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Firm strategies, sectoral environments, and government policies: Three essays on the catching-up of Chinese firms

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ABSTRACT

This dissertation is focused on one question: how can emerging market firms catch-up with established multinationals? Guided by a sectoral system of innovation (SSI) framework, I developed three essays at the intersection between SSI and "catching-up".

The first essay, ***"Foreign Cuisine or Local Delicacies? How Sectors Matter in Acquisition-Productivity Linkage"***, investigates how different types of acquisitions can be used as catch-up strategies for enhancing firm productivity. The results demonstrate that overseas acquisitions tend to be effective catch-up strategies for enhancing firm productivity in high-tech sectors, whereas domestic acquisitions tend to be effective catch-up strategies for enhancing firm productivity in low-tech sectors. The value-creation mechanisms underlying the acquisition-productivity link differ across different sectoral environments.

The second essay, ***"Segmented Markets, Generational Technological Changes, and the Catching-up of Domestic Firms: A History-friendly Model of China's Mobile Communications Industry"***, investigates how market/technological regimes affect the catching-up of domestic firms. Using a "history-friendly" modeling approach, we find that segmented markets, in combination with generational technological changes, facilitated the catching-up of Chinese domestic firms with respect to foreign multinationals in the mobile communications industry.

The third essay, ***"Is a Protective FDI Policy Good (or Bad) for Domestic Firms' Productivity Catch-up? A Comparison of Firms under Different FDI Policies"***, investigates how China's policies toward foreign direct investments (FDI) affect the catching-up of domestic firms. The results suggest that a protective FDI policy that requires foreign multinationals to form joint ventures with local firms cannot promote knowledge transfer. However, such a policy might reshape the competition landscape in an industry.

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DISSERTATION OVERVIEW

This dissertation is motivated by one question, “how can emerging market firms catch-up with established multinational enterprises?”

“Catching-up” refers to a process through which latecomers narrow the gap between themselves and forerunners (Abramovitz, 1986), where the “gap” is often measured in terms of productivity or market share (Lee & Malerba, 2014). Understanding the process of catching-up is important, because the process of catching-up is essentially a process that drives economic development in emerging economies (Malerba & Nelson, 2012).

Although many emerging market firms may have the strategic intent of catching-up (Hamel & Prahalad, 2005), only a few of them can fulfill such a strategic intent. Prior studies on the catching-up phenomenon have shown a few examples of successful catching-up achieved by firms from a small set of newly industrialized economies (Kim, 1997; Keun Lee & Lim, 2001; Mathews, 2002). However, the majority of developing countries have not seen their firms catching-up (Lee, 2013). A better understanding of the catching-up phenomenon at the firm-level is urgently needed (Fagerberg, Mowery, & Nelson, 2006). This dissertation aims to contribute to this field by investigating factors that impact Chinese firms’ catching-up. Although China is a latecomer even among catching-up economies (e.g., South Korea), the magnitude of China’s economic growth in the past three decades makes what explains Chinese firms’ catching-up a relevant question. Additionally, the sheer size of the Chinese economy also implies that Chinese firms’ catching-up might have a greater impact on established multinational enterprises both inside and outside China, compared with the impact of catching-up occurred in other smaller economies. This means that a better understanding of Chinese firms’ catching-up is not only relevant from the Chinese firms’ point of view, but it is also relevant from the foreign multinationals’ point of view.

Prior studies (e.g., (Gao, 2014; Mu & Lee, 2005)) on the phenomenon of Chinese firms' catching-up have often fallen into the so-called tradition of "appreciative theory" (Malerba, Nelson, Orsenigo, & Winter, 1999; Nelson & Winter, 1982), in which scholars verbally articulate their explanations for a phenomenon based on their observations about the real world. Although "appreciative theories" can bring us important insights into real world phenomena, their qualitative nature makes the "appreciative theories" only the first step for identifying the key variables behind a phenomenon and for testing the relationships among these key variables (Malerba, Nelson, Orsenigo, & Winter, 2016). This dissertation aims to shed light on the mechanisms behind Chinese firms' catching-up by conducting two quantitative studies (Essay 1 & Essay 3) and one simulation study (Essay 2).

From the theoretical point of view, this dissertation adopts the Sectoral System of Innovation (SSI) framework (Malerba, 2002; Malerba & Nelson, 2011) as the conceptual framework to guide the investigation. Catching-up is a challenging task for latecomers, which requires deliberate efforts from multiple actors within an innovation system. The SSI framework is an eclectic framework to guide the investigation, because on the one hand, it covers multiple actors that are key for making a successful catching-up (e.g., firms and governments), and on the other hand, it captures the sectoral environments surrounding these actors (e.g., technological / market regimes) that also played an important role in domestic firms' catching-up.

Following the SSI framework, this dissertation develops three essays that examine the role of firm strategies, the role of sectoral environments, and the role of government policies in the process of Chinese firms' catching-up respectively.

Insert Figure 1 about here

The first essay addresses the question, when can certain types of acquisitions (cross-border or domestic) be used as appropriate catch-up strategies for enhancing firm productivity? This paper compares the domestic acquisitions and overseas acquisitions conducted by Chinese listed firms in the period of 2003-2013. The results suggest that the acquisition-productivity link varies across different sectoral environments. In the high-tech sectors, overseas acquisitions tend to be an appropriate productivity-enhancing strategy. This is because in the high-tech sectors, "promoting technological innovation" tends to be the primary mechanism through which acquisitions enhance firm productivity. In the low-tech sectors, domestic acquisitions tend to be an appropriate productivity-enhancing strategy. This is because in the low-tech sectors, "enhancing market power" and "enhancing operating efficiency" tend to be the primary mechanisms by which acquisitions enhance firm productivity.

The second essay addresses the question, what kind of sectoral environments would allow Chinese domestic firms to catch-up with foreign multinationals in the mobile communications industry? Through a "history-friendly" modeling approach, this paper demonstrates that segmented markets, together with generational technological changes, facilitated domestic firms' catching-up with respective to foreign multinationals. Generally speaking, segmented markets provided Chinese domestic firms with a "nurturing ground" for surviving their "infant ages", whereas generational technological changes open up the "window of opportunities" (Perez & Soete, 1988) for domestic firms in new product segments.

The third essay addresses the role of government policies in domestic firms' catching-up. This paper answers two questions related to China's foreign direct investment (FDI) policies. The first question is whether a protective FDI policy (e.g., restrictions on the mode of foreign entry) can promote knowledge transfer through an arranged international joint venture (IJV) partnership or not. The second question is whether a protective FDI policy would lead to an inefficient industry or not. The results suggest that, although there is no evidence of knowledge transfer under a protective FDI policy, there is also no evidence of an inefficient industry under such a policy. This means that a protective FDI policy may not be as “good” as policy makers expect, but it also may not be as “bad” as some critics expect.

Although the three essays are focused on different building blocks of the SSI framework, “sectors” and “sectoral contexts” always played a role in each of the three essays. In the first essay, sectoral differences (“high-tech” versus “low-tech”) can be considered as a moderating variable that changes the effectiveness of certain acquisition strategies for productivity enhancement. In the second essay, the sectoral characteristics (technological / market regimes) *per se* became the main drivers of the study. In the third essay, the discussion of government policies is also based on a comparison of two sectors that implemented different FDI policies in China’s post-WTO era. The next three chapters contain the three essays, which are followed by the concluding remarks.

References

Abramovitz, M. (1986). Catching up. forging ahead, and falling behind. *Journal of Economic History, 46*(2), 385-406.

Fagerberg, J., Mowery, D. C., & Nelson, R. R. (2006). *The Oxford handbook of innovation*: Oxford Handbooks Online.

