovation.

2. Theoretical background and hypotheses

2.1. Ownership concentration and firm innovation

Previous studies have shown that firms with concentrated ownership perform better because concentration provides an efficient way of resolving agency problems (Claessens and Djankov, 1999; Prowse, 1992; Shleifer and Vishny, 1996). From an agency perspective, concentrated ownership is important for innovation activity as it provides effective monitoring mechanisms (Belloc, 2010). Large shareholders have strong incentives and the capacity to monitor and influence management; voting control puts pressure on the firm by threatening takeover. Small atomistic shareholders within a dispersed ownership structure will neither be able to afford the costs nor profit from the benefits of monitoring (Grossman and Hart, 1980). However, other studies have shown that the relationship between the two variables is either negative or insignificant. In this view concentrated ownership has disadvantages of eliminating private benefits of control, the expropriation of minority shareholders, and risks from a lack of diversification (Demsetz and Lehn, 1985; Barclay and Holderness, 1989).

This notwithstanding, the concentrated ownership structure is popular in transition countries. Previous studies find that concentrated ownership has a positive effect on firm performance, for instance, Blasi and Shleifer (Blasi and Shleifer, 1996) in Russia, Claessens and Djankov (Claessens and Djankov, 1999) in the Czech Republic, Dean (Dean, 2000) for the Ukraine, Xu and Wang (Xu and Wang, 1999) in China. Concentrated ownership can also encourage R&D and innovation activity within firms; these are crucial elements for increased profitability. Other studies show that concentrated ownership by large-block shareholders has positive effects on firms' innovation performance (e.g., Chang et al., 2006; Shleifer and Vishny, 1996; Chang and Hong, 2000; Rowley and Bae, 2004; Mahmood and Mitchell, 2004). These studies suggest that a small number of large-block shareholders prefer to make long-term investments in R&D in order to increase the stability of the firm, rather than seek short-term profit maximization. Consequently, ownership concentration is perceived to have played an important role in the technological development of many countries. Hence we hypothesize:

H1. Ownership concentration will be positively related to the innovation performance of firms in a transition economy.

2.2. State ownership and firm innovation

The innovation process is seen as a dynamic interactive learning and cumulative process conducted under a national economic structure and institutional configuration (Lundvall, 1992; Lundvall, 1998). Institutional factors affect firms' innovation activities by providing sources for the creation of new technology. Governments play an important role in developing these activities (Johnson, 1982; Amsden, 1989; Haggard, 1994). The economic success of countries such as Taiwan and Korea has been attributed to state-led technological development strategy (Amsden, 1989; Koo, 1987; Wade, 1990; Kim, 1997). These governments have designed a series of policies in Science and Technology (S&T) to stimulate learning and innovation activities of firms. Policy instruments include the facilitation of R&D investments in strategic industries, the management of government-funded research institutes, the establishment of patent regulations and law, the importation of advanced technology from foreign countries, and launch of national strategic projects. Government ownership has positive effects on the performance of firms both in advanced countries (Kole and Mulherin, 1997) and transition countries (Sun et al., 2002).

Others emphasize less positive aspects of direct government ownership on firm performance (e.g., Boardman and Vining, 1989; Vickers and Yarrow, 1991; Boycko et al., 1996; Dewenter and Malatesta, 2001). These studies argue that problems arise from the nature of a government's choices with regard to social and political policy goals beyond profit maximization. For instance, China has focused on the privatisation of state-owned enterprises (SOEs) in the early stage of economic reforms, converting property rights from state sectors into non-state sectors with various types of ownership (Child, 1994; Child and Lu, 1996). In this literature, government ownership has a negative impact on firm performance because of its inefficient structure and lack of managerial knowledge. In addition, corruption and crony capitalism can develop through 'unhealthy' ties between government and businesses. However, the bureaucratic nature and inefficient effects of government ownership on financial performance of firms do not automatically imply negative effects on the innovation performance of firms.

In transition economies such as China, government plays a key role in the process of industrialisation. We would expect that government also plays an important role in developing innovation capabilities through direct intervention and through its industrial and S&T policies. A wider set of government objectives and long-term policy choices beyond the specific aim of short-term profit maximization have a positive effect on firms' innovation (Chang

et al., 2006). In addition, state-owned firms have significant incentives and access to important infrastructure that will facilitate government-initiated innovation (Chang et al., 2006). According to Motohashi and Yun (Motohashi and Yun, 2007), Chinese state-owned firms became actively involved in S&T outsourcing activities in the 1990s, contributing to an overall increase in innovative activity. Hence we hypothesize:

H2. State ownership will be positively related to the innovation performance of firms in a transition economy.

2.3. Insider ownership and firm innovation

Insider ownership means firm equity is held by individuals closely related to the management of the firm, individuals with exclusive voting rights. Insider shareholders include the founders of firms and their families, affiliates, managers, executive directors, and employees (Xu and Wang, 1999; Chang et al., 2006). Firms tend to align insiders' interests, rather than those of dispersed outsider ownership shareholders. Insiders are better informed of the reality of the corporate situation than outsiders, particularly individual investors. Prior research indicates insider ownership to be positively linked to firm performance through a reduction in agency cost in terms of managerial ownership (Jensen and Mecking, 1976; McConnell and Servaes, 1990), family and affiliate ownership (Chang, 2003; Chang and Hong, 2000), and employee ownership (Nickel, 1990; Kruse, 1993; Tseo et al., 2004). The logic behind this argument is closely related to the idea of increasing the convergence of interests between managers and other shareholders (Jensen and Mecking, 1976). On the other hand, managerial non-value maximizing activities such as 'empire building for the manager's reputation' and 'perquisite-taking' are mitigated by such engagement mechanisms. Agrawal and Knoeber (Agrawal and Knoeber, 1996) and Cho (Cho, 1998) have shown the positive effects of increasing the percentage of insider ownership by managers and directors on a firm's value. Chang (Chang, 2003) also provides evidence of these positive effects in the context of Korean business group-affiliated companies. In contrast, other studies have demonstrated an inverse relationship between insider ownership and firm profitability (e.g., McConnell and Servaes, 1990; Morck et al., 1988). However, these studies focus on entrenchment within the incumbent management and the managerial consumption of perquisites, rather than on the ownership structure of insider shareholders.

