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Foreign vs. domestic: What determines the origin of Chinese firms' inward technology licensing?

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Abstract

The increasing prominence of cross-border technology sourcing urges us to ask a question: what factors and conditions may influence firms' decisions of sourcing technology domestically or internationally? Research on this topic is scattered in the literature but a comprehensive understanding of these factors and conditions on this issue is still lacking. The aim of this paper thus is to establish a comprehensive framework that integrates factors affecting a firm's propensity to make technology sourcing decisions regarding foreign or domestic origins of technologies. We identify four distinct categories of factors that are relevant in this respect: (1) technology supplier's characteristics; (2) technology seeker's characteristics; (3) features of technology itself; and (4) external contextual factors. We test our hypotheses based on Chinese firms' inward technology licensing. We found well-established incumbent firms that are export-, and high-tech-oriented with strong absorptive capacity are more likely to in-license foreign technology rather than domestic ones if the in-sourced technology is mature, the technology suppliers have strong desorptive capacity, and the external knowledge environment is innovative.

Key words: Technology sourcing; technology license; external knowledge acquisition; China

1. Introduction

An increasingly prominent debate on how in-sourced technologies from different national origins may influence a firm's performance and competiveness has drawn significant attention in the literature, with special focus on the catching-up latecomers in the developing countries (Ahuja & Katila, 2004; Cantwell & Santangelo, 2000; Castellacci & Archibugi, 2008; Dunning & Lundan, 2009; Fu & Gong, 2011; Lahiri, 2010; Zhao, 1995). Foreign technologies are commonly considered as a "building block" for latecomer firms to improve their productivity (Katrak, 1990; Kim, 1980). Basan and Brian (1996) found the return to foreign technology purchase in Indian high-tech firms is estimated to be 166%, while the return to domestic technology investments falls to only 1%. Recently, scholars have documented that global technology is often superior to that available domestically for firms to build up their sustainable competitive advantages (Dunning et al., 2009; Lahiri, 2010; Singh, 2008). However, there has been little specific research that focuses on distinguishing the influential factors and conditions under which firms prefer to source foreign technology over the domestic ones. In the literature, there are two seemingly contradictory orientations towards the geographic boundary of technology sourcing. One orientation is based on the territorial innovation theory, i.e. national innovation systems, industrial clusters, and innovative milieus (Cooke, 2001; Freeman, 1995; Oerlemans & Meeus, 2001; Porter, 1990), to emphasize the role of spatial proximity that enables knowledge flows with low barriers among agents when they have shared history, institutions, and values, particularly when the transfer of tacit knowledge is involved (Ambos & Ambos, 2009; Jaffe & Trajtenberg, 1993; Morgan, 2007; Nachum, Zaheer, & Gross, 2008). Firms are advised to first source locally before search globally. It is particularly the case for small and medium-sized firms due to their coherent disadvantages in resources and capabilities (Kingsley & Malecki, 2004).

The other theoretical orientation is based on the globalization of innovation and emphasizes the importance of technology heterogeneity from foreign countries. Such an understanding suggests that firms need to source technology across borders to reap another country's specializations in particular technological fields or qualified scientists and engineers (Desyllas & Hughes, 2008; Lahiri, 2010; Malmberg & Maskell, 2006; Singh, 2008). In this perspective, multinational enterprises in particular have advantages because they hold sufficient resources allowing them to tap into the global technology pool.

As far as specific determinants for domestic vs. foreign technology sourcing decisions are concerned, we have demonstrated some scattered evidence, e.g., characteristics of technology seekers (Atuahene-Gima, 1993; Huggins, 2008; Jiří, Pavla, Petr, & Karel, 2011; Kingsley et al., 2004; Martin, 2010; Martin & Moodysson, 2011; Xu, 2011), factors from the technology supplier side (Kim, 2009), Characteristics of technology itself (Nerkar & Shane, 2007), and external environments (Basan et al., 1996; Fu et al., 2011; Malecki, 2010). Based on these prior studies, we in this paper try to establish a framework that integrates these various factors and investigate how they jointly determine firms' technology sourcing territorial decision, especially regarding the choice between domestic and foreign technology sources.

Moreover, our empirical test is based on a unique dataset on Chinese firms' inward technology licensing (ITL) and the results of our test enriches our understanding on this research topic, which has been dominated by using data and samples from developed countries. Indeed, given the current Chinese domestic knowledge landscape based on rapid development of science-, technology- and education-infrastructure since the 1980s, Chinese firms' technology sourcing decision making has become widely diversified. In fact, nowadays Chinese firms' are capable of sourcing domestic technologies or foreign ones (Altenburg, Schmitz, & Stamm, 2008; Liu &

Zhi, 2010; Sun & Du, 2010). Chinese firms are substantially active in global and domestic technology sourcing. According to the *China Science and Technology Yearbook* (2000-2003, Beijing), in 2002 Chinese large and medium sized industrial firms spent RMB 56,017 million on internal R&D, and RMB 76,785 million on technology sourcing (mainly via technology licensing). The expenditures on foreign and domestic technology sourcing were RMB 37, 250 million and RMB 39,535 million, respectively. These statistics indicated that although firms in developing countries have a historical dependence on foreign technology, the domestic options increasingly become an important alternative that is equally important as foreign technologies (Altenburg et al., 2008; Chen & Qu, 2003; Liefner, Hennemann, & Lu, 2006). Therefore, an analysis of firms' technology sourcing propensity pertaining to national border will provide a more in-depth understanding that is not only necessary for Chinese firms to make better technology sourcing decisions but also for foreign technology suppliers to design more effective strategy that better exploits the value of their technologies when licensing to Chinese firms. Finally, our study also questions the validity of the "indigenous innovation strategy" in China, which clearly indicates the Chinese government's ambition to encourage firms to select domestically developed technologies. This study, thus, in this sense also renders some interesting implications for the Chinese national innovation policy.

This paper is organized as follows. We first conduct a literature review, based on which we propose a conceptual framework that distinguishes various determinants of firms' domestic vs. foreign technology sourcing decisions into four categories. In order to verify this framework we test one factor from each category against the relevant hypotheses the second section of this paper. Next, we introduce the dataset and describe our methodology. The empirical results are presented in section four, followed by an in-depth discussion and some suggestions for future research.