Gao, X. (2014). A latecomer's strategy to promote a technology standard: The case of Datang and TD-SCDMA. *Research Policy, 43*(3), 597-607.

Hamel, G., & Prahalad, C. K. (2005). Strategic intent. *Harvard Business Review, 83*(7), 148-161.

Kim, L. (1997). *Imitation to innovation: The dynamics of Korea's technological learning*: Harvard Business Press.

Lee, K. (2013). *Schumpeterian Analysis of Economic Catch-up: Knowledge, Path-Creation, and the Middle-Income Trap*: Cambridge University Press.

Lee, K., & Lim, C. (2001). Technological regimes, catching-up and leapfrogging: findings from the Korean industries. *Research Policy, 30*(3), 459-483. doi:10.1016/s0048-7333(00)00088-3

Lee, K., & Malerba, F. (2014). *Changes in Industry Leadership and Catch-up by the Latecomers: Toward a theory of catch-up cycles.* Paper presented at the Future perspective on innovation and governance in development, UNU-MERIT/MGSoG Conference, 26e.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy, 31*(2), 247-264.

Malerba, F., & Nelson, R. (2011). Learning and catching up in different sectoral systems: evidence from six industries. *Industrial and Corporate Change, 20*(6), 1645-1675. doi:10.1093/icc/dtr062

Malerba, F., & Nelson, R. (2012). *Economic Development as a Learning Process: Variation Across Sectoral Systems*: Edward Elgar Publishing, Incorporated.

Malerba, F., Nelson, R., Orsenigo, L., & Winter, S. (1999). 'History-friendly'models of industry evolution: the computer industry. *Industrial and Corporate Change, 8*(1), 3-40.

Malerba, F., Nelson, R., Orsenigo, L., & Winter, S. (2016). *Innovation and the evolution of industries: History friendly models*: Cambridge: Cambridge University Press.

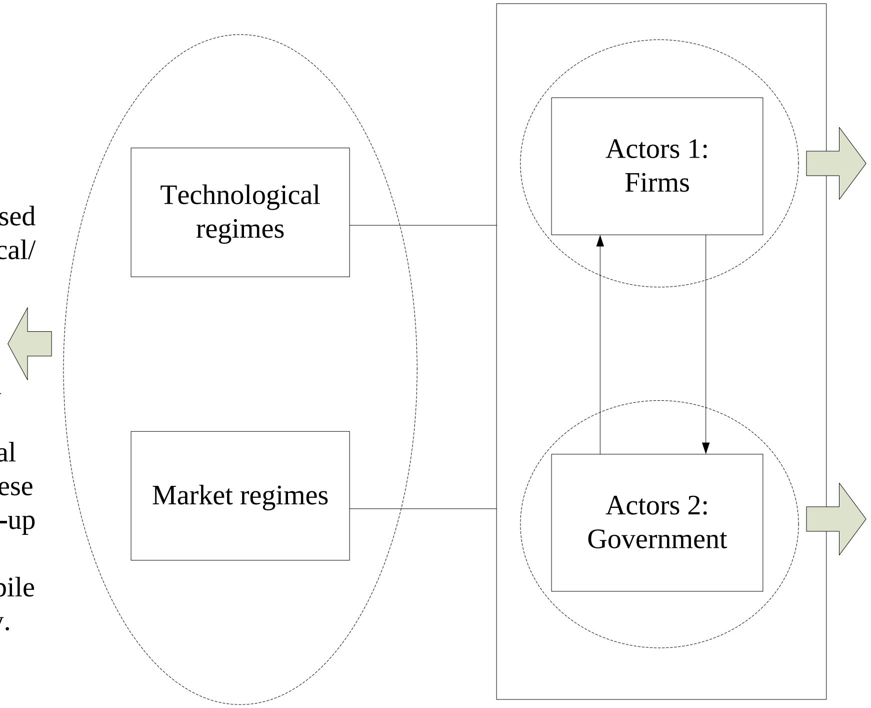
Mathews, J. (2002). Competitive Advantages of the Latecomer Firm: A Resource-Based Account of Industiral Catch-up Strategies. *Asia Pacific Journal of Management, 19*, 467-488.

Mu, Q., & Lee, K. (2005). Knowledge diffusion, market segmentation and technological catch-up: The case of the telecommunication industry in China. *Research Policy, 34*(6), 759-783. doi:10.1016/j.respol.2005.02.007

Nelson, & Winter. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.

Perez, C., & Soete, L. (1988). Catching up in technology: entry barriers and windows of opportunity. *Technical change and economic theory*, 458-479. doi:10.2139/ssrn.224582

Figure 1. The positioning of the three essays within the SSI framework



First Essay:
The first essay is focused on the role of firm strategies in the catching-up process.

Main results: Whether domestic acquisitions or overseas acquisitions are effective strategies for enhancing firm productivity depends on whether the acquirers operate in high-tech sectors or low-tech sectors. The value-creation mechanisms behind the acquisition-productivity link differ across sectors.

Second Essay:
The second essay is focused on the role of technological/ market regimes in the catching-up process.

Main results: Segmented markets, together with generational technological changes, facilitated Chinese domestic firms' catching-up with respect to foreign multinationals in the mobile communications industry.

Third Essay:
The third essay is focused on the role of government policies in the catching-up process.

Main results: The protective FDI policy (that requires MNEs to form IJVs with local firms) is not an effective instrument for promoting knowledge transfer; However, it might reshape the competition landscape in an industry.

Source: modified from the SSI framework in the work of Malerba and Nelson (2012)

ESSAY 1. FOREIGN CUISINE OR LOCAL DELICACIES? HOW SECTORS MATTER IN ACQUISITION-PRODUCTIVITY LINKAGE[1]

ABSTRACT

This paper examines the impacts of cross-border and domestic acquisitions on the productivity of firms with sectoral differences. Studying the acquisitions that were pursued by Chinese listed firms during the period from 2003 to 2013, we find that in the high-tech sectors, cross-border acquisitions are positively associated with firm productivity. However, in the low-tech sectors, domestic acquisitions are positively associated with firm productivity. We further investigate the mechanisms causing the above associations, and we find that "technological innovation" is the primary mechanism by which acquisitions enhance firm productivity in the high-tech sectors, whereas "enhancing operating efficiency" and "enhancing market power" tend to be the main mechanisms by which acquisitions enhance firm productivity in the low-tech sectors. This paper contributes to the literature on the catch-up strategies of emerging market firms by shedding light on when certain types of acquisitions can be used as an appropriate productivity-enhancing strategy.

Keywords:

cross-border M&A, domestic M&A, high-tech sectors, low-tech sectors, productivity

[1] The paper is co-authored with Giovanni Valentini (IESE Business School).

INTRODUCTION

The notion of "catch-up" is a topic with a long history in the economics literature (Abramovitz, 1986; Gerschenkron, 1962), and it has attracted increasing attention in strategy research (Awate, Larsen, & Mudambi, 2012; Kumaraswamy, Mudambi, Saranga, & Tripathy, 2012). Catching-up with global leaders is a strategic goal for which many emerging market firms have strived (Mudambi, 2008). According to Abramovitz (1986)'s definition, "catching-up" refers to a process by which latecomers narrow the productivity gap between themselves and forerunners. Without expecting forerunners to automatically fall back, emerging market firms with a "strategic intent" (Hamel & Prahalad, 2005) of catching-up should focus on the enhancement of their own productivity. In fact, China has been narrowing its productivity gap relative to advanced economies in the past 15 years. The question that deserves explanations is, "what are effective catch-up strategies that enhance the productivity of Chinese firms?"