We identify two principal reasons for a link between insider ownership and firm innovation. First, insider owners are more likely to invest in long-term R&D projects that will increase a firm's stability and the probability of long-lasting success, rather than investing in short-term profit maximization (as outside shareholders might prefer). The founder and their families are likely to align their long-term goals with the firm's stability beyond the narrow confines of financial performance. Second, workers in firms seek to maintain stable long-term employment contracts by pursuing technological innovation, rather than short-term returns. Hence we hypothesize:

H3. Insider ownership will be positively related to the innovation performance of firms in a transition economy.

2.4. Institutional ownership and firm innovation

Large 'blockholders' have emerged as very powerful institutional investors over recent decades, having a positive effect on firm performance through their capacity to monitor, discipline, and influence corporate managers (Grossman and Hart, 1980; McConnell and Servaes, 1990; Del Guercio and Hawkins, 1999). Institutional investors have not only a positive influence on financial performance (Del Guercio and Hawkins, 1999) but also a positive effect on strategy formulation, such as R&D and diversification (David et al., 2001; Tihanyi et al., 2003). Institutional investors contribute to reducing agency costs because they have a greater incentive to pressure managers to focus more on firm performance. This contrasts with individual shareholders, who may have a lesser stake. Some studies have found an extensive role for institutional investors by examining the various types of institutional investors (commercial banks, insurance companies, mutual and hedge fund and venture capital), and different kinds of institutional shareholder activism, including corporate governance proposals, forced CEO turnover, and the direct selling of shares (Smith, 1996; Carleton et al., 1998; Gillan and Starks, 2000). Aghion, Van Reenen and Zingales (Aghion et al., 2008) argue higher institutional ownership is positively associated with greater incentives to innovate by acting to alleviate career concerns that risk-averse managers may have.

We consider three reasons for the influence of institutional investors on innovation performance in transition economies. First, banks and their related commercial investment companies play critical roles as primary institutional investors in countries where financial markets do not function properly. In many emerging countries, high-risk national R&D projects that require huge amounts of investment have been launched with the direct help of large institutional investors for building national R&D infrastructure. These arrangements involve cooperation between the government and financial institutions. Second, institutional investors play an important coordination role among internal and external stakeholders, including government, boards of directors, employees, and suppliers. Institutional investors such as banks act as both major shareholder of the firm and key players in the national economy. As a result they exert pressure on the firm to pursue a more long-term vision of success for social welfare, rather than for short-term profit maximization (Chang et al., 2006). Third, institutional investors' distinctive role as regulators and researchers for corporate governance and financial markets can substantially affect managers' investment decisions and behaviours. Banks and major financial institutions often monitor and report firms' changes in corporate governance and performance. However, where performance is low, institutional investors are not likely to dispose their shares immediately; they are principal creditors and have better information about the actual situation of the firm. Opler and Sokobin (Opler and Sokobin, 1997) and Bushee (Bushee, 1998) show the positive impact of an institutional investor's role on the R&D investment behaviour of firms. Thus, institutional investors reduce agency costs, as well as increase the stability and competitiveness of firms through their distinctive role as monitors, coordinators, and financial resource providers for innovation. Hence we hypothesize:

H4. Institutional investors' ownership will be positively related to the innovation performance of firms in a transition economy.

2.5. Foreign ownership and firm innovation

Shareholding by foreign corporations is not conducted merely through equity participation, but through a range of relationships and business activities (Child, 1994; Douma et al., 2006). Foreign partners provide domestic firms with advanced technical and managerial knowledge and resources beyond mere financial contributions. This is particularly important for firms in transition economies, where recent studies have shown foreign-owned firms to be more innovative than domestic firms (Falk, 2008). We consider three reasons for a positive relationship between foreign ownership and innovation. First, foreign investment by MNCs tends to focus on the domestic market as it relates to core business. This requires a technological competitive advantage, in contrast with domestic companies (Johanson and Vahlne, 1977; Kogut, 1983; Chang, 1995). Hence, foreign corporations provide a valuable

model for developing the technological and innovation capabilities of domestic firms. Second, foreign partners may encourage the innovation activities of domestic firms by transferring advanced technological resources and helping them boost their R&D efforts. Third, foreign investors also encourage domestic partners to invest more in technology development by using their ownership shares as leverage (Chang et al., 2006).

Studies on the Chinese economic transition have shown that increasing foreign ownership and foreign inward investment is positively associated with successful industrial growth (e.g., Child, 1994; Peng, 2000). Foreign investors provide specific innovation and managerial knowledge. Others have found that this positive association originates from the commitment of resources to technology transfer, technical collaborations, managerial resource sharing, and the appointment of foreign directors to boards (Douma et al., 2006; Chibber and Majumdar, 1999; Khanna and Palepu, 2000). Firms with a high proportion of foreign ownership may be in a better position to access advanced foreign innovation resources than firms with private investors. This also explains why the Chinese government has supported the entry of foreign MNCs into the domestic market by providing various financial incentives and tax benefits. Hence we hypothesize:

H5. Foreign ownership will be positively related to the innovation performance of firms in a transition economy.

2.6. Business group affiliation and firm innovation

A business group is defined as "a multi-company firm that transacts different markets and does so under entrepreneurial and financial control" (Leff, 1978, p. 662), and is considered "a gathering of formally independent firms under the single common administrative and financial control" (Chang, 2003, p. 238]). Business groups are seen as a distinctive organisational arrangement common to developing and developed countries (Chang and Hong, 2000; Leff, 1978; Granovetter, 1995; Khanna and Palepu, 1999; Rowley and Warner, 2005), playing a positive role in the processes of industrialisation and economic development (Chang, 2003; Kock and Guillen, 2001). Research has shown that business groups are inter-organisational forms that add value through efficient market intermediation functions (e.g., Nakatani, 1984; Lincoln et al., 1996) for Japanese keiretsu; (Chang, 2003; Rowley and Bae, 2004; Rowley et al., 2002) for Korean Chaebols; (Khanna and Palepu, 2000) for business groups in Chile; (Fisman and Khanna, 2004) for India; (Warner et al., 2004) for China; (Khanna and Yishay, 2005) for comparative studies of Japanese, Korean and Thai business groups). In the case of China, business groups have contributed to 60% of the national industrial output in 2004 (Yiu et al., 2005).