2. Literature review and hypotheses

2.1 Literature review and a unified framework

In the extant literature, the concept of cross-border technology sourcing is mostly related to long geographic distances that firms have to be through for external technology (Archibugi & Pietrobelli, 2003). An explicit line between national and global boundaries is really exceptional. Instead, most publications frequently use “local”, “regional” or “national” in their studies to represent different geographic distances rather to set an explicit line on the national border (Malecki, 2010). In explaining why some firms prefer to source foreign technology, while others domestically developed technology, there have been a large range of factors scattered in these publications, mostly, as a “byproduct” of their research of other purposes. To best of our knowledge, particular work to address the factors determining a firm’s national boundaries of technology sourcing is scant. The most frequently discussed of such factors is absorptive capacity (Cohen & Levinthal, 1990). Scholars found that firms with low levels of absorptive capacity tend to source domestically, whilst those with higher absorptive capacity are often sourcing globally (Barnard & Chaminade, 2011; Dunning et al., 2009; Howells, 1996; Plechero & Chaminade, 2010). Following absorptive capacity is the firm size which usually relates to the character of a firm’s finance situation and organizational capabilities (Almeida & Kogut, 1997). Studies suggest that scale economies and superior organizational capabilities allow larger firms to successfully access and exploit technology developed in another country. In this case, multinational corporations (MNCs) have long been recognized for having advantages in resources and capabilities when sourcing external technology across borders (Doz, 1996; Kotabe & Mudambi, 2009). A firm's presence in foreign markets generally attracts the firm in applying foreign technology in pursuing foreign customers' demand (Chaminade, 2011; Xu, 2011). Thus, a firm's market orientation has a potential effect on its technology sourcing boundary decisions. At the same time, the age of a firm, related to younger firms, such as new venture firms or start-ups has been also suggested in some literature as a crucial factor to decide the firm's technology sourcing boundary. A study by Zahra and colleagues (2000) documents that venture firms have a higher propensity to source knowledge globally, while others doubt this view (Almeida et al., 1997).

Afore mentioned factors mainly internal to a seeker firm, indeed, the source objective—technology itself plays a key role in determining firms' sourcing boundary (Contractor & Ra, 2002). Technology development is often biased corresponding to the factor endowment of firms' internal and external conditions (Acemoglu, 2002). It is thus idiosyncratic in terms of advance, applicability, complexity, uniqueness, and newness etc. across firms and countries (Kogut & Zander, 1992; Singh, 2008). Cross-border technology sourcing is thus synonymous with net returns to reap this idiosyncratic technology developed in other countries over its relevant searching, adaption, and other kind of necessary costs.

Next, factors from the technology supplier side, in an extreme example if all foreign technology suppliers close their doors to seeker firms in certain countries, then no cross-border technology sourcing can come into being. In reality, this might rarely happen. Scholars commonly mentioned the willingness, product strategies, marketing capabilities of supplier firms for their sellable technology, and the organizational nature of supplier (universities versus firms) might influence seekers' technology sourcing boundaries (Atuahene-Gima, 1993; Kim, 2009;

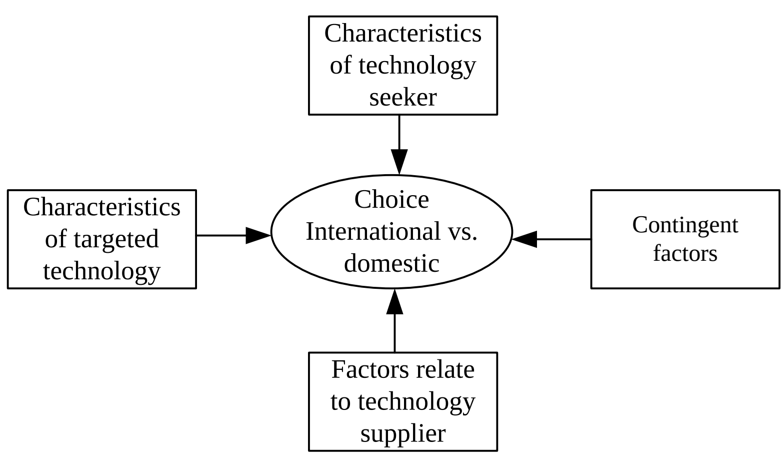
Lichtenthaler & Lichtenthaler, 2010). For instance, knowledge from universities might ask for a closer proximity for seekers (Roach, 2010).

Finally, contingent factors, these determinants might from both technology supplier and demand sides. A well-known one is the government policy. For instance, in the 1970s, 1980s, Indian government did not allow Indian firms to source foreign technology in the form of licensing, particularly, in high-tech sectors (Basan et al., 1996). Currently, there are still lots of developed countries they prohibit certain technology export to some developing countries. Besides, seeker firms' industry characteristics usually decide firms' technology sourcing boundary. It is well recognized that firms in high-tech sectors have a higher propensity to source technology across national borders than medium- and low-tech industries (Asheim & Coenen, 2005; Gerybadze & Reger, 1999; Martin et al., 2011). Furthermore, as we mentioned previously that seeker firms' local site plays a crucial role regarding to their technology sourcing boundary. For instance, recently, Chaminade (2011) states that it is not enough as only taking firms' industrial characteristics into account, that the regional innovation system in which firms are located should also be included when understand firms' technology sourcing territories. Similarly, Kim (2009) emphasizes the role of intellectual property rights protection levels in seeker firms' countries.

In short, research into the determinants of technology sourcing regarding domestic-versus-foreign boundary has started to materialize. However, a thorough literature review points to a general framework can be outlined in prior studies, see Figure 1. Factors influencing a firm's technology sourcing across national border can be categorized into four different groups: (1) characteristics of seeker firm; (2) sourced technology itself; (3) factors inheriting in technology supplier; and (4) contingent factors (from both technology supplier and seeker sides).

The mechanisms underlying these four cohorts of determinants in deciding the technology sourcing boundary might be different from each other and inapplicable varying across countries and firms. However, this does not prevent us from taking common criteria to predict firms' technology sourcing propensity towards abroad or domestic. Generally speaking, for most firms that advanced technologies are generally generated and concentrated in few advanced countries and regions (Perez & Soete, 1988). In principle, technology was not easy to acquire, diffuse, and adopt regardless of its nature and type, where firms have to pay more to source them, while comparatively less will be paid when they source locally developed ones (Archibugi et al., 2003; Dunning et al., 2009; Lahiri, 2010). That is, different sourcing territories signal different gains and losses. Thus a central premise of this study guiding our hypotheses is that firms source foreign technology when the net anticipated benefits exceed the costs. In general, as the benefits of foreign technology sourcing accrue to the firms, we should observe an increased propensity in the use of this foreign technology by them. Similarly, as a firm is better able to mitigate the costs of assessing, transferring, and using foreign technology, it should use more foreign technology as well.