As a means of restructuring firm resources and capabilities, acquisitions (M&A)[2] have often been argued as a potential catch-up strategy for the improvement of firm productivity (Child & Rodrigues, 2005; Luo & Tung, 2007; Rui & Yip, 2008). In theory, M&A mainly increase (revenue-based) firm productivity by three value-creation mechanisms (Bertrand & Betschinger, 2012): (1) promoting technological innovation; (2) enhancing operating efficiency; and (3) enhancing market power. However, the effectiveness of these value-creation mechanisms may vary according to the technological regimes of different sectors (Malerba & Orsenigo, 1997). This means that when M&A are used as an effective catch-up strategy, the strategy should be contingent upon the sectoral environment in which the firms operate (Drazin & Van de Ven, 1985).

[2] Following the tradition in the literature (Bertrand & Betschinger, 2012), we use M&A as an abbreviation for acquisitions; although literally, M&A stands for Mergers and Acquisitions.

In this paper, we compare how two types of M&A (overseas M&A and domestic M&A) are linked to firm productivity in different sectors (high-tech sectors versus low-tech sectors). As a parsimonious way to capture the complicated nature of sectoral differences, the “high-tech” versus “low-tech” dichotomy has often been used in prior literature (Cefis & Marsili, 2011; Czarnitzki & Thorwarth, 2012).

Using a dataset that is constructed by combining the M&A data from Zephyr and Thomson with firm-level data from CSMAR, we conducted sample-split analyses (Salomon & Jin, 2008, 2010) to examine how the M&A-productivity relationship varies between the high-tech and low-tech sectors. What we find is that overseas M&A are positively correlated with firm productivity in the high-tech sectors, whereas domestic M&A are positively correlated with firm productivity in the low-tech sectors.

Beyond merely testing the M&A-productivity linkage, we further explored the mechanisms behind such linkage. We explored the three mechanisms by which M&A might enhance firm productivity. The results show that “technological innovation” tends to be the primary mechanism by which M&A enhance firm productivity in the high-tech sectors; whereas “enhanced operating efficiency” and “enhanced market power” tend to be the main mechanisms by which M&A enhance firm productivity in the low-tech sectors.

The contribution of this paper is mainly three-fold. First, this paper contributes to the literature of the catch-up strategies of emerging market firms (Awate et al., 2012; Kumaraswamy et al., 2012). Although M&A have long been argued as a potential catch-up strategy for emerging market firms (Child & Rodrigues, 2005; Luo & Tung, 2007; Rui & Yip, 2008), these arguments remain largely qualitative. This paper empirically investigates when certain types of M&A can be used as catch-up strategies to enhance firm productivity. Secondly, this paper contributes to the strategy literature on M&A-productivity linkages.

Although there have been numerous studies on the M&A-productivity relationship, the prior studies have often shown mixed results (Bertrand & Capron, 2014; Bertrand & Zitouna, 2008). This paper provides fine-grained analyses of the value-creation mechanisms under different sectoral environments and sheds light on a more nuanced picture of the M&A-productivity linkage. Lastly, this paper contributes to the international business literature by revealing the performance outcomes of Chinese firms' overseas M&A. Although the antecedents of Chinese firms' overseas M&A have often been discussed in the international business literature (Deng, 2009; Sun, Peng, Ren, & Yan, 2012), less attention has been paid to the performance outcomes of Chinese M&A. This study serves as a response to the increasing voices in the international business literature that have called for more rigorous evaluations of the performance outcomes of Chinese firms' overseas M&A (Deng, 2013; Peng, 2012).

The remaining sections are organized as follows: First, we introduce the theoretical background of the study. Second, we develop two hypotheses. Third, we describe the data. Fourth, we test the hypothesized relationships. Fifth, we further examine the mechanisms behind the hypothesized relationships. Sixth, we present a general discussion. Lastly, we present our conclusions.

BACKGROUND

China has been catching-up with advanced economies in terms of labour productivity. Although the labour productivity of most of the G7 countries (except the US) has remained more or less the same in the past 15 years, the labour productivity of China has increased significantly. Even compared with the US, a country with the fastest productivity growth among the G7 countries, the productivity gap between China and the US has been largely narrowed. For example, in 2001, China's labour productivity was only 7.6% of the US productivity. However, in 2015, China's labour productivity has already increased to about 20.7% of the US productivity.

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Prior studies have shown different explanations for the productivity growth among Chinese firms. Chuang and Hsu (2004) found that inward FDI and trade (both import and export) tended to increase the productivity of domestic firms. Similarly, Wei and Liu (2006) found that productivity spillovers from inward FDI and R&D tended to increase the productivity of Chinese firms. Zhang, Zhang, and Zhao (2003) suggested that ownership types mattered for firm productivity, because state-owned firms were often less productive than non-state-owned firms. And, Yu, Dosi, Lei, and Nuvolari (2015) suggested that the restructuring of state-owned enterprises was a driver of productivity growth in China's manufacturing sectors.

More recently, an alternative strategy for productivity enhancement has been articulated in the "springboard perspective" (Luo & Tung, 2007). The "springboard perspective" posits that emerging market firms can enhance their capabilities by acquiring strategic assets through outward foreign direct investment (OFDI). According to UNCTAD (2015), firms from emerging economies invested 468 billion US dollars abroad in 2014, reaching a record 35 % of global FDI. As a fast-growing emerging economy, China has already become one of the largest global investors, and its OFDI is expected to further expand over the next decade (Anderlini, 2015). Overseas acquisitions constitute the main form of Chinese OFDI (Peng, 2012; Rui & Yip, 2008), which have attracted both public attention (Economist, 2010, 2016) and academic attention (Luo & Tung, 2007; Peng, 2012).

Despite the rapid increase of overseas acquisitions from China and other emerging economies, the performance implications of such acquisitions have not been rigorously tested as it should be (Deng, 2013; Peng, 2012). Most of the prior studies on the performance implications of cross-border acquisitions by emerging market firms have focused on the stock market performance (Aybar & Ficici, 2009; De Beule & Sels, 2016; Gubbi, Aulakh, Ray, Sarkar, & Chittoor, 2010). Some scholars (Gubbi et al., 2010) find that cross-border acquisitions by emerging market firms create value for the acquirers, especially for acquisitions conducted in advanced economies. The argument for value-creation through overseas acquisitions is in line with the springboard perspective (Luo & Tung, 2007). The new resources and capabilities from overseas acquisitions can enhance the competitiveness of emerging market firms. However, other scholars (Aybar & Ficici, 2009) find that cross-border acquisitions conducted by emerging market firms are value-destructive, especially in the high-tech sectors. This is because firms that conduct overseas acquisitions face a high level of information asymmetry, and emerging market firms lack the experience and capabilities to identify, absorb, and transform knowledge (Zahra & George, 2002) from overseas acquisitions. De Beule and Sels (2016) revealed a more complicated picture, where the stock market performance of acquirers following overseas acquisitions is contingent upon the acquirers' absorptive capacity.

Anderson, Sutherland, and Severe (2015) examined the patenting performance of Chinese acquirers and foreign targets after Chinese firms' acquisitions in advanced economies. The authors found that overseas acquisitions improved the patenting performance of the Chinese acquirers, but they did not improve the patenting performance of the foreign targets. This implies that there is indeed reverse knowledge transfer from foreign targets to Chinese acquirers.

However, little research has been done regarding how overseas acquisitions impact the productivity of Chinese acquirers, except two recent studies (Cozza, Rabellotti, & Sanfilippo, 2015; Guo & Clougherty, 2015). Cozza et al. (2015) examined Chinese OFDI in European countries, and they found that OFDI in general increased the labour productivity of Chinese firms. However, the productivity-enhancing effect of Chinese OFDI mainly comes from greenfield investments instead of overseas acquisitions. Guo and Clougherty (2015) also examined the productivity impacts of cross-border acquisitions on Chinese acquirers, with a focus on the comparison between state-owned firms and private firms. The authors found that private firms were more capable of benefiting from cross-border acquisitions than state-owned firms.