According to Chang and Hong (Chang and Hong, 2000), the reason that group-affiliated firms outperform independent firms is because they share various forms of group-wide resources and internal business transactions. The intermediation functions of business groups are a primary source of competitive advantage for member firms and an impetus for industrial development. On the other hand, in China, where various inadequacies of legal and basic supporting systems for economic activities and market imperfections are common (Peng, 2000), business groups have provided both actual institutional coordination and scale (or scope) of economies to provide access to financial and technological resources necessary for innovation (Lee and Hahn, 2005). Several studies have observed the increasing role of business groups in China and confirmed the positive effects of these groups on the financial performance of affiliated firms (e.g., Yiu et al., 2005; Keister, 1998; Ma et al., 2005).

Four important elements of innovation infrastructure can be made more accessible by business groups in a transition economy: capital, scientific-labour markets, knowledge sourcing, and vertical intermediation. First, business groups can act as *de facto* venture capitalists for new innovation opportunities for firms that lack internal cash flow and external sources for funding (Mahmood and Mitchell, 2004). Second, they can play a crucial role as an incubator for talented scientists and the internal labour market by conducting research, engineering, and vocational institutes and by providing employment and training (Chang et al., 2006). Third, in the form of strategic alliances and joint ventures, business groups facilitate various technological relationships with foreign firms from developed countries and help domestic firms access advanced technology and develop tacit knowledge for innovation. Fourth, business groups hold their own robust vertical intermediaries, such as suppliers and distributors, which are considered an important part of the innovation infrastructure (Chang, 2003; Lee and Hahn, 2005). Hence we hypothesize:

H6. Business groups' affiliations are likely to produce more innovations than independent firms in a transition economy.

3. Methodology

3.1. Sample and data

We constructed a comprehensive set of data on ownership and innovation performance of Chinese firms publicly trading in 2001 in eight different industries. These industries were automotive, chemicals, communication, electronics, machinery, pharmaceuticals, textiles, and power industries. We identified the industries for Chinese firms according to International Standard Industry Classification (ISIC). We limited our sample to firms publicly listed on the Shanghai Stock Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE) in China.[3] We selected large listed firms for two reasons: (1) it is difficult to collect reliable financial and innovation performance data about small-sized or unlisted firms in China; (2) large Chinese firms tended to belong to industries where innovation is important for success. The financial service industry was not included. Reform of the S&T system had already started in 1985 when China passed its patent law (Motohashi and Yun, 2007; Hu and Jefferson, 2009) and the trend for Chinese firms to move away from a reliance on technology imports and to pursue indigenous R&D was already well underway in the 1990s (Guan et al., 2009; Hu and Jefferson, 2009).

In keeping with previous research (Xu and Wang, 1999; Sun et al., 2002), the main corporate and financial information for the Chinese firms were collected from *China Listed Company Reports, Handbook for Listed Companies, the Shanghai Stock Exchange Statistics Annual and Fact Book of Shenzhen Stock Exchange*. These sources constitute the most comprehensive and reliable data for Chinese firms. Our initial target frame consisted of all firms from eight industries listed in the Chinese Shanghai and Shenzhen stock markets in 2001. After excluding small firms, financial services firms, and firms that did not report consistently, we obtained 548 observations, representing 45% of listed firms. The sample includes 60 firms in textiles, 31 in the automotive industry, 124 in chemicals, 114 in electronics, 107 in mechanical engineering, 60 in pharmaceuticals, 41 in the power industry, and 11 in communications. We combined corporate ownership data with patent registration data collected from the domestic patent office. The online database managed by the State Intellectual Property Office of the People's Republic of

[3] The Chinese stock market did not exist until the late 1980s when the Chinese state enacted a large-scale restructuring program for the industrial sector. The Shanghai Stock Exchange (SHSE) was opened in December 1990, and the Shenzhen Stock Exchange (SZSE) was established in April 2001. China's Securities Regulatory Commission (CSRC) is responsible for controlling public listings. The number of firms listed increased from 183 in 1993 to 1346 in 2004.

Table 1
Summary of independent and control variables.

Variables	Description	Hypothesized sign
Independent variables		
(1) Ownership concentration	Proportion of firm shares owned by top 5 large shareholders	H1 (+)
(2) State shares	Proportion of firm shares owned by all levels of government, its related agencies and solely state-owned enterprise	H2 (+)
(3) Inside shares	Proportion of firm shares owned by managers, directors, supervisory board members and workers	H3 (+)
(4) Institutional ownership	Proportion of firm shares owned by Non-bank financial institutions	H4 (+)
(5) Foreign shares	Proportion of firm shares owned by foreign corporation and institutional investors (total portion of B and H shares)	H5 (+)
(6) Business groups	1 for an affiliated firm of business groups and 0 others	H6 (+)
Control variables		
Firm size	Total assets of the firm in million of Chinese RMB	
Firm profitability	Return on asset (ROA)	
Sales growth	The annual growth of sales	
Firm age	The number of years elapsed since a firm was listed	
Leverage	The ratio of total debt to assets	
Long-term investment	The ratio of long-term investment expenditure to sales	
Knowledge stock	Total number of accumulated patents during the period from the year of establishment to year $t-1$	
Public A-shares	Proportion of firm shares owned by individuals	
Sectoral context	Industry sector by technology intensity dummy; low technology industry as reference category	

China (SIPO) (http://www.sipo.gov.cn) was used as the main source for patent data. The SIPO was founded in 1980 to protect intellectual property and encourage invention and creation. It is a government institution under the control of the State Council. The main responsibilities of the SIPO are administrative and research functions related to patent affairs such as receiving, examining, and granting patent applications. This institution offers detailed information on patents registered in China since 1980. Patents have been widely used in innovation studies in other Asian countries to capture innovative capacity (Hu and Mathews, 2008). China has outperformed other emerging Asian countries such as India in terms of patenting (Rongping and Wan, 2008).

Previous studies have used patent data as an indicator of innovation output of firms (e.g., Scherer, 1965; Albert et al., 1991; Almeida et al., 2002). There are certain limitations in using patent data. First, as Almeida et al. (Almeida et al., 2002) argue, not all innovation activities of firms lead to patents. Second, not all patent registrations can represent innovation performance of firms. Third, patents can represent only codified and explicit technological knowledge. Moreover, there is a structural bias inherent to the size of firms with regard to patenting, because of the high registration and maintenance costs of patenting, as well as different administrative processes for patent applications.