Figure 1 A unified framework for determinants of technology sourcing territory



In order to verify this conceptual framework, analyzing and categorizing determinants of firms' national technology sourcing boundary, this study selects four factors from each cohort as the representative. Besides technology suppliers' desorptive capacity, other three are most prominently featured in the extant literature, namely technology seekers' absorptive capacity, technology age, and seekers' external knowledge richness. Desorptive capacity is a newly emerged concept which pertains to technology suppliers' efforts, resources, and capabilities to identify potential buyers, transfer technology and assist buyers to use transferred technology (Lichtenthaler et al., 2010). This comes into being reasonably because when firms are sourcing technology, they also have to consider their searching cost, and resources and skills that the technology supplier can allocate to them to efficiently use the in-sourced technology. In what follows we will develop our hypotheses based on a technologically backward country—China and its native firms technology activities in forms of patent technology licensing. To better understand our hypotheses and follow-up predictor choice, hereafter we first present a short introduction about Chinese firms' technology resources and main sourcing means, then we turn to develop hypotheses.

2.2 Technology sourcing by Chinese firms

China was once the center of global innovation with such inventions as the compass, gun powder, paper and printing. However, due to various reasons China lost the plot on innovations for centuries. Since the establishment of new China in 1949, China has never stopped their efforts to become innovative. In 1950s the former Soviet Union was the major source of technology for China, the form of technology was characterized by complete sets of capital plant and equipment. During 1960s and 70s the foreign technology source becomes diverse and China imported technology from the West and Japan. The technology imported included turnkey plants and complete sets of equipment in textiles, chemical refining, petroleum, steel sectors (Zhao, 1995). This is the era of China central planning time where Chinese companies mostly relied on foreign technology embodied in equipment, turn-key plants, and instruments and so on.

During the past 30 years since Deng Xiaoping launched reform and opening in 1978, China has risen remarkably with an unprecedented global achievement, particularly its size of economy has ranked top second behind the US in the world. China becomes the world manufacturing center serving the world with different products in the lower position of global value chain. Throughout this period, specially, in the 1980s and early 1990s, Chinese science and technology system reforms and new programs went into fast-forward. As a result, Chinese domestic knowledge landscape has been well endowed with internationally recognized leading universities and public research institutes, increasing-growth of private innovative companies, and considerable number of R&D subsidiaries of foreign multinational companies (Dahlmann & Aubert, 2001; Liu et al., 2010). For instance, China's overall patent filings grew by 26% a year between 2003 and 2009. Growth was much slower elsewhere: 6% in the US, 5% in South Korea, 4% in Europe and 1% in Japan (Economist, 2010). Corresponding to this change with the increasing globalization and competition, Chinese firms' technology sourcing strategy has shifted to a new era. Currently, Chinese firms actively involved in foreign and domestic technology sourcing with different sourcing channels. In-sourced technology constantly takes place in the form of disembodied technology such as patent-protected technology, unlike that in the pre-reform period.

However, the successful catch-up of Chinese economy and science sectors did not bring its firms with strong innovative capabilities. Currently, 84% of Chinese large firms do not have R&D departments (McGregor, 2010). Indeed, Chinese firms' technology capabilities have been largely left in a lagging position compared to other firms in industrialized countries (Fu et al., 2011; Liu, 2005). Thus, with weak internal technology capabilities, Chinese firms learn to effectively source and apply externally developed technology, particularly, that ready-to-use technology as a primary means to catch-up technological deficiency, and mainly responding to market demands (Liu, 2005). Chinese firms have been able to survive only by understanding and responding to market needs; innovation and technology development has not been the critical factor.

Therefore, there are reasons to expect that Chinese firms source technology in different ways than those in developed countries. From a resourced-based view, due to constrained resource, innovative capacities, and market-oriented strategy, Chinese firms are more imitative than innovative. Therefore, they might source foreign advanced technology when they become more innovative and much older, i.e. with accumulated technology capabilities and other resources perhaps already reaped the economies of scale, more sensitive to foreign markets. Meanwhile, limited technological capabilities make Chinese firms more dependent on external assistance to search, use and diffuse foreign technology, such as that assistance from technology suppliers, and their local external environments. Therefore, they might tend to source foreign technology when they are most accessible, absorbable due to either technology suppliers' efforts or those from their external conditions, for instance, local universities and research institutes or other firms. From an institutional perspective, China "indigenous innovation" policy perhaps stimulates more domestic technology sourcing and less foreign technology sourcing, that is, the anti-foreign force. Thus, we expect that domestic technology suppliers, particularly government-financed Chinese universities and research institutes negatively influence firms' technology sourcing towards foreign technology. For these concerns, a focus on the domestic-versus-foreign technology sourcing decision by Chinese firms will deepen our understanding on technology souring territory and its implications for various kinds of relevant literature and involved parties, i.e. technology suppliers, seekers, and policy makers.

2.3 Hypotheses

Hereafter, we will develop four hypotheses with regard to factors that were carefully picked out from each cohort of determinants. They are only representatives for each group, but not can be arbitrarily interpreted that we discriminate others. We first discuss absorptive capacity, then suppliers' desorptive capacity, next technology age, and finally seekers' external knowledge richness.

Absorptive capacity and technology sourcing territory

In Cohen and Levinthal's (1990) seminal work they state that the ability of a firm to recognize the value of new, external technology, assimilate, and apply it to commercial ends is crucial to its competitive advantage building. This ability, which is called by them, "absorptive capacity", is history-dependent, and to a large extent reflects how much a firm has invested in technology and innovation efforts (Cohen et al., 1990; Zahra & George, 2002). With respect to the technology sourcing, scholars state that technology searching, acquisition, and use cannot be seen as simple as the purchase of a capital good or the acquisition of its blueprint (Anand & Khanna, 2000; Arora, 1996; Cohen et al., 1990). Technology recipients need enough absorptive capacity to recognize the value of external technology, and further, to assimilate, adapt, and improve upon this sourced technology. Therefore we expect that firms, invested in more internal absorptive capacity have a higher propensity to engage in cross-border technology sourcing because foreign developed technology is much harder to be absorbed (Li, 2011). Higher absorptive capacity can be able to overcome this hardness and unlock the higher value of foreign technology. Everything being equal, this leads us to hypothesize:

H1: *a Chinese firm's absorptive capacity positively influences its propensity to license in technology from abroad*