Because enhancing productivity is critical for Chinese firms' catching-up, in this study, we choose labour productivity as our dependent variable and investigate when certain types of M&A can be effective catch-up strategies for enhancing firm productivity.

Value creation mechanisms behind the M&A-productivity linkage

As one of the most studied strategies, there has been a long history of research on the performance implications of M&A. Early studies have found both negative and positive impacts of M&A on firm productivity (McGuckin, Nguyen, Reznek, & Census, 1995; Ravenscraft & Scherer, 1987). As M&A activities became increasingly globalized, international business scholars introduced a geographic dimension into the M&A literature by comparing the performance outcomes between domestic and cross-border M&A. Such comparisons have revealed a more complicated picture about the M&A-productivity link. For example, Bertrand and Zitouna (2008) examined the performance outcomes of domestic and cross-border M&A on French target firms, and they found that both types of M&A tended to increase target firm total factor productivity. However, using Russian data, Bertrand and

Betschinger (2012) found that both domestic and cross-border M&A were negatively correlated with Russian acquirers' performance (even though the performance was measured by ROA). More recently, Bertrand and Capron (2014) found that cross-border M&A were positively associated with French acquirers' productivity, whereas domestic M&A were not[3].

The ambiguous findings regarding the performance impacts of M&A largely stem from the multiple mechanisms by which M&A may affect firm productivity (Anand, Capron, & Mitchell, 2005). The prior literature (e.g.,(Bertrand & Betschinger, 2012)) suggests that the main mechanisms by which M&A can enhance (revenue-based) productivity can be summarized using three factors: (1) technological innovation, (2) enhanced operating efficiency, and (3) enhanced market power.

The "technological innovation" argument suggests that M&A may promote technological innovation through the acquisition of new knowledge (Luo & Tung, 2007), and such technological innovation will increase customers' willingness to pay for the acquirers' products. First, M&A may enlarge firm knowledge repertoire by bringing the acquirers complementary knowledge and resources (Capron, 1999). Because innovation, to a large extent, is a product of recombination (Nelson & Winter, 1982), the new knowledge that is brought by M&A can serve as a stepping stone for future innovation. Second, the prior research shows that R&D activities are also subject to "economies of scale" and "economies of scope" (Henderson & Cockburn, 1996). In this sense, by acquiring complementary assets from the targets, M&A may also increase firm efficiency in doing R&D (Cassiman, Colombo, Garrone, & Veugelers, 2005). Third, if M&A can increase firm effectiveness and their efficiency in conducting R&D, they may also increase firm incentives to conduct R&D. The

[3] In the supplementary analyses, the authors mentioned that "we also took into account the possibility of domestic acquisitions. We found that their effect was not significant…." (Bertrand & Capron, 2014, page 13).

positive relationship between M&A and "technological innovation" has been confirmed by empirical evidence. For example, using patent data, Valentini (2012) found that M&A had a positive impact on firm innovation output.

The "enhanced operating efficiency" argument suggests that M&A may increase firm productivity by increasing firm operating efficiency. First, M&A may increase firm size, which would advance firm economies of scale (Seth, 1990). For example, firms may be able to share fixed costs among multiple operating activities after M&A. Such fixed costs may include physical input costs, managerial costs, advertising costs, and other costs. Second, M&A increase operating efficiency through bilateral resource redeployment (Capron & Mitchell, 1998). Through resource redeployment, firms may be able to rationalize their operations, thereby obtaining synergistic efficiency gains.

The "enhanced market power" argument suggests that M&A can increase firm productivity by enhancing the acquirer's market power. All things being equal, a decrease in the number of competitors in a market may lead to an increase in all of the players' market power. Such market-power benefits will be disproportionately greater for the acquirer, whose size and resources have also been enlarged during the M&A (Moatti, Ren, Anand, & Dussauge, 2015). Enhanced market power may allow acquirers to extract a greater consumer surplus that would be subsequently transformed into greater revenue-based productivity.

Departing from the three main mechanisms by which M&A might affect firm productivity, we argue that the effectiveness of the three mechanisms varies according to sectoral environments. Therefore, the question of whether certain types of M&A strategies could enhance firm productivity should be examined in cases of sectoral differences.

HYPOTHESES

High-tech sectors

High-tech sectors are knowledge-intensive sectors in which the long-term success of a firm is tied to their technological capabilities (Chaudhuri & Tabrizi, 1998). Among the three main mechanisms by which M&A can affect productivity, "technological innovation" tends to be more influential than the other two in the high-tech sectors. This is because, in the high-tech sectors, the frequency of technological change is relatively high, and consumers tend to have a higher willingness to pay for new products or new features (Golovko & Valentini, 2014). If firms can successfully innovate, they may be able to extract a greater consumer surplus. Otherwise, they may have to compete with a large number of players that produce homogeneous products. This is not to say that "enhancing operating efficiency" is not important in the high-tech sectors, but it is probably a less important mechanism by which M&A can enhance firm productivity, compared with "technological innovation". In addition, "enhancing market power" is also unlikely to be the primary mechanism by which M&A can affect firm productivity because frequent technological changes in the high-tech sectors often open windows of opportunities for latecomers to enter the market (Perez & Soete, 1988).

Compared with domestic M&A, overseas M&A are more likely to promote technological innovation because overseas M&A are more likely to bring new knowledge and capabilities to firms. As the prior literature suggests, diversity of knowledge increases as the geographic distance between two firms increases (Morosini, Shane, & Singh, 1998). Because, to a large extent, innovation comes from recombination (Nelson & Winter, 1982), the new knowledge and capabilities that are obtained from overseas M&A can provide acquirers with crucial ingredients for future innovation. For example, the acquisition of a small US firm, OptiMight, facilitated Huawei's development of optical network technologies (Hennart, 2012). This is especially true for emerging market firms, for which advanced foreign knowledge may not be available in their home countries (Luo & Tung, 2007). Therefore, in the high-tech sectors, overseas M&A tend to be an appropriate catch-up strategy to enhance firm productivity.

Hypothesis 1. In the high-tech sectors, overseas M&A are positively associated with firm productivity.

Low-tech sectors

Conversely, the low-tech sectors tend to be less knowledge-intensive but more labour-intensive compared with the high-tech sectors. In such sectors, technological innovation may be less relevant for productivity growth due to the relatively slow pace of technological change. “Dominant designs” (Suarez & Utterback, 1995) may have already been established and diffused within the industry. Thus, firms in the low-tech sectors may mainly compete in terms of their “output capabilities” instead of “innovation capabilities” (Awate et al., 2012). If this is the case, then “enhancing operating efficiency” and “enhancing market power” tend to be the main mechanisms by which M&A can enhance firm productivity.

Compared with overseas M&A, domestic M&A tend to be more effective for enhancing firm operating efficiency or enhancing market power due to the geographic proximity of the parties that are involved in domestic M&A. Generally speaking, the benefits of “economies of scale” (Seth, 1990) and the benefits of “resource redeployment” (Capron & Mitchell, 1998) are easier to realize when the distance between the acquirer and the target is relatively short. Similarly, domestic M&A are more likely to enhance the market power of acquirers than overseas M&A because the merging of geographically proximate firms is more likely to induce the anti-competition effect than the merging of distant firms (Bertrand &

Zuniga, 2006). Therefore, in the low-tech sectors, domestic M&A tend to be an appropriate catch-up strategy to enhance firm productivity.

Hypothesis 2. In the low-tech sectors, domestic M&A are positively associated with firm productivity.