Despite such limitations, using patent data for China in this research has a number of benefits. Firstly, patent data constitutes the most detailed and systematically compiled and managed data about innovation in China. Data is maintained through a uniform and rigorous process of examination and registration across firms, time periods, and types of technology (SIPO, 2007). China has ratified all major international conventions on intellectual property rights including the World Intellectual Property Organisation (WIPO) (1980), the Paris Convention (1985), the Madrid Agreement (1989) and has signed the Integrated Circuits Treaty (1989) (Yang and Clarke, 2005). Secondly, China has been transitioning from an economy of imitation to one of innovation (Keister and Hodson, 2009; Cai and Tylecote, 2008; Guan et al., 2009; Rongping and Wan, 2008). During the transition, policies stimulating patenting activities have been put in place. As a consequence, productivity of innovation, as measured in terms of patents, has increased rapidly since the mid-1990s. Given the historically weak institutional environment, amendments to patent law and ownership reform have encouraged patenting by indigenous firms (Hu and Jefferson, 2009). In addition, as part of its joining of the World Trade Organization (WTO) in 2005, China signed up to the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 2001 and enhanced its enforcement of patent law (Yang and Clarke, 2005). Our data collection coincided with this period (i.e., 2001–2004). Thirdly, external stimulus has also prompted indigenous firms in China to engage in patenting. For instance, competitive patenting in China has increased at a rate of over 30% per year from 1995 to 2004, and this has been influenced by foreign firms' competitive and innovative activity in China (Hu and Jefferson, 2009; Hu, 2010).

3.1.1. Dependent variables

We used the number of patent registrations in domestic patent offices to measure *innovation performance* of each firm over four years. We used domestic patent data rather than internationally recognised patent data, such as US patent data or European patent data in order to measure firms' overall innovation output without bias caused by high costs of different registration processes, which may favour large firms (Chang et al., 2006). Studies using patents as the dependent variable normally apply at least a one year lag in order to capture the lead-lag effect of explanatory variables. We applied initial year (t) to three year ($t+3$) lags to the dependent variable with respect to explanatory variables in order to make robust interpretation of results. We also generated a variable for the total number of patents over the four years of interest.

3.1.2. Independent variables

To test Hypotheses 1–5, the specific characteristics of corporate ownership structure were captured. In the Chinese stock market, shares are divided into domestic (A-shares) and foreign (B-shares, H-shares, and N-shares) depending on the shareholder's residency. There are four types of domestic A-shares. These are state shares, legal person shares, employee shares, and tradable A-shares (Xu and Wang, 1999; Lin and Zhu, 2000). Among domestic shares, tradable A-shares have mostly been held by individuals and traded in the open market. B-shares are available exclusively to foreign investors and some authorised domestic securities firms, while H-shares and N-shares are listed on the Hong Kong Stock Exchange and the New York Stock Exchange, respectively (Chadee and Qiu, 2001). In recent years, as the Chinese government has encouraged companies to become listed on overseas stock markets, foreign investors in Chinese listed firms have emerged as one of the most powerful shareholder groups.

Using this system, we captured the key variables of interest as follows. O*wnership concentration* was measured as the total percentage of shares held by the five largest shareholders (Xu and Wang, 1999; Claessens and Djankov, 1999; Shleifer and Vishny, 1996) (Hypothesis 1). *State ownership* was captured as

the percentage of shares held by governmental entities, including various levels of government, their related agencies, and solely state-owned enterprise (Xu and Wang, 1999; Chang et al., 2006) (Hypothesis 2). *Insider ownership* was captured as the total proportion of firm shares owned by managers, directors, supervisory board members, and workers (Xu and Wang, 1999; Chang et al., 2006; Carney, 2005; Chang and Hong, 2000) (Hypothesis 3). *Institutional ownership* was captured as the proportion of shares owned by domestic non-bank financial institutions, including securities firms, trust and investment companies, finance and insurance companies, and mutual funds (David et al., 2006; Chang and Hong, 2000) (Hypothesis 4). *Foreign ownership* was captured as the percentage of shares held by foreign industrial corporations, foreign financial institutions, and individuals, i.e., the total proportion of B-shares and H-shares (Xu and Wang, 1999) (Hypothesis 5). In order to test the effect of *business group affiliation* (Hypothesis 6), we created a dummy variable with 1 depicting an affiliation of the firm with a business group and 0 for no business group affiliation (Chang, 2003; Lee and Hahn, 2005).

3.1.3. Control variables

We used a number of control variables. *Firm size* was measured as the total assets of the firm (in million Chinese RMB). *Firm profitability* was measured using return on assets (ROA), and *sales growth* was calculated as percentage annual growth of sales. *Firm age* was taken as the number of years since the firm's first listing. *Leverage* was measured as the book value of the firm's debt divided by total assets. In general, we expect that a high debt to equity ratio affects investment decisions about innovation resources and firm performance, since higher leveraging increases the likelihood of bankruptcy (Froot et al., 1994) and the burden on R&D investment (Bradley et al., 1984). *Knowledge stock* was estimated by the total number of patents registered since the year of establishment to one year before the dependent variable to test any effect of knowledge accumulated since the initial stage of technology development. Guan et al. (Guan et al., 2009) provide evidence that high-tech status is a key predictor of innovation performance in China during its economic transition. *Long-term investment* was measured as the ratio of the firm's long-term capital expenditure to sales. We included *A-tradable shares* to control the possible effects of the dispersion of ownership on the innovation performance of firms by measuring the proportion of firm shares owned by individuals. Public A-shares in China are equivalent to individual shares in other countries, such as Korea. Two reasons support the inclusion of the public A-shares. First, in contrast to shareholders in other markets, individual shareholders in China are a new entity. They have rapidly increased as a component of a firm's ownership structure since the establishment of the stock market. Second, in considering dominant network-based business activities in China (Peng, 2000; Boisot and Child, 1996), powerful individual investors may make important investment decisions by using their political and business connections.