Suppliers' desorptive capacity and technology sourcing territory

Desorptive capacity is a new concept opposite to the term of absorptive capacity, referred to a supply firm's ability to transfer technology to the recipient, and help recipient firms make full use of the transferred technology (Lichtenthaler et al., 2010). It is emerged consist with the shift of industrial innovation strategy towards more market-based on model. With most industrial firms traditionally focusing on internal technology development, external technology sourcing based on market, such as technology licensing, often played a minor role in the past (Markman, Gianiodis, & Phan, 2009). However, according to Arora and Gambardella's (2010) report that almost 60% of the firms reported increased inward and outward licensing during the 1990s. Nowadays, technology can be traded as products on market. Thus, to make full use of this mechanism firms need to new capabilities—desorptive capacity to efficiently implement outward technology licensing (Lichtenthaler & Muethel, 2012). Although the transfer of necessary knowledge, skills, and training licensees has been widely discussed in literature, licensor firms are constantly reluctant to do this in the old time (Desai, 1988; Scott-Kemmis & Bell, 1985). This is known as the double sided moral hazard problems (Arrow, 1962). Currently, firms are largely motivated by the increasing improvement of technology market efficiency and consequently they can actively involve large extent of relevant knowledge transfer to sell their technologies. Because the range of capable providers of external technology and complements has also increased, creating new possibilities for extracting value from their existing technologies that would otherwise be missed (Chesbrough & Melissa, 2007). We thus believe this factor is gaining importance in extending firms' sourcing distance, even across the national border.

Desorptive capacity matters a firm's technology licensing decision can be drawn from Atuahene-Gima's (1993) earlier work. He documents that it behooves licensor managers, that intend to sell technology to Austrian firms to efficiently assess not only the skill needs of a potential licensee firm to exploit the licensed technology, but also their own firms' capability to transfer these skills to the licensee firms. Thus, when firms are sourcing technology, they also have to consider the resources and capabilities that the technology supplier can allocate to them to overcome disadvantages related to the long distant sourcing. The determinants of external technology sourcing decisions have been largely investigated by the transaction costs approach (Bonesso, Comacchio, & Pizzi, 2011; Mowery, Oxley, & Silverman, 1998; Steensma, 1996). Relatively, they state with the sourcing distance becoming longer the search and sourcing cost will significantly increase. Because long distance entails the large differences in language, culture, difficulty in communication, and factor endowments used as inputs for technology development. Consequently, we can expect that firms' technology sourcing distance becomes longer, even across borders as desorptive capacity increases. Everything being equal, we hypothesize,

H2: *a technology supplier's desorptive capacity positively influences a Chinese firm's propensity to license in foreign technology*

Technology age and technology sourcing territory

As mentioned before, firms source technology primarily to help them to achieve some overall objective. That objective is likely to be the growth of profits by introducing some new products or processes, rather than the development of technological capabilities (Katrak, 1990). However, scholars emphasize that external technology sourcing also provides recipient firms with an opportunity to develop their own technological effort and innovating some new products, mostly new to the company or their domestic markets (Liu & Buck, 2007). This comes about because the external sourced technologies have to be adapted to its local economic environment. The adaptive activities provide the firm with an opportunity for technological learning-by-doing which, in turn, gives it the experience to subsequently develop in-house technologies. More importantly, external technology provides firms with novel combinations, important for innovations by combining firms' own knowledge element with externally acquired technology (Dahlman, Ross-Larson, & Westphal, 1987). This is because innovation is a recombinant process by which (new and old, internal and external, national and global) knowledge elements are mixed (Fleming, 2001; Katila & Ahuja, 2002; Rosenkopf & Nerkar, 2001). So it might be wrong if we consider that the purpose of firms' technology sourcing is only to use for short-term profit without any concerns of their technological and innovative capability building. As Liu (2005) states Chinese firms are implementing a more open innovation strategy to learn from technology outsourcing. This makes us believe that when sourcing external technology Chinese firms still pay attention to what this sourced technology can bring for their long-term effects—technological and innovation capabilities.

In line with this inquiry, we take the age of technology as the sample to demonstrate how technology attributes influence firms' technology sourcing choice with respect to the domestic-versus-foreign boundary. In knowledge search theory that knowledge age means the potential value for recombination with old knowledge elements with new ones to generate novel innovations (Katila et al., 2002; Rosenkopf et al., 2001). That is because firms tend to search locally along the neighborhood of their current expertise towards the knowledge development path. Some valuable knowledge might not be used because complementary knowledge was not available in the firm at a particular point in time. This unused knowledge in the past may nevertheless have a high potential in the future because complementary knowledge become available. Thus, from recombination perspective regarding innovations, sourcing for rather "old" technologies may render advantage for technological exploration. It is much likely that a rather mature technology was chosen by Chinese firms because this is much suitable for their comparative weak absorptive capacity. For old technology its characteristics are relatively well understood and there exists considerable knowledge, and technician people who are familiar with this technology, firms thus can easily find assistance from outside to recombine this with other more recent knowledge elements (Katila et al., 2002). Compared to domestic old technology, foreign technology seems more attractive for Chinese firms because it more heterogeneous and unfamiliar for Chinese firms. This, in turn, brings up more novel configurations of innovations for Chinese firms. Hence, everything being equal, we propose,

H3: *the age of licensed technology positively influences a Chinese firm's propensity to license in technology from abroad*

Firm external knowledge richness and technology sourcing territory

In the first two hypotheses we predicted that Chinese firms with their own absorptive capacity or with those from technology senders will induce Chinese firms to benefit foreign technology.

Now we extend this absorptive capacity concept to Chinese firms' external context that can be used to compensate firms' weak absorptive capacity. Thus, the knowledge richness of Chinese firms' local site can be a predictor for Chinese firms' technology choice for foreign technology as well. The detailed mechanism behind this prediction is explained as follows. We already know that technology is not simply a set of blueprints, instructions, manuals, and patent rights or copyrights (Arora, 1996; Evenson & Westphal, 1995). In order to make firms assimilate and use effectively in-sourced technology, the transfer of tacit knowledge to technology seekers is inevitably needed, such as the information about procedures and practices, rules of thumb, trade-secrecy, metrology, standards, testing and quality controls (Teece, 1977). However, there are at least three barriers that matter the efficiency of this type of tacit knowledge transfer. First, much tacit knowledge is based on the cumulative experience of the supplier about the process as it actually works under the condition consistent with the factor endowment of its country. That is, knowledge spillovers are geographically bounded due to the requirement of proximity for the transfer of this tacit knowledge (Jaffe et al., 1993). Second, particularly, in the case of overseas technology sourcing, that is constantly suffered from double sided moral hazard problems (Arora, 1996; Arrow, 1962). For example, the supplier may not send its best engineers over to the recipient firms to provide sufficient technical service or some important trade secrets may not be revealed to the recipients. Studies of technology imports in India provide evidence to support this, they suggest that Indian firms importing technology from abroad tend not to receive sufficient amounts of technological know-how (Desai, 1988; Scott-Kemmis et al., 1985). As a consequence, this leads to insufficient knowledge, particular know-how, directing to recipient firms (Lin, 2003). This situation will become worse when the institutional protection of intellectual property rights (IPRs) in technology recipient countries are weak, foreign technology suppliers are largely reluctant to transfer their know-how to these countries (Teece, 1977). Even China IPR system has been significantly improved after China's entry to WTO in 2001 criticism is still frequently heard from foreign companies.