DATA

Sample

This research examines acquisitions that are conducted by Chinese listed firms[4] in the period from 2003 to 2013. This period witnessed a rapid increase of both overseas M&A and domestic M&A following the country's accession to the WTO. Although the number of listed firms is relatively small compared with the entire population of Chinese firms, the economic significance of these listed firms is disproportionately high. For example, in 2012, the market value of the approximately 2,500 Chinese listed firms accounted for 43.7 percent of the country's GDP (World Bank, 2015).

We first collected M&A information from the Zephyr M&A database and the Thomson One Banker database. Zephyr has a special team that is devoted to monitoring Chinese sources (e.g., regulators' websites and stock exchange announcements).[5] Therefore, the information about acquisitions that are pursued by Chinese listed firms from Zephyr can be considered to be reliable. Then, we merged the M&A data with firm-level data (2003 to 2014) from the China Stock Market & Accounting Research (CSMAR) database.

One potential problem of studying listed firms is that the results may be biased towards large firms. However, the topic of using M&A as a catch-up strategy may be a topic

[4] Firms listed in the A-share market of the Shanghai Stock Exchange and the Shenzhen Stock Exchange

[5] The authors contacted the owner of Zephyr (Bureau Van Dijk) to confirm the database's coverage of Chinese M&A deals.

that is more relevant for large emerging market firms. Firms in the financial sector are excluded from the sample due to their unique characteristics. We included only majority acquisitions (at least a 50 % stake acquired) because majority acquisitions would ensure that the acquirers have significant influence on the resources of the target firms. Table I shows the number of deals by year, and Table II shows the distribution of overseas M&A by host countries.

INSERT TABLE I ABOUT HERE

INSERT TABLE II ABOUT HERE

Variables

The dependent variable, labour productivity, is measured as the operating revenue minus operating expenses, divided by the number of employees (Hillier, Marshall, McColgan, & Werema, 2007; Subramony & Holtom, 2011). This method of measuring productivity has the advantage of reflecting the value-creation that is driven by intangibles (e.g., knowledge, R&D or marketing capabilities) that are embedded in talented employees (Bryan, 2007).

The independent variables include a set of M&A variables such as “overseas M&A” and “domestic M&A”. The variable “overseas MA” is measured as the number of overseas M&A that are conducted by a firm in a specific year. The variable “domestic MA” is measured as the number of domestic M&A that are conducted by a firm in a specific year.

We control for a set of covariates that may affect firm productivity. Capital intensity is measured as the net fixed assets divided by the number of employees (Bertrand & Capron, 2014). Debt intensity is measured as long-term debts plus short-term borrowings divided by total shareholder equity (Pathak, Hoskisson, & Johnson, 2014). Average wage is measured as the cash that is paid to and on behalf of employees divided by the number of employees. Following Arnold and Javorcik (2009), all of the above variables are log-transformed. We also control for a dummy variable, SOE, which captures whether a firm is state-owned in a given year (Guo, Clougherty, & Duso, 2016).

Descriptions of variables (including the variables that are used in supplementary analyses) are listed in the Appendix. And, the summary statistics of the variables are shown in Table III.

INSERT TABLE III ABOUT HERE

Definition of high-tech sectors versus low-tech sectors. Based on the OECD definition and China’s industry classification, we classified the following sectors as the high-tech sectors: “raw chemical materials and chemical products”, “railway, shipbuilding, aerospace and other transportation equipment manufacturing”, “chemical fibre manufacturing”, “automobile manufacturing”, “computer, communication and other electronic device manufacturing”, “electric machines and apparatuses manufacturing”, “instrument and metre manufacturing”, “Internet and related services”, “pharmaceutical manufacturing”, “software and IT services”, “special equipment manufacturing”, “telecommunications, broadcast, television, and satellite transmission services”, “professional technological service,” and “research and experimental development”. All other sectors are classified as low-tech sectors.

MEASURING THE EFFECT OF M&A ON PRODUCTIVITY

Our arguments suggest that overseas acquisitions are positively associated with firm productivity in high-tech sectors, whereas domestic acquisitions are positively associated with firm productivity in low-tech sectors. To test these hypotheses, we started by comparing the average productivity of acquiring firms from four-year before the acquisitions to four-year after the acquisitions. As expected, Figure 2 shows that the average productivity of high-tech firms that conducted overseas acquisitions was largely increased three years after the acquisitions. Similarly, Figure 3 shows that the average productivity of low-tech firms that conducted domestic acquisitions also increased after the acquisitions.

INSERT FIGURE 2 ABOUT HERE

INSERT FIGURE 3 ABOUT HERE

Then, we conducted split-sample analyses, which have often been used in the prior research to explore how a certain relationship varies across different conditions (Golovko & Valentini, 2014; Salomon & Jin, 2008). The model specification was as follows:

$$Productivity_{it} = \beta_1 MA_{i,t-1} + \beta_2 MA_{i,t-2} + \beta_3 MA_{i,t-3} + \gamma X_{it} + \sigma_i + \rho_t + \vartheta_{it}$$

where $MA_{i,t-1}$, $MA_{i,t-2}$, and $MA_{i,t-3}$ are sets of M&A variables (including both domestic M&A and overseas M&A); X_{it} represents a set of control variables; σ_i represents firm-fixed effects; ρ_t represents a set of year dummies; and ϑ_{it} represents the error term.

First, we estimated a fixed-effects panel model in the whole sample. Then, we split the whole sample into a “high-tech” sub-sample and a “low-tech” sub-sample, and we estimated the same model in each subsample. This provides an idea of how the sectors matter in M&A-productivity linkage. According to the hypotheses, we expect to see that in the “high-tech” sub-sample, overseas M&A are positively associated with productivity, whereas in the “low-tech” sub-sample, domestic M&A are positively associated with productivity.

Table IV presents a comparison between the high-tech sectors and low-tech sectors. Model 1 shows the estimation for the whole sample. Unlike in the common understanding that is based on the springboard perspective (Luo & Tung, 2007), we actually find no significant association between overseas M&A and firm productivity in the whole sample. However, after we divided the whole sample into a “high-tech” sub-sample and a “low-tech” sub-sample, we see that overseas M&A are positively associated with firm productivity in the high-tech sectors, whereas domestic M&A are positively associated with firm productivity in the low-tech sectors. These positive associations are significant in both economic terms and statistical terms. For example, for a high-tech firm, one overseas M&A deal conducted three years ago is associated with a 13 percent (more precisely, $e^{0.125} - 1$) increase of productivity in the current year (Model 2 of Table IV). The association is statistically strong, with a p-value that is equal to 0.020. Meanwhile, for a low-tech firm, one domestic M&A deal conducted one year ago is associated with a 3 percent increase of productivity in the current year (Model 3 of Table IV). And, the association is also statistically strong, with a p-value that is equal to 0.023. The results support Hypothesis 1 and Hypothesis 2.

INSERT TABLE IV ABOUT HERE

EXPLAINING THE EFFECT OF M&A ON PRODUCTIVITY

There has been increasing recognition among management scholars that researchers need to test not only hypotheses *per se*, but they also need to test the mechanisms behind the hypotheses (Miller & Tsang, 2011). Because our hypotheses hinge on the reasoning that the value-creation mechanisms differ across the high-tech sectors and low-tech sectors, we endeavour to test the value-creation mechanisms that we proposed for the two types of sectors.

Mechanism 1: In the high-tech sectors, M&A enhance firm productivity mainly through promoting technological innovation.