Finally, we controlled for *sector*. Variances in sectoral structure lead to different conditions for competition in R&D activities and product markets (Dasgupta and Stiglitz, 1980). Different sectors have different technological and learning regimes shaping specific patterns of innovation (e.g., Breschi et al., 2000; Malerba, 2002). *Four sectoral groups* classified by technology intensity were created through dummy variables. We followed previous discussions based on Pavitt's (Pavitt, 1984) taxonomy of innovation patterns and the OECD (Organisation for Economic Co-operation Development, 2003) classifications of manufacturing industries based on technology. Thus, *the low-technology sector* included the textile and power industries, while mechanical engineering was classified as a *medium-low technology sector*. The chemical and automotive industries were grouped in the *medium-high technology sector*, and we allocated the microelectronics, pharmaceutical, and communications industries into the *high-technology sector*.

Table 1 shows a summary of data descriptions and predicted signs for the independent variables in our model.

3.2. Model specification

We used negative binomial regression analysis for our estimation model. Consistent with other empirical studies of innovation based on patent data (Chang et al., 2006; Almeida et al., 2002), we applied the dynamic count data models to firm-level patent data on technological innovation. Our sample firms have a wide range of distribution in patenting activities, showing that the majority of firms produce few innovations, while a small number produce a considerable volume of innovations. The over-dispersion problem of our patent data naturally implies that there are important dynamics and unobservable cross-section heterogeneity in the analysis. In order to capture such characteristics in the data, we use a negative binomial regression.

We followed the approach of Hausman et al. (Hausman et al., 1984) and Blundel et al. (Blundell et al., 1995) for studying the patent counts in general and Almeida et al. (Almeida et al., 2002) and Chang et al. (Chang et al., 2006) for empirical applications. A negative binomial model extended from the logic of Poisson's regression model is preferable for estimating the model of counts of an event that has extra-Poisson variations in the form of over-dispersion. We checked large values for chi-square by using Poisson's goodness of fit; significantly different value in over-dispersion parameters indicates that negative binomial estimation is more appropriate to the model. In other words, we follow the underlying Poisson model but relax the variance restrictions. Hence, in the Poisson model the conditional probability density function for firm i in year t is given by (Blundell et al., 1995):

$$Pr(Y_{it} = y_{it}|X_{it}) = \frac{e^{-\lambda_{it}}\lambda_{it}^{y_{it}}}{y_{it}!}.$$

We constructed negative binomial models[4] based on (Almeida et al., 2002) and (Chang et al., 2006). First, we introduced an individual, unobserved effect into a conditional mean as follows:

$$\log \mu_i = \log \lambda_i + \log \mu_i = a_{i'} x_i + \varepsilon_i.$$

As the disturbance ε_i is defined as the specific error term caused by cross-sectional heterogeneity, the distribution of y_i conditioned on x_i and μ_i(i.e. ε_i) remains Poisson with a conditional mean and variance μ_i:

$$f(y_i|x_{i,}\mu_i) = \frac{e^{-\lambda_i \mu}(\lambda_i \mu_i)^{y_i}}{y_i!}.$$

Thus, in our negative binomial model, the dependent variable y_i reflects a patent registration count of firm i, while x_i is the explanatory variable of firms, such as the ownership structure, business groups, and sectoral context dummy variables. μ_i represents unobserved, omitted variables, and e^{μ_i} follow a gamma distribution with mean 1 and variance α as the over-dispersion parameter. The larger the α, the greater the over-dispersion. In order to estimate the dynamic change of innovation performances over time, our regression model has a one- to three-year lag with respect to the independent variables.

[4] $e = 2.718$, the exponential constant; λ = the mean of number of success; χ = number of successes; $y_i!$ = factorial y_i.

4. Results

The basic characteristics of ownership structure are illustrated in Table 2. Table 3 shows the characteristics of the sectoral structure via innovation activities, long-term investment, sales growth, and assets in our sample. These characteristics show that we have a sufficient number of firms in each industrial sector to allow us to control for sector-specific effects on innovation performance. As expected, the electronics and chemical industries predominate in terms of patent and knowledge stock. Firms in the electronics and power industries spend more on R&D than other industries. The largest firms measured by assets were in the chemical and power industries. The textile industry is the least technologically intensive sector with respect to overall innovation activities. The communications and pharmaceutical industries are the most dynamic and fastest growing industries in term of the growth rate of sales.

Table 4 shows the inter-correlations between the variables of interest. This indicates that there are unlikely to be problems in multicollinearity among the independent variables, although we observe a relatively high correlation between state ownership and institutional ownership. To test for multicollinearity, we examined the Variance Inflation Factor (VIF) for each independent variable. The highest VIF was 3.34 indicating that multicollinearity should not be a major problem in our regression analysis (Ryan, 1997).

Table 5 shows the full estimation models including control variables. This provides strong support for Hypotheses 5 and 6 (foreign ownership and business group affiliation). There is partial support for Hypotheses 2 and 4 (state and institutional ownership): we only see a positive influence in years $t+2$ and $t+3$. We find no support for Hypotheses 1 (ownership concentration.) and for Hypothesis 3 (insider ownership) we observe a significant negative relationship in year $t+3$.

Table 2
Descriptive statistic: means and standard deviations.

Variables name	Units of measurement	Mean	Std. Dev.	Lowest	Highest
1. Patent[a]	Number of	5.67	36.94	0.00	586.00
2. Asset	Million RMB	257,402.60	1,557,753.00	1,453.00	36,029,400.00
3. Age	Number of Year	4.14	2.54	0.00	11.00
4. ROA	Percent	2.03	24.28	−397.07	62.10
5. Sales growth	Percent	−7.09	141.64	−1,356.75	868.47
6. Leverage	Percent	44.17	21.77	−38.02	224.61
7. R&D intensity	Percent	18.45	34.18	0.00	261.77
8. Knowledge stock	Number of Patent	20.42	124.41	0.00	2,004.00
9. Public A-share ownership	Percent	34.53	13.85	0.00	100.00
10. Business groups	Dummy	0.76	0.42	0.00	1.00
11. Ownership concentration	Percent	20.42	124.41	0.00	100
12. State ownership	Percent	34.13	26.57	0.00	88.58
13. Institutional ownership	Percent	27.92	26.81	0.00	100.00
14. Foreign ownership	Percent	4.06	11.06	0.00	53.49
15. Insider ownership	Percent	0.40	2.16	0.00	23.35

[a] Measured as a number of patent registration counted in 2003; $N = 548$.