As a result, the ability of technology recipients to assimilate and use the imported technology is largely limited. That is, the recipient firms barely have the full information and knowledge about the imported technology. To compensate this insufficiency, the local supply of this knowledge, technical information, and other support services becomes increasingly important. These suppliers may be universities, research institutes, and other private firms in technology seekers' regions (Zhou, 2011). Hence, Chinese firms might expand their absorptive capacity by connecting them with local important innovation parties (Liu, 2005). That is, this external technology richness can be a determinant for firms' technology sourcing boundary regarding the choice between domestic and foreign. Everything being equal, we predict,

H4: *the external knowledge richness positively influences a Chinese firm's propensity to license in technology from abroad*

3. Empirical analysis

3.1 Data and sample

In the introduction section we argued that Chinese firms will be chosen to test our hypotheses. Besides this, we represent firms' technology sourcing by their patent technology licensing activities. Technology sourcing can take place in different means and at different stages during the technology development and application process. Patent technology licensing represents a much visible means and more advanced stage that comparatively mature technology was exchanged among different economic agents. Recent studies show that patent technology licensing has increasingly become popular in technology sourcing mode portfolio (Arora et al., 2010). A striking advantage by using patent technology licensing to analyze technology sourcing behavior is also in the reliable information that we can use for our study, because technology licensing generally takes place under certain formal contracts which can be easily traced and recorded. For instance, in 2001 the Chinese government issued the law—Administration of Record Filing of Technology Licensing. According to this law, China's State of Intellectual Property Office (SIPO) is authorized to register technology license agreements in China. Under this situation, licensee firms are required to register their technology license agreements in the SIPO or its branches scattered throughout every province and municipality within three months of the establishment of license deals. This law came into force on January 1, 2002. However, SIPO has initially registered technology license agreements from 2000. This is common because there is in general a transition period for experimentation for almost all laws in China before they came into force. Each record contains the following information: number of registration, licensor and licensee name, main patent classification code, patent number, patent application date, patent grant date, contracting period, and changing term of contract. So far, the available data for some cases in 1998 and 1999 are incomplete, while more complete data are accessible from 2000 onward. This data include technology transfers among different parties, individuals, universities, R&D institutes, and different kinds of firms. In total, from 1998 to 2009 there are 15,449 license agreements which cover 36,497 patents. These agreements connect 6,037 licensors (including 3,332 individuals) to 6,905 licensees (including 48 individuals).

Among these, we selected technology license agreements forged between organizations, excluding any licensee agreements involving individual licensees or licensors. For firms involved in technology license, parties can be joint ventures between Chinese and foreign firms or foreign-owned subsidiaries, and Chinese indigenous firms. Because for the former two types of firms, their technology sourcing are largely influenced by foreign partners or parent firms, we therefore focused on the native firms which have rooted deeply in Chinese domestic markets. In addition, the effort of Chinese indigenous firms in technology is also easy to observe. In line with these criteria we take all Chinese firms, who entered technology licensing activities during 2000 to 2005 as our sample. Eventually we get 389 Chinese indigenous licensee firms. There are no licensee firms involved in both domestic and foreign technology licensing during our observation period. Technologies from subsidiaries are aggregated into their parent companies. One observation refers to a licensee firm’s yearly license activities, with at least one license agreement in the observation year. All licensing and patent application data were collected from SIPO patent retrieval system[1]. Other supplemental data was collected from firms’ publications, books, newspapers, and e-mail or telephone inquiries to the top managers of firms.

3.2 Measurements

(1) Dependent variable

Boundary choice (BC), we use a dummy variable to measure this dependent variable, it is denoted as 1 when a Chinese native firm licenses-in technology from foreign licensors, including their China subsidiaries, otherwise 0.

(2) Independent variables

[1] The link to the SIPO patent retrieve system for domestic and foreign patents: http://search.cnipr.com

Licensee absorptive capacity (LAC), we use the accumulative number of Chinese patent applications within the 5 years prior to the licensing year to measure this variable. According to the original definition of absorptive capacity by Cohen and Levinthal (1990), it refers to a firm's existing technological capabilities. In literature this variable has been operationalized in different forms. In this study we are following some important publications that apply firms' patents accumulated in five years as the measurement (Ahuja & Katila, 2001; Vanhaverbeke, Duysters, & Noorderhaven, 2002).

Desorptive capacity (DC), this is a new concept and the measurement is still in its infancy. In Lichtenthaler and Muethel's (2012) recent work they use survey data to measure it. For this study, we use the accumulative number of patents that the licensor applied for in SIPO within five years preceding the licensing year to measure this. More patent applications represent higher technological capabilities they are. This might partially reflect their desorptive capacity. For foreign companies, the number of their applied Chinese patents thus can be interpreted as the extent of their intentions to tap into Chinese product and technology markets.

Technology age (TA), the average number of years between the patent filing years in their home country patent system, covered in license agreements and the license contracting years;

External knowledge richness (EKR), the number of 5-year patent application in SIPO of the province (a natural logarithm) that a licensee firm (or headquarter when they have multiple facilities in different provinces) resides is used to develop this variable.