If "technological innovation" is the mechanism by which M&A enhance firm productivity, we may expect that leading firms tend to benefit more from overseas M&A than lagging firms. This is because the productivity growth that is driven by "technological innovation" often follows an "increasing returns" model (Romer, 1986). Compared with lagging firms, leading firms are more likely to have adequate "absorptive capacity" (Cohen & Levinthal, 1990; Zahra & George, 2002) to identify, assimilate, and transform external knowledge from M&A. Such absorptive capacity is especially important for overseas M&A, where uncertainty and information asymmetry are high due to the large distance between the acquirer and the target (Chakrabarti & Mitchell, 2013). Therefore, if "technological innovation" is the mechanism by which M&A enhance firm productivity in the high-tech sectors, we expect to see that the positive association between overseas M&A and firm productivity would be stronger among leaders than among laggards.

Mechanism 2: In the low-tech sectors, M&A enhance firm productivity mainly through enhancing operating efficiency and market-power.

Instead, if "enhancing operating efficiency" and "enhancing market-power" are the mechanisms by which M&A enhance firm productivity, we may expect to see that lagging firms tend to benefit more from domestic M&A than leading firms. This is because the productivity growth that is driven by efficiency gains or market-power enhancement often follows a "decreasing returns" model (Färe, Grosskopf, Norris, & Zhang, 1994). As the theory of firm growth (Penrose, 1995) suggests, scale-related efficiency gains will diminish as firm size continues to grow because at a certain point, increasing administrative costs will offset the benefits of economies of scale. Similarly, productivity gains from enhancing market power may also exhibit diminishing returns because the maximum returns from anti-competition moves are bounded by social norms and formal institutions (e.g., the Anti-competition Law (Owen, Sun, & Zheng, 2008)). Therefore, if “enhancing operating efficiency” and/or “enhancing market power” are the mechanisms by which M&A enhance productivity in the low tech-sectors, we expect to see that the positive association between domestic M&A and productivity in the low-tech sectors would be stronger among laggards than among leaders.

Leaders versus laggards

To disentangle the value-creation mechanisms behind M&A-productivity linkage, we further split each of the two sub-samples (“high-tech” and “low-tech”) into “leaders” and “laggards”.

Definition of leaders versus laggards. We classified firms as “leading firms (leaders)” or “lagging firms (laggards)” based on their prior productivity relative to other firms in the same industry. The firms whose prior productivity was greater than (or equal to) the median productivity of that industry in that year were classified as a “leading firm”. The firms whose prior productivity was below the median productivity of that industry in that year were classified as a “lagging firm”. This approach of classifying leaders versus laggards based on the median has been widely adopted in the literature (e.g., (Alcacer & Chung, 2007)). For the purposes of this study, “prior productivity” refers to the productivity of a firm when the firm is observed in the dataset for the first time. This classification takes into account the unbalanced nature of the panel. Additionally, it is not confounded with any M&A strategies that firms might adopt in subsequent years. In addition because the same firm will be consistently assigned to a specific group, it allows us to include the firm fixed-effects in estimations to control for time-invariant, unobserved heterogeneity.

Table V presents a comparison between leaders and laggards in each sub-sample. Model 1 and model 2 show how the M&A-productivity link varies between leaders and laggards in the high-tech sectors. As model 1 suggests, for leaders in the high-tech sectors, overseas M&A are strongly associated with firm productivity. The effect size is even greater than the effect size that we estimated from the entire high-tech sample. For leaders in the high-tech sectors, one overseas M&A deal that was conducted in year (t-3) is associated with an approximately 26 percent increase of firm productivity in year t, with a p-value that is equal to 0.001. However, as model 2 suggests, for laggards in the high-tech sectors, the associations between overseas M&A and productivity are not statistically significant. In fact, for laggards in the high-tech sectors, there are some weak positive associations between domestic M&A and productivity.

Model 3 and model 4 of Table V show how the M&A-productivity link varies between leaders and laggards in the low-tech sectors. From model 4, we can see that there are significant positive associations between domestic M&A and productivity among lagging firms in the low-tech sectors. The effect size is even greater than the effect size that we estimated from the entire low-tech sample. For laggards in the low-tech sectors, one domestic M&A deal that was conducted in year (t-1) is associated with an approximately 4 percent increase of firm productivity in year t, with a p-value that is equal to 0.026. However, as model 3 suggests, for leaders in the low-tech sectors, the positive associations between domestic M&A and productivity are not statistically significant.

Additionally, the temporal pattern of the associations is also consistent with the proposed mechanisms. In the high-tech sectors, the effect of overseas M&A on firm productivity is most pronounced three-year after the acquisition (Model 1 of Table V), whereas in the low-tech sectors, the effect of domestic M&A on firm productivity is significant since one-year after the acquisition (Model 4 of Table V). Prior studies on "exploration vs. exploitation" (e.g., (He & Wong, 2004)) suggest that returns from "exploration" are more distant in time, whereas returns from "exploitation" are less distant in time. Three years represent a reasonable lag before firms can transform external knowledge into innovation outcomes. Because, in the high-tech sectors, the primary mechanism by which M&A enhance productivity is "technological innovation", it would take a longer period of time for the benefits of M&A to emerge. Instead, in the low-tech sectors, the effect of domestic M&A on firm productivity is observable since one-year after the acquisition, because the benefits from enhanced operating efficiency and market power seem to be accessible soon after the acquisition.

Overall, the results in Table V are consistent with Mechanism 1 and Mechanism 2.

INSERT TABLE V ABOUT HERE

Additional analyses of mechanisms

We conducted two additional analyses to further disentangle the mechanisms behind the M&A-productivity linkage. First, we adopted more fine-grained classification of M&A types. Second, we related M&A variables to additional outcome variables.

More fine-tuned M&A types. We further divided overseas M&A into overseas acquisitions from high productivity countries and overseas acquisitions from low productivity countries based on the median value of host-country labour productivity.[6] If "technological innovation" is the main mechanism by which acquisitions can enhance firm productivity in high-tech sectors, we may expect that the productivity-enhancing effect mainly comes from acquisitions conducted in high productivity countries. This is because the learning opportunity is presumably greater in high productivity countries than in low productivity countries. The

[6] Data of the host-country labour productivity comes from the World Bank.

results in Table VI are consistent with our explanations regarding the value-creation mechanism in high-tech sectors.

INSERT TABLE VI ABOUT HERE

Similarly, we further divided domestic acquisitions into within-region acquisition and cross-region acquisitions. If “enhanced operating efficiency” and/or “enhanced market power” are the main mechanisms by which domestic acquisitions enhance firm productivity, we expect that the positive associations should mainly come from within-region acquisitions. This is because scale-related productivity gains are more likely to be realized when the distance between the acquirer and the target is relatively short. The results in Table VII are consistent with our explanations regarding the value-creation mechanisms in low-tech sectors.

INSERT TABLE VII ABOUT HERE

Additional outcome variables. We further examined the impacts of different types of M&A on three additional outcome variables, which include operating efficiency, R&D intensity, and market share for the purpose of better understanding the value-creation mechanisms of M&A. If M&A increase firm productivity through “technological innovation”, we expect to observe positive associations between M&A variables and R&D intensity, because firms may need additional R&D activities to integrate and transform the external knowledge from acquisitions. Instead, if M&A increase firm productivity through “enhanced operating efficiency” and “enhanced market power”, we expect to see negative associations between M&A variables and operating efficiency (here, operating efficiency is inversely coded), and positive associations between M&A variables and market share.

Table VIII and Table IX show the associations between different types of M&A and the three additional outcome variables (operating efficiency, R&D intensity, and market share) in the high-tech sectors and low-tech sectors respectively. From Table VIII, we can see that overseas M&A are positively associated with firm R&D intensity in the high-tech sectors, which is consistent with Mechanism 1. From Table IX, we can see that, domestic M&A are negatively correlated with (inversely coded) operating efficiency and positively correlated with firm market share in the low-tech sectors, which is consistent with Mechanism 2.