Table 3
Characteristics of sectoral innovation activities by technology.

Industry	Mean	Median (N)	Lowest	Highest	Sum (sum/total)
Number of patent[a]					
Low-technology sector	1.28	0.00 (101)	0	33	130 (1.5)
Medium-low technology sector	18.36	2.00 (107)	0	582	1,965 (21.9)
Medium-high technology sector	19.75	0.00 (160)	0	1,734	3,164 (35.3)
High-technology sector	20.51	0.00 (180)	0	1,457	3,692 (41.24)
Total	16.33	0.00 (548)	0	1,734	8,951 (100)
R&D investment					
Low-technology sector	17,092.77	6,634.00 (101)	0.00	186,360	1,726,369 (.24.4)
Medium-low technology sector	8,332.37	4,064.00 (107)	0.00	77,567	891564(12.6)
Medium-high technology sector	9,464.09	2,890.50 (160)	0.00	326,320	1,514,255 (21.4)
High-technology sector	16,251.08	5,536.00 (180)	0.00	185,957	2,925,195 (41.4)
Total	12,878.44	4,693.50 (548)	0.00	326,320	7,057,383(100)
Knowledge stock					
Low-technology sector	1.62	0 (101)	0	33	164(1.5)
Medium-low technology sector	23.36	2 (107)	0	742	2,500(22.3)
Medium-high technology sector	23.54	1 (160)	0	2,004	3,767(72.0)
High-technology sector	26.32	1 (180)	0	1,774	4,738(4.1)
Total	20.38	0 (548)	0	2,004	11,169(100)
Assets					
Low-technology sector	241,642.10	136,226.00 (101)	4896.00	4,722,971.00	2.44e+07(17.3)
Medium-low technology sector	144,912.90	105,994.00 (107)	20769.00	7,65,289.00	1.55e+07(10.9)
Medium-high technology sector	415,801.9	123,592 (160)	1453.00	3.60e+07	6.65e+07(33.72)
High-technology sector	192,315.60	124,698.50 (180)	14384.00	1,763,751.00	3.46e+07(42.42)
Total	257,402.60	119,429.50 (548)	1,453	3.60e+07	1.41e+08(100)
Sales growth					
Low-technology sector	−6.32	10.25 (101)	−1,103.90	100	−638.93(16.4)
Medium-low technology sector	−17.18	13.30 (107)	−1,356.75	100	−1,839.14(47.3)
Medium-high technology sector	−2.17	10.23 (160)	−792.80	100	−348.44 (8.9)
High-technology sector	−5.89	11.24 (180)	−1151.00	100	−1,061.74 (27.3)
Total	−7.09	11.07 (548)	−1356.75	100	−3,888.28(100)

[a] Measured as a total number of patent registration counted from 2001 to 2004; $N = 548$.

Table 4
Pearson's correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Patents 2003	1													
2. Asset	.01	1												
3. Age	.01	.17	1											
4. ROA	.02	.01	−.10	1										
5. Sales growth	−.05	.00	−.14	.16	1									
6. Leverage	−.00	.06	.29	−.21	−.06	1								
7. R&D intensity	−.05	−.01	.13	−.00	−.16	−.01	1							
8. Knowledge Stock	−.01	.04	.04	−.09	−.17	−.00	−.00	1						
9.Public A-share ownership	−.03	−.04	.15	.01	.01	.01	.01	.02	1					
10. Business groups	.09	.13	.01	.01	.01	−.01	−.05	.02	−.02	1				
11. Ownership concentration	.00	−.02	−.26	.04	−.00	−.10	.01	−.00	−.48	.00	1			
12. Insider ownership	−.02	.01	−.16	.02	.02	−.04	−.00**	.00	−.08	−.04	−.05	1		
13. State ownership	−.03	.03	−.19*	−.06	.10	.02	.00*	.00	−.24	.12	.32	−.04	1	
14. Institutional ownership	−.00*	−.03	.07	.06	−.07**	−.04*	−.03**	−.00	−.11	−.11	−.06	.03	−.85	1
15. Foreign ownership	.09	.23	.18	−.02	.01	.02	−.01**	−.03	−.51	.06	−.08	.03	.03	.06

Note: $N = 548$; Two-tailed tests.
* $P < 0.1$.
** $P < 0.05$.

Table 5
Negative binomial regression analysis for firm innovation activities.

	Hypotheses	Patent (t)	Patent ($t+1$)	Patent ($t+2$)	Patent ($t+3$)	Total patent ($t \sim t+3$)
Explanatory variables						
Concentration	H1	0.00 (0.02)	−0.00 (0.02)	0.01 (0.02)	−0.00 (0.02)	0.00 (0.02)
State ownership	H2	0.01 (0.02)	0.01 (0.01)	0.02 (0.01)*	0.03 (0.02)*	0.02 (0.01)*
Insider ownership	H3	−0.08 (0.09)	−0.09 (0.08)	−0.06 (0.07)	−0.16 (0.09)*	−0.16 (0.09)*
Institution ownership	H4	0.01 (0.02)	0.00 (0.01)	0.01 (0.01)	0.03 (0.02)*	0.03 (0.02)*
Foreign ownership	H5	0.06 (0.02)***	0.06 (0.02)**	0.06 (0.02)***	0.03 (0.02)*	0.03 (0.02)*
Business groups	H6	1.65 (0.46)***	1.98 (0.44)***	3.61 (0.49)***	2.66 (0.48)***	2.13 (0.32)***
Control variables						
Firm size (Asset)		0.00 (0.00)	0.00 (0.00)**	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)**
Firm age		−0.20 (0.08)***	0.08 (0.07)	−0.08 (0.06)	-0.08 (0.08)	−0.10 (0.05)*
Leverage		−0.01 (0.01)	0.00 (0.01)	−0.01 (0.01)**	0.00 (0.01)	0.00 (0.01)
Firm profitability (ROA)		0.04 (0.01)***	0.04 (0.13)***	0.04 (0.01)***	0.03 (0.01)	0.04 (0.01)***
Sales growth		−0.00 (0.00)*	−0.00 (0.00)	−0.01 (0.00)	−0.00 (0.00)	−0.00 (0.00)
Long-term investment		−0.01 (0.01)	−0.00 (0.01)	−0.02 (0.01)**	−0.01 (0.01)	−0.01 (0.00)**
Knowledge stock		−0.01 (0.01)	−0.00 (0.01)	−0.00 (0.01)	−0.01 (0.01)	−0.00 (0.00)
A shares		0.03 (0.02)	0.02 (0.02)	0.04 (0.02)*	0.02 (0.02)	0.03 (0.02)
Medium-low technology		3.95 (0.66)***	1.52 (0.58)***	1.64 (0.55)***	2.65 (0.64)***	2.07 (0.42)***
Medium-high technology		3.17 (0.64)***	1.46 (0.59)***	1.33 (0.50)***	2.46 (0.60)***	1.78 (0.48)***
High-technology		3.53 (0.62)***	1.84 (0.54)***	1.85 (0.50)***	2.79 (0.63)***	2.12 (0.41)***
Constant		−5.38 (2.21)*	−3.74 (1.95)*	−6.18 (1.96)***	−7.06 (2.62)***	−3.35 (1.52)**
Chi-square (d.f.)		80.16 (17)	86.19 (17)	115.74 (17)	89.00 (17)	135.62 (17)
Pseudo R^2		0.06	0.06	0.07	0.07	0.05
Log-likelihood		−601.79	−740.77	−797.40	−591.99	−1231.21