(3) Controls

We control a number of potential factors drawn from different levels that are related to licensed technology, licensee, licensor, and external environments. At the technology level, we control

technology complexity (TC). It is measured as the average number of patents that a licensee firm's yearly license agreements cover; Technology complexity refers to the extent to which knowledge is derived from the combination of a variety of knowledge streams (Singh, 1997). In our case, a license deal covers at least one patent. A patent tells how to use skills to produce certain products. Thus, we predict that if a license deal contains more patents then this technology becomes more complex. At the firm level, from the licensee side, we control: ***firm size (FS),*** we measure this by using the number of employees of a licensee firm in the licensing year (a natural logarithm); ***firm market orientation (FMO),*** this is measured by using a dummy variable with its value at 1 to indicate that a firm belongs to an exporting company, that is, its products are mainly made for export market, otherwise 0. And ***firm age (FA),*** we measure this by using the number of years from the founded year to the licensing year of licensee firms. The dependent variable increases with this variable, but it decreases if the firm is a startup. Meanwhile, at this level, we also control ***licensor type (LT).*** A dummy is used to measure this variable, 1 when a licensor is a Chinese university or research institute, otherwise 0. Finally, we also control licensee firms' external conditions. First, we control firms' industry characteristics, ***industry dummy (ID),*** it is denoted as 1 when a Chinese firm belongs to a high-tech industry, otherwise 0[2]; and ***market competition (MC),*** in economics, this variable is usually measured using a function of the number of firms and their respective shares of the total production in a market. In the case of China, we are not able to collect individual firms' production capacity, then we use the number of firms in the industry in which licensee firms locate in their licensing years, to roughly measure this (a natural logarithm). The data is thus collected from *China*

[2] Chinese high-tech industries are divided into 5 main sectors with 17 sub-sectors according to the National Bureau of Statistics. Based on the technology licensing data, this study defines those as high-tech firms when they belong to any of these 5 sectors, namely, Medical and Pharmaceutical Products, Aircraft and Spacecraft, Electronic and Telecommunications, Computer and Office Equipment and, Medical Equipment and Meters.

Statistics Yearbook (2000-2005). Finally, in order to control time-varying effects on firms' technology sourcing decisions, we include ***year dummies*** (2000-2005) into our analysis. "Year 2000" was the omitted category.

3.3 Model specification

The hypotheses are tested using the logistic panel model where the dependent variable is dichotomous (0/1). Moreover, because we have panel data where unobserved heterogeneity is commonly present and the failure to include firm-specific effects may lead to heteroskedasticity. Although either fixed or random effects of logistic model can, in theory, be used to control for firm-specific unobserved heterogeneity (Greene, 2003), both kinds of models fail to control time serial correlations. Consequently, we use the logistic panel model with population-averaged method. One more advantage of employing the population-averaged method is that it allows us to use the White estimator of variance that produces valid standard errors. Robust standard errors are calculated by the generalized estimating equations (GEE) approach. Moreover, this estimator has been proved that it is more efficient than other panel data methodologies because it provides multiple correlation matrix structures (exchangeable is used in this study) to best match the data (Liang & Zeger, 1986). Additionally, to account for any overdispersion in the data, we report all results with White (1980) robust standard errors.

4 Results

Table 1 provides descriptive statistics of the variables and the correlation matrix. The independent variables are not highly correlated among themselves with the maximum value 0.42 between the market orientation and licensor technology capability. This implies that our model will not be subject to a multicollinearity problem. Further tests of the value of the variance inflation factor (VIF) yielded a value less than 3.13 for all cases below the critical point 10, indicating no existence of severe multi-colinearity (Belsley, 1980).

Insert tables 1 and 2 here

Table 2 provides the results of all estimated models with the variance and log-likelihood statistics. Model 1 presents the baseline model including only control variables. Firm size, firm age, firm market orientation, market completion, and firm industry characteristics show positive and significant effects. The variables reflecting the hypothesised effects are entered into the regression sequentially. Finally, Table 2 shows the full model (Model 5) that we use as the basis for testing our hypotheses. It noticed that the log-likelihood statistics provide evidence that adding licensee absorptive capacity, desorptive capacity, technology age, and external knowledge richness significantly improves the model fit over the model with the control variable only (Model 1), supporting the idea that Chinese firms' decisions in technology sourcing boundary is indeed a multidimensional construct, at least four in our study. This, turn out, verified our comprehensive framework.

Hypothesis 1 predicts that a Chinese firm with higher absorptive capacity has a higher propensity to involve in foreign technology licensing activities. The coefficient for licensee absorptive capacity in Model 5 is positive and significant (β=0.0084, p<0.10), thus providing evidence for Hypothesis 1. In Hypothesis 2, we propose that technology suppliers' desorptive capacity can help seeker firms to overcome search cost, efficiently utilizing sourced technology, and other disadvantages related to long distance technology sourcing. Higher desorptive capacity promotes longer distance of technology sourcing. We thus predicted that desorptive capacity positively influences firms' decisions in foreign technology sourcing. From Model 5 in Table 2 we found that the coefficient for desorptive capacity is positive and significant (β=0.0008, p<0.05). We can thus accept Hypothesis 2. Hypothesis 3 predicts that older technology bring seekers a higher propensity to engage in foreign technology sourcing activities. The coefficient for the corresponding explanatory variable in Model 5 is positive and significant (β=0.0180, p<0.10), allowing us to accept Hypothesis 3. Our fourth hypothesis proposes that Chinese firms operating in rich knowledge regions are very likely to prefer foreign technology to domestically developed technology. This hypothesis is supported by the results at a 5% significance level (β=0.0276, p<0.05).

Some findings with respect to the control variables are noteworthy. Consistent with our prediction, firms' technology sourcing territory is influenced by seeker firms' age, market orientation, and industry feature in which they locate. Foreign technology is advanced and promising for firms from developing countries, like Chinese firms. However, applying foreign technology is not costless and unconditional. A key factor promotes or prevents them from sourcing foreign technology is their absorptive capacity and finance resources. For most Chinese firms they are younger and constantly constraint by limited owned resources, with the time elapses, they are gradually accumulate their technology capabilities and finance resources by probably successfully tapped Chinese domestic markets or foreign markets linked to the global value chain (Altenburg et al., 2008; Liu, 2005). So the results are consistent our expectations that older firms show higher propensity to source foreign technology, and firms' occurrence in foreign markets influence their boundary technology sourcing decisions. In line with the existing studies high-tech firms have a higher propensity to source technology widely (Martin et al., 2011). The unexpected result of this study, the effect of licensor type is negative but not significant. Technology complexity show insignificant effect, and the market competition shows inconsistent effect on firms' technology sourcing territory toward overseas.