INSERT TABLE VIII AND IX ABOUT HERE

Additional analyses on endogeneity

The regression results have shown that, in the high-tech sectors, overseas M&A are positively associated with firm productivity (especially among leaders in the high-tech sectors), whereas in the low-tech sectors, domestic M&A are positively associated with firm productivity (especially among laggards in the low-tech sectors). However, regression results might suffer from endogeneity problems such as reverse causality. To mitigate potential endogeneity problems, we adopt an alternative identification strategy, which is to use the matching estimators. The matching technique first constructs a control group based on a set of relevant covariates. And, this control group will serve as an approximation of the unobserved counterfactual of the treatment group. Then, the matching estimator evaluates the treatment effect of interests by comparing the treatment group and the control group.

Although different matching estimators exist, we adopted a "fast" and "easy-to-understand" matching technique called, "Coarsened Exact Matching (CEM)" (Blackwell, Iacus, King, & Porro, 2009). To be more specific, the CEM method involves two steps: Step one, researchers need to create a matched sample of treatment and control observations based on selected observable covariates. In this step, the CEM algorithm will first temporarily coarsen the selected variables, and then conduct exact matching between treatment observations and control observations based on the coarsened variables. Following De Figueiredo, Meyer-Doyle, and Rawley (2013), we coarsened on the continuous variables (e.g., capital intensity, debt intensity, average wage, number of employees). To avoid additional assumptions on how to partition each covariate, we used the default automatic coarsening algorithm. We also tried to manually specify the number of cutoff points to be 3, 4, and 5 for each covariate, and the results remain qualitatively similar. Step two, researchers conduct their analyses based on the matched sample. If the treatment group and the control group are well balanced after the matching, then a simple comparison of the group mean will give us the treatment effect. However, if there is still remaining imbalance between the two groups after the matching, then researchers may want to run OLS regressions with additional control variables by including the "cem_weights" that was obtained from the first step (which is what we did in this study). The coefficient of the treatment variable can be interpreted as the sample average treatment effect (SATT). Results from the matching approach are largely consistent with the results from the regression analyses. Table X shows, for firms in the high-tech sectors, the SATT effect of overseas M&A on firm productivity is positive and significant three years after the overseas M&A. This means that in the high-tech sectors, overseas M&A conducted three years ago tend to have a positive effect on firm productivity of the current year.

INSERT TABLE X ABOUT HERE

Similarly, Table XI shows that, in the low-tech sectors, there are positive SATT effects of domestic M&A on firm productivity. The temporal pattern of the effects is also consistent with the results from the regression analyses. In the low-tech sectors, domestic M&A tend to have a positive effect on firm productivity since one-year after the acquisition.

INSERT TABLE XI ABOUT HERE

DISCUSSION

One key question in the literature on emerging market firms is how latecomers from emerging economies can catch-up with forerunners from advanced economies. By definition, "catching-up" is a process by which latecomers narrow the productivity gap between themselves and forerunners (Abramovitz, 1986). This means that "catching-up" is always relative. Although whether emerging market firms can catch-up with forerunners also depends on how emerging market firms define the forerunners (with whom they want to catch-up) and the performance of the forerunners (in theory, forerunners may also fall back), one thing that is clear is that latecomers will be more likely to catch-up with forerunners if they can enhance their own productivity.

Many scholars have postulated that M&A (especially overseas M&A) could be a potential catch-up strategy for emerging market firms (Child & Rodrigues, 2005; Luo & Tung, 2007; Rui & Yip, 2008). However, such logic has not been as rigorously tested as it should be (Deng, 2013; Peng, 2012). In fact, the ambiguous findings in the strategy literature cast doubts on the effectiveness of M&A as a catch-up strategy to improve emerging market firm productivity. This paper contributes to this conversation by asking when certain types of M&A strategies (cross-border and/or domestic) could be an appropriate catch-up strategy for enhancing emerging market firm productivity. We submit that whether certain types of M&A can enhance firm productivity largely depends on the sectoral environment in which a firm operates.

After analysing both the domestic and cross-border M&A that were conducted by Chinese listed firms during the period from 2003 to 2013, we find that in the high-tech sectors, overseas M&A tend to be an appropriate productivity-enhancing strategy. This is because in the high-tech sectors, “technological innovation” is the primary mechanism by which M&A increase firm productivity. Overseas M&A tend to facilitate such “technological innovation” in high-tech sectors by bringing the acquirers new knowledge. However, promoting technological innovation through overseas M&A is not equally feasible for all firms in the high-tech sectors. It seems that leading firms tend to have adequate capabilities to enhance their productivity by leveraging on the foreign knowledge from overseas M&A. Instead, lagging firms in the high-tech sectors seem to lack the crucial capabilities to enhance their productivity from overseas M&A.

In contrast, in the low-tech sectors, domestic M&A tend to be an appropriate productivity-enhancing strategy. This is because in the low-tech sectors, “enhancing operating efficiency” and “enhancing market power” tend to be the main mechanisms by which M&A enhance firm productivity. Lagging firms whose prior productivity was relatively low tend to have a greater potential for enhancing productivity through domestic M&A.

Contributions

The contribution of this paper is three-fold. First, this paper contributes to the burgeoning literature on the catch-up strategies of emerging market firms (Awate et al., 2012; Kumaraswamy et al., 2012). Although many scholars (Child & Rodrigues, 2005; Luo & Tung, 2007; Rui & Yip, 2008) have theoretically argued that overseas acquisitions could be a catch-up strategy for emerging market firms, these arguments remain largely qualitative. This paper investigates when M&A could be an appropriate catch-up strategy by comparing the productivity impacts of overseas and domestic M&A. We believe the comparison of the productivity impacts of the two types of M&A under different sectoral environments is meaningful because firms often face resource trade-offs (Levinthal & Wu, 2010) when they make M&A decisions.

Second, this paper contributes to the strategy literature on M&A by shedding additional light on the complex relationship between M&A and productivity. Due to multiple mechanisms by which M&A could affect firm productivity, prior literature on the M&A-productivity link has often shown us inconclusive results (Bertrand & Capron, 2014; Bertrand & Zitouna, 2008). This paper demonstrates how value-creation mechanisms differ across the high-tech and low-tech sectors.

Third, this paper contributes to the international business literature by shedding light on the performance outcomes of Chinese M&A. As China has become one of the largest global investors (Anderlini, 2015), the overseas M&A that are conducted by Chinese firms have attracted much attention in international business research. Although the antecedents of Chinese firms' overseas M&A have often been discussed in the international business literature (Deng, 2009; Sun et al., 2012), less attention has been paid to the performance outcomes of Chinese firms' overseas M&A. This paper comes as a response to the call for further investigations on the performance outcomes of overseas M&A by Chinese firms (Deng, 2013; Peng, 2012).

Limitations

This study has several limitations. First, we constructed the dependent variable, labour productivity, using accounting-based measures. As a result, the revenue-based productivity deviates from the traditional conceptualization of productivity as "efficiency in production" (Syverson, 2011). Although revenue-based productivity may not reflect the true variation in firm technical efficiency, it is more relevant for firm survival compared with physical output-based productivity measures (Foster, Haltiwanger, & Syverson, 2008). In fact, our productivity measure tends to better capture a firm's value-creation capabilities (Bryan, 2007). Second, given that many of the target firms are private firms (or even subsidiaries), we do not have enough information to control for target firm characteristics. The productivity impacts may differ according to the characteristics of the target firms. This is a common problem in the prior studies (e.g., (Bertrand & Capron, 2014)). We tried to mitigate the problem by distinguishing the locations of the target firms (e.g., high-productivity countries versus low-productivity countries), but this requires the assumption that target firm characteristics are correlated with their country of origin. Third, although we tried to mitigate the endogeneity problem by using different estimation strategies, endogeneity is still a concern. Therefore, we do not claim causality in this study.