Note: The dependent variable is the number of patents registered in domestic patent offices; $N = 548$; Standard errors are in parentheses; the total number of patents is the total number of patent registrations for 4 years from 2001 to 2004.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

5. Discussion and conclusion

According to agency theory (Berle and Means, 1932; Jensen and Mecking, 1976), effective firm response in rapidly changing environments hinges on an appropriate fit between ownership, control and monitoring mechanisms (Wright et al., 2005). Our results suggest that a specific profile of ownership structure is indeed needed to boost innovation performance in a transition economy. However, we find that this ownership profile is somewhat different to that suggested by disparate findings from studies of ownership and innovation.

Firstly, concentrated ownership does not appear to play a positive role in monitoring and controlling managers' behaviour as it relates to innovation in Chinese firms. Our result is not consistent with previous corporate governance studies suggesting ownership concentration reduces agency costs in emerging countries (Claessens and Djankov, 1999; Prowse, 1992; Shleifer and Vishny, 1996). It may be that listed Chinese firms are generally highly concentrated and that the market is not sensitive enough to distinguish among firms according to ownership features (Hovey et al., 2003). In addition, the reform of the corporate governance system in China has focused on a large-scale transformation from firms' concentrated state ownership into various non-state entities. As a consequence, concentrated ownership by the state has been transformed into public and individual ownership, increasing the high dispersion of ownership shares (Tenev et al., 2002). Recent studies have also questioned the direct influence of ownership concentration on innovation. Li, Guo, Yi, and Liu (Li et al., 2010) highlight an inverted U-shape relationship between ownership concentration and innovation performance in Chinese firms. Ortega-Argilés, Moreno, and Caralt (Ortega-Argilés et al., 2005) found a negative relationship between capital concentrated in a few hands and R&D decisions. Our findings align with these recent studies insofar as they raise questions about the ability of ownership concentration to reduce agency costs associated with innovative activity.

Secondly, we observe a lagged relationship between state ownership and innovation. Because Chinese firms have a strong association with the state, this relationship may not be the result of direct state ownership itself. A certain level of state ownership seems necessary to improve the innovation performance of firms, providing a positive signal to complementary economic institutions. This encourages effective monitoring and provides business connections and positive signalling, important factors for firms' R&D activities (Sun et al., 2002). The state functions as mediator between the market and the firm in an underdeveloped financial and labour market context. State ownership thus offers greater protection to shareholders when the legal protection framework for investors is weak and obscure (Sun et al., 2002). In addition, state ownership improves access to finance for Chinese firms, although it does impinge the ability of the corporate governance mechanism to cope with low-visibility technological capability (Cai and Tylecote, 2008). This could be a possible reason why we only see a lagged relationship in our results.

Thirdly, the results indicate that insider ownership has little impact on firm innovation performance. Not only have employee shares typically amounted to less than 10% of total ownership shares, they are also less structured in comparison to state and legal person shares. Employees in both the Shanghai and the Shenzhen stock markets in 2002 held only 6% of all shares (Ho, 2003). Accordingly, employees have no strong financial incentives to control key investment decisions of firms. Another possible explanation is that mechanisms for aligning incentives between managers and shareholders, such as equity-based compensation for the manager and board of directors, is less developed in transition countries. Hence, managers focus more on forging and strengthening their political connections to secure their future position, rather than improving firm performance (Peng, 2000; Boisot and Child, 1996; Xin and Pearce, 1996).

Fourthly, our findings suggest that institutional ownership has little positive impact on innovation. A possible reason for this is as follows. Unlike those in other Asian countries such as Korea and Japan, institutional investors in China seem to be another form of state-owned entity, albeit with weaker control and monitoring systems than the state. At the time of our data collection, Chinese banks were still owned by the state. Other institutional entities, known as legal person shareholders, were established through a direct transformation of state ownership. The distinctive characteristics of such institutional investors in China is that the majority of institutional investors are not financial institutions but other companies closely related to focal firms as business partners; suppliers, buyers, and alliance partners united by mutual shareholding and board interlocking (Peng, 2004). Hence, institutional investors in China do not intervene and monitor managers' investment behaviour as they do in other Asian advanced countries. Rather, they are more likely to pursue constant business relationships with managers and are more willing to avoid risky investments.

Fifthly, foreign corporations and foreign institutional investors in China have played important roles in encouraging corporate governance reform. This affects firms' innovation activities, particularly during economic reform. As many emerging economies have experienced, foreign partners have been a main source of knowledge and advanced technology for domestic firms, while also acting as crucial drivers of reform in corporate governance and related institutional frameworks. In particular, large-scale investments from international funds and foreign investors in China have systematically influenced the speed and process of corporate governance reforms and restructuring in these countries. In turn, this corporate reform has facilitated a favourable institutional environment for foreign investors and ownership dispersion. This result shows the validity of documented positive effects of foreign ownership on firm performance in emerging countries (Douma et al., 2006).