4. Conclusions and discussion

In terms of specific factors, our empirical findings are largely consistent with the existing studies. Firms endowed with strong absorptive capacity have a higher propensity to engage in global knowledge sourcing (e.g. Barnard et al., 2011). Concerning the newly emerged concept of desorptive capacity, our study provides support for this line of inquiry that firms need strong desorptive capacity to sell out their technology and further benefit from technology market. This consists of important factors that technology buyers need to consider particularly when involve cross-border technology trading. Next, the positive effects of technology age on seeker firms' propensity to choose foreign technology confirm our expectation that firms have also long-term consideration in initiating their innovative capability development by sourcing foreign old technology. Aligned with considerable publications which highlight the role of local site in development countries to help their firms to tap into foreign technology (Chen et al., 2003; Kim, 1980), our study is in line with this argument. As to the firm age, our findings are similar with Liefner and colleagues' work (2006) that Chinese younger firms preferred more domestic technology rather than foreign technology. Witt (1998) states that firms' presence at foreign markets increases the relevance of their technology sourcing towards foreign technology suppliers. China as the world manufacturing center, we expect this effect is most likely happen in Chinese firms. The empirical results support our argument, that foreign market-oriented firms have a higher tendency to source foreign technology. This is also similar to Xu's (2011) finding based on China context as well. Finally, we support the argument that compared to firms from traditional industries; those from high-tech industry show a higher possibility to source technology across national borders (Almeida, 1996; Dunning et al., 2009).

Our empirical study contributes to research into technology sourcing, technology market, and technology policy. First, regarding the technology sourcing literature our study extends the extant literature by detailing the theoretical construct of a general framework for analyzing the technology sourcing boundary. More importantly, our analysis is among the first empirical studies that help to understand what antecedents can be used to explain firms' decisions in domestic-versus-foreign technology sourcing boundary. External technology sources, particularly those from abroad, increasingly become an important input for firms' innovations and technological capability formation (Chesbrough, 2003; Dunning et al., 2009). However, there are no systemic considerations on geographic locations of external technology resources. Relevant research mainly can be drawn from territorial innovation theory and R&D globalization literature. The available empirical evidence shows a mixed picture about firms' choice in knowledge sourcing territory with little understanding how firms make decisions across borders or not. Meanwhile, researchers draw their geographical lines at different levels of detail, such as local, regional, national, and global. These vague lines are hard to match the coverage of public policy, for instance the national border that a country's policy can cover. As a result, this type of study implies little for policy making.

In this regard, we readdressed the research imbalance of technology sourcing and obtained some new insights. Prior studies in the technology sourcing field mostly focused on firms in developed countries and held the absorptive capacity logic, and consequently ignored the active technology sourcing by latecomers (Cohen et al., 1990). They believe that the level of absorptive capacity provides better conditions to recognizing and learning from external sources technology (Zahra et al., 2002). On the contrary, the firms situated in developing countries do not devote considerable efforts to their absorptive capacity thus cannot exploit the external sources of technology, in fact, in many cases their domestic knowledge bases are week, and lack appropriate support systems (Liu & White, 2001). Under this logic, they rather use technology transfer, from developed to developing, dominated by multinational companies, than technology sourcing, reflecting seeks' active roles (Laursen, Leone, & Torrisi, 2010). Our findings support that absorptive capacity plays a crucial role in latecomers' technology sourcing strategy, and those with strong absorptive capacity can benefit from foreign advanced technology. However, we also found that absorptive capacity is not necessarily owned by firm itself; in contrast, the firm can expand his absorptive capacity by using external knowledge to better absorb foreign technology. Moreover, the effect of absorptive capacity is mostly likely to couple with the nature of external technology. That is low level of absorptive capacity preclude firms from sourcing foreign technology, but not the case of domestic technology, which needs less absorptive capacity. In addition, we also found there are other factors beyond absorptive capacity, playing an important role in deciding latecomer firms' technology sourcing territories, such as export. In line with prior studies (Burpitt & Rondinelli, 2000; Grossman & Helpman, 1991; Zahra et al., 2000), we find that exporting stimulates learning, imitation, and innovation. This implies that exporting firms are likely to benefit more from foreign technology sources than firms serving the domestic market. All might point to the fact that instead of passively receiving technology transfer from outside, latecomers increasingly engage in external technology sourcing aligned with their internal and external conditions. Their active roles and bargaining powers might be enhanced on one hand with the emergence of more competitive technology suppliers, on the other hand, with the rapid growth of latecomers' domestic markets.

Secondly, with regard to the emerging technology market research, our study extends the extant literature licensor by shedding light on both licensor and licensee firms. Recently, a thorough literature review in the field of technology market by Arora and Gambardella (2010) concluded the aspect of technology markets that has received the attention of researchers is the supply perspective of technology. In this aspect, they highlighted that scholars paid considerable attention on the factors that lead firms to license or sell technology, the implications thereof, and the conditions that facilitate the rise of technology specialists. In contrast, the demand side for external technology has not received the same attention. Our findings appear to contribute to the supply and demand aspects. From the licensor perspective, our study indicates that firm characteristics, such as firm age, firm existing technology strength, firm technology orientation (high-tech versus others), market orientation (foreign versus domestic market), are likely to be helpful to licensors to screen and select potential licensee firms. Meanwhile, for that licensor firms that demonstrated their desorptive capacity, for instance, strong technology capabilities, willingness, in particular, filling patents in their target markets, seems advantageous. We also find that domestic technology suppliers, i.e. universities and research institutes, in China are not yet competitive with foreign technology suppliers. Likewise, from the license perspective, this study responds to recent calls for investigating determinants of the demand for external technology. Precisely, we answered the question what factors decided their preference regarding inward foreign and domestic technology licensing. At the same time, we also support the recent consideration that licensee firms acquire external technology not only with the attempt to pursue short-term benefits, for instance, profit, in-house R&D saving, but also keeping the consideration to facilitate their long-term competitiveness building, such as technological learning and innovation (Leone & Reichstein, 2011; Tsai, Hsieh, & Hultink, 2011).

Finally, our study contributes to the discussion of Chinese so-called "Indigenous Innovation Policy". Since 2006, China government initiated its so-called indigenous innovation policy towards building up its firms' technological capabilities through large internal R&D investment and a dynamic domestic technology transfer system with less dependence on foreign technologies. This policy has stirred a hot debate among government officials, academic scholars, and practices from both at home and overseas. Our work says, yes, the substitute effect has emerged, but it is still small. Chinese technology suppliers mainly located at the lower- and middle-tech industries, and serve domestic young firms with limited finance and absorptive capacity. They emerged but not capable of competing with foreigners at the high-tech field. Most fast growing firms still choose technology from abroad. Similarly, an important policy that Chinese government implemented to embrace its indigenous innovation strategy, through heavily investing in Chinese universities and research institutes seems also be overlooked. A salient feature of Chinese national innovation systems is the fact that roles of science and industry sectors in innovation have been reversed (Liu et al., 2001). That is, universities and research institutes have strong research capabilities and qualified scientists and engineers, while not in the industries. Our empirical work demonstrated local technology suppliers, i.e. universities and research institutes have not become what are supposed to be. In the followings we draw some implications and acknowledge some limitations of our study.