Finally, our findings suggest that business group affiliation has a positive effect on the innovation performance of firms in China. Business groups are an important resource-facilitator as well as a provider of intermediate mechanisms that link various actors for innovation under conditions of weak institutions. Consistent with that of previous research (Chang et al., 2006; Chang and Hong, 2000; Khanna and Palepu, 2000), our finding suggests business groups play a crucial role as efficient economic institutions not only in developing the overall national economy, but also in boosting the innovation capabilities of firms. Chinese business groups have rapidly grown through the various paths of transformation of existing SOEs and newly established ones. Chinese business groups have become key players in China's industrial development and technological advancement (Lee and Hahn, 2005). Our results suggest that business groups are a distinctive economic arrangement that play an important role in enhancing technology and developing innovation, thereby helping to make firms competitive in both domestic and global markets.

The profile that emerges from this is that innovation performance in a transition economy such as China is influenced by ownership structures that expose the firm to knowledge and resources that are not readily available in traditional concentrated, institutional forms. There is an abundance of qualitative evidence that adds support to this result, and to the role played by international and network actors in promoting technological development within Chinese firms. The pattern we find reinforces Tse's (Tse, 2010) assertion that, where there has been restricted ownership in China since 1990, there has been restricted product market freedom, i.e., "the ability to make business decisions without government restrictions" [126:41]. In two case studies of Chinese small-medium sized state-owned firms, Cooke (Cooke, 2002) reports these types of firms are disadvantaged because their "organisational system [is] incomplete and their technology management backward" [127:22]. In an additional case of Longxi Machinery Works (Klassen et al., 1998), a state-owned Chinese enterprise (Longxi) suffered from a high defect rate for a critical part of its engine product. Its main Chinese competitor (Changchai) did not appear to have quality problems, had better growth and R&D performance. Changchai had invested earlier in joint ventures and backward integration, and from 1994 was part-owned by Japanese high quality equipment manufacturer, Kubuta Corporate.

Hu and Mathews (Hu and Mathews, 2008) show how innovation performance in China has become strongly influenced by universities and less and less by the public sector. In the case of Beijing Mirror Corp (Beamish et al., 1998), the company produced a new rear-view mirror technology in conjunction with "high quality personnel" from Tsinghua University (TU). TU ended up owning 70% of the patent and provided on-going technology support to the company as well. Tse (Tse, 2010) highlights the role of foreign technology transfer to China within JVs and through supply chain networks. IBM arrived in 1993, eventually selling its PC business to Lenovo in 2005, and in the meantime it saw "massive supply networks develop in the Pearl River Delta" [126:36]. IBM has also set-up an R&D centre in Beijing (its China Research Laboratory in Zhongguancun Software Park), also recruiting from TU.

5.1. Policy implications

The first policy implication arising from our study is that reform of ownership structure is necessary for firm innovation in transition countries. Our study suggests that on-going reforms in China are geared toward pursuing effective mechanisms to protect shareholder wealth from various anticipated managerial and opportunistic behaviours of large-block shareholders. Thus, a

specific profile of ownership will boost innovation performance. Potential problems in setting up the kind of ownership structure suggested in our study should be discussed and addressed by policy makers. This implies the on-going process of state ownership transformation should become more sophisticated and should include an awareness of the impact of the complete range of ownership types and business group affiliation on innovation performance. Secondly, although business group affiliation has been criticized in terms of distinctive governance structure, we see they are not necessarily detrimental to firm innovation performance. Our finding with respect to business group affiliation suggests policy makers should focus on developing a context-specific reform model of corporate governance by considering the traditions of industrialisation and institutional context, rather than just imitating the model of advanced countries. Thirdly, the present study also highlights the significance of institutional complementarities. Successful technological catch-up and innovation not only requires policies for upgrading technology capabilities, but also setting up suitable supporting institutional and organisational arrangements. Difficulties in economic transition and corporate reform have been related to the lack of a supporting institutional framework; in Central and Eastern European countries the reform program was adopted without serious consideration of local reality (Peng, 2000; Filatotchev et al., 1996). Consequently, country and sector specific features are important factors in maximizing the effect of public policies for the development of innovative firms. Fourthly, the results raise an important question for intellectual property management. The best innovative performance occurs under conditions of foreign ownership and business group affiliation. It is therefore in the interests of Chinese firms owned in this way to guard against intellectual property abuse: this would deter further foreign owner and business group collaboration and undermine future innovative performance. One way of doing this is to reach agreement with foreign owners and business group affiliates in advance on how knowledge and technology are shared and distributed. In addition, social controls that aim to engender long-term shared values and collaboration between partners can be used. Finally, our study raises implications for policy in terms of the role that exogenous factors may play in determining ownership structure. We find a strong role for foreign ownership and business group affiliation in promoting firm innovation in China. But these ownership patterns may be determined by more than over-arching national policy. Industry specific aspects such as demand and supply structures, market size and level of maturity, the types of capabilities needed to compete, the nature of change in the environment, may ultimately all play a role in determining the efficacy of a particular ownership profile when it comes to innovating. Policy makers may need to take into account these factors when focusing their attention on industries that require ownership reform.

5.2. Limitations and directions for future research

The study has several limitations that may be addressed in future research. Firstly, we measure innovation performance of firms by using patent data: a legal form protecting holders' intellectual property. However, not all firms protect their technological assets and innovation performance with patents. Some may prefer to keep their expertise as trade secrets, or implement organisational mechanisms for protecting innovations. Secondly, we do not assess how the type of the industry (i.e., manufacturing vs. service) impacts ownership and innovation strategy of firms in China. Thirdly, we do not split out the various ownership types into lower levels. For example, the effect of insider ownership may change if we consider managers vs. workers, or family vs. non-family. Fourthly, the generalisability of the findings is limited by our use of one country as the research context. Fifthly, recent research in the field of innovation management in transition economies has highlighted various factors that were not accounted for in the present study, but which could improve the fit of our models. Examples are visibility of technology (Cai and Tylecote, 2008), high-technology status of the firm (Guan et al., 2009), S&T outsourcing (Motohashi and Yun, 2007), and diversification strategy within business groups (Chang et al., 2006). Future work should aim to address these limitations by considering different types of innovation measurement, service as well as manufacturing industries, more fine-grained decomposition of the various forms of ownership, and other transitioning economies. These extensions would further develop our understanding of innovation performance of firms in a transition economy from an ownership perspective.

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