We discern several firm-level and macro-level implications for our findings. At the firm-level there is a strong need for firms to take a systemic examination of different factors that related to knowledge sourcing boundary. Firm specific factors, for instance absorptive capacity play a major role in determining a firm's knowledge sourcing territory. Besides this, we also suggest firms should take a look around their external technology conditions, technology domain, market places, and knowledge suppliers' characteristics when they are leveraging the choice of high quality but relative costly from abroad with lower quality, but relative cheaper knowledge from domestic suppliers. Technology in-licensing should be performed before a strategic thinking when leveraging short-term and long-term gains. Licensee firms also need to be more selective and active in inward technology licensing in pursing the benefits that increasing technology empower to them. At the macro-level policy makers are suggested to make their innovation policy more harmonious with firms' knowledge sourcing behaviors which are generalized more based on the market rule. For instance, in this study we based our arguments on a Chinese context, and we found that the underlying logic guiding Chinese firms' technology sourcing territory is much similar as what scholars found in well-functioning market economies. In this view, we a consolidation between firms' technology sourcing behavior and government's strategy goal is needed. Inappropriate policies perhaps lead to a discrepancy between the policy orientation and the real practice of firms' technology boundary choice. Rather forcing Chinese native firms to choose technology originated from domestic technology suppliers, including that from subsidiaries of foreign companies, we suggest innovation policy for instance, probably might be more effective if it focuses more on improving some innovation infrastructure, and strengthen market competition, and improve the IPR environment.

The limitations of our research are diverse. First of all, we use the Chinese licensing dataset where firms sourcing their technology either domestic or foreign. This does not mean that domestic and foreign technologies cannot coexist. Most recent studies show that both domestic and global knowledge can be integrated into a firm's knowledge base at the same time (Martin et al., 2011). Foreign and domestic knowledge sourcing should be a problem of extent, relying on more or less on foreign or domestic supply. While due to the limitation of our dataset we only can use a binary choice. Simultaneously, Chinese firms also can source technology from abroad through various means, such as consulting projects, and technology transfer projects, strategic alliance, and outward FDI. Future study needs to take a careful look at other means by which firms use to source knowledge so as to make a full picture of firms' knowledge sourcing territory. Second, Chinese technology licensing records now can be fully accessible until 2009, while we only use data ending in 2005 and focus on Chinese native firms. More work should be dedicated into cleaning much more sample firms and perhaps also including other types of firms into our analysis. Finally, the factors we present in this study cannot act solely, thus the missing of interaction term analysis consists of another drawback of our study. This thus deserves more attention from researchers in advancing this stream of study in future.

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Table 1 Descriptive statistics and correlations

Variable	Mean	S. D.	1	2	3	4	5	6	7	8	9	10	11
1.DC	582.25	982.04											
2.TC	2.70	3.97	0.01										
3.TA	7.23	3.48	0.27	0.12									
4.FA	9.72	11.01	-0.07	-0.07	-0.01								
5.EKR	4.46	0.44	0.40	0.01	0.34	-0.18							
6.FS	3.08	0.68	0.09	0.15	0.18	0.30	-0.10						
7.LAC	19.18	121.98	0.01	0.04	0.02	0.11	-0.03	0.30					
8.BC	0.52	0.49	0.34	0.01	0.31	0.05	0.26	0.14	0.10				
9.LT	0.24	0.43	-0.06	0.01	-0.09	-0.02	-0.20	0.02	0.10	-0.06			
10.ID	0.60	0.49	0.11	-0.10	0.01	-0.03	0.12	0.03	0.03	0.04	-0.08		
11.FMO	0.34	0.47	0.42	-0.07	0.23	-0.10	0.34	0.01	-0.04	0.34	0.00	-0.05	
12. MC	5.31	0.65	0.21	-0.00	-0.05	0.35	0.29	0.09	0.01	0.31	0.21	0.07	0.29

a. Number of observations=425; Number of firms=389

Table 2 Regression Results

Variables	Model 1 Boundary Choice	Model 2 Boundary Choice	Model 3 Boundary Choice	Model 4 Boundary Choice	Model 5 Boundary Choice
Constant	-6.189***	-5.750***	-4.507***	-4.776***	-3.631**
	(1.531)	(1.562)	(1.578)	(1.598)	(1.631)
TC	0.0185	0.0091	0.0075	0.0110	0.0204
	(0.0281)	(0.0301)	(0.0303)	(0.0313)	(0.0317)
LT	-0.0756	-0.118	-0.140	-0.114	-0.0458
	(0.279)	(0.283)	(0.288)	(0.292)	(0.299)
FS	0.355*	0.241	0.180	0.105	0.0994
	(0.193)	(0.208)	(0.212)	(0.220)	(0.220)
FMO	1.567***	1.585***	1.213***	1.211***	1.140***
	(0.303)	(0.305)	(0.303)	(0.303)	(0.311)
FA	0.120***	0.116***	0.105***	0.108***	0.068*
	(0.0394)	(0.0390)	(0.0373)	(0.0375)	(0.0408)
MC	0.636**	0.621*	0.407	0.452	0.253
	(0.324)	(0.330)	(0.332)	(0.339)	(0.343)
ID	1.306***	1.315***	1.191***	1.188***	1.202***
	(0.255)	(0.256)	(0.257)	(0.255)	(0.258)
LAC		0.0091*	0.0095*	0.0094*	0.0084*
		(0.0048)	(0.0054)	(0.0054)	(0.0047)
DC			0.0008***	0.0009***	0.0008**
			(0.0003)	(0.0003)	(0.0003)
TA				0.0188*	0.0180*
				(0.0106)	(0.0109)
EKR					0.0276**
					(0.0111)
Deviance	435.1	431.6	417.1	414.3	405.9
Difference in log likelihood vis-à-vis prior model	-	3.5*	14.5***	2.8*	8.4***
df	12	13	14	15	16

a. Number of Observations=415; Number of firms=389

b. Standard errors are in parentheses

c. * significant at 10%; ** significant at 5%; *** significant at 1%

d. Two-tailed tests for controls, one-tailed tests for hypothesized variables, year dummies were included, but are not shown