CONCLUSIONS

This paper examines when certain types of M&A strategies (cross-border or domestic) can be appropriate productivity-enhancing strategies for emerging market firms. The results suggest that cross-border M&A tend to be an appropriate productivity-enhancing strategy in the high-tech sectors, especially for leading firms in the high-tech sectors. "Technological innovation" seems to be the primary mechanism by which M&A enhance firm productivity in the high-tech sectors. In contrast, domestic M&A tend to be an appropriate productivity-enhancing strategy in the low-tech sectors, especially for lagging firms in the low-tech sectors. "Enhancing operating efficiency" and "enhancing market power" seem to be the main mechanisms by which M&A enhance firm productivity in the low-tech sectors. The findings from this study may inspire new thinking among scholars and practitioners regarding how emerging market firms should formulate their catch-up strategies.

REFERENCES

Abramovitz, M. (1986). Catching up. forging ahead, and falling behind. *Journal of Economic History, 46*(2), 385-406.

Alcacer, J., & Chung, W. (2007). Location strategies and knowledge spillovers. *Management Science, 53*(5), 760-776.

Anand, J., Capron, L., & Mitchell, W. (2005). Using acquisitions to access multinational diversity: thinking beyond the domestic versus cross-border M&A comparison. *Industrial and Corporate Change, 14*(2), 191-224.

Anderlini, J. (2015). China to become one of world' s biggest overseas investors by 2020. *Financial Times*.

Anderson, J., Sutherland, D., & Severe, S. (2015). An event study of home and host country patent generation in Chinese MNEs undertaking strategic asset acquisitions in developed markets. *International Business Review, 24*(5), 758-771.

Arnold, & Javorcik. (2009). Gifted kids or pushy parents? Foreign direct investment and plant productivity in Indonesia. *Journal of International Economics, 79*, 42-53.

Awate, S., Larsen, M. M., & Mudambi, R. (2012). EMNE catch-up strategies in the wind turbine industry: Is there a trade-off between output and innovation capabilities? *Global Strategy Journal, 2*(3), 205-223.

Aybar, B., & Ficici, A. (2009). Cross-border acquisitions and firm value: An analysis of emerging-market multinationals. *Journal of International Business Studies, 40*(8), 1317-1338.

Bertrand, O., & Betschinger, M.-A. (2012). Performance of domestic and cross-border acquisitions: Empirical evidence from Russian acquirers. *Journal of Comparative Economics, 40*(3), 413-437.

Bertrand, O., & Capron, L. (2014). Productivity enhancement at home via cross-border acquisitions: The roles of learning and contemporaneous domestic investments. *Strategic Management Journal*, n/a-n/a. doi:10.1002/smj.2256

Bertrand, O., & Zitouna, H. (2008). Domestic versus cross-border acquisitions: which impact on the target firms' performance? *Applied Economics*, *40*(17), 2221-2238.

Bertrand, O., & Zuniga, P. (2006). R&D and M&A: Are cross-border M&A different? An investigation on OECD countries. *International Journal of Industrial Organization, 24*(2), 401-423.

Blackwell, M., Iacus, S., King, G., & Porro, G. (2009). cem: Coarsened exact matching in Stata. *Stata Journal, 9*(4), 524.

Bryan, L. L. (2007). The new metrics of corporate performance: Profit per employee. *McKinsey Quarterly, 1*, 56.

Capron, L. (1999). The long-term performance of horizontal acquisitions. *Strategic Management Journal, 20*(11), 987-1018. doi:10.1002/(SICI)1097-0266(199911)20:11<987::AID-SMJ61>3.0.CO;2-B

Capron, L., & Mitchell, W. (1998). Bilateral resource redeployment and capabilities improvement following horizontal acquisitions. *Industrial and Corporate Change, 7*(3), 453-484.

Cassiman, B., Colombo, M. G., Garrone, P., & Veugelers, R. (2005). The impact of M&A on the R&D process: An empirical analysis of the role of technological-and market-relatedness. *Research Policy, 34*(2), 195-220.

Cefis, E., & Marsili, O. (2011). Born to flip. Exit decisions of entrepreneurial firms in high-tech and low-tech industries. *Journal of Evolutionary Economics, 21*(3), 473-498.

Chakrabarti, A., & Mitchell, W. (2013). The persistent effect of geographic distance in acquisition target selection. *Organization Science, 24*(6), 1805-1826.
Chaudhuri, S., & Tabrizi, B. (1998). Capturing the real value in high-tech acquisitions. *Harvard Business Review, 77*(5), 123-130, 185.
Child, J., & Rodrigues, S. B. (2005). The Internationalization of Chinese Firms: A Case for Theoretical Extension? *Management and Organization Review, 1*(3), 381-410.
Chuang, Y.-C., & Hsu, P.-F. (2004). FDI, trade, and spillover efficiency: evidence from China's manufacturing sector. *Applied Economics, 36*(10), 1103-1115.
Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 128-152.
Cozza, C., Rabellotti, R., & Sanfilippo, M. (2015). The impact of outward FDI on the performance of Chinese firms. *China Economic Review, 36*, 42-57.
Czarnitzki, D., & Thorwarth, S. (2012). Productivity effects of basic research in low-tech and high-tech industries. *Research Policy, 41*(9), 1555-1564.
De Beule, F., & Sels, A. (2016). Do innovative emerging market cross-border acquirers create more shareholder value? Evidence from India. *International Business Review, 25*(2), 604-617.
De Figueiredo, R. J., Meyer-Doyle, P., & Rawley, E. (2013). Inherited agglomeration effects in hedge fund spawns. *Strategic Management Journal, 34*(7), 843-862.
Deng, P. (2009). Why do Chinese firms tend to acquire strategic assets in international expansion? *Journal of World Business, 44*(1), 74-84.
Deng, P. (2013). Chinese Outward Direct Investment Research: Theoretical Integration and Recommendations. *Management and Organization Review, 9*(3), 513-539.
Drazin, R., & Van de Ven, A. H. (1985). Alternative forms of fit in contingency theory. *Administrative Science Quarterly*, 514-539.
Economist, T. (2010). China buys up the world. Retrieved from http://www.economist.com/node/17463473
Economist, T. (2016). Better than barbarians. Retrieved from http://www.economist.com/news/business/21688389-rich-world-firms-are-warming-idea-being-chinese-owned-better-barbarians
Färe, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *The American economic review*, 66-83.
Foster, L., Haltiwanger, J., & Syverson, C. (2008). Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?. *The American Economic Review, 98*(1), 394-425.
Gerschenkron, A. (1962). *Economic Backwardness in Historical Perspective*. Cambridge, MA: Harvard University Press.
Golovko, E., & Valentini, G. (2014). Selective Learning-by-Exporting: Firm Size and Product Versus Process Innovation. *Global Strategy Journal, 4*(3), 161-180.
Gubbi, S. R., Aulakh, P. S., Ray, S., Sarkar, M., & Chittoor, R. (2010). Do international acquisitions by emerging-economy firms create shareholder value? The case of Indian firms. *Journal of International Business Studies, 41*(3), 397-418.
Guo, W., & Clougherty, J. A. (2015). The Effectiveness of the State in Chinese Outward Foreign Direct Investment: The “Go Global” Policy and State-Owned Enterprises. *Advances in International Management: Emerging Economies and Multinational Enterprises. Bingley: Emerald Group Publishing, Ltd*, 141-160.

Guo, W., Clougherty, J. A., & Duso, T. (2016). Why Are Chinese MNES Not Financially Competitive in Cross-border Acquisitions? The Role of State Ownership. *Long Range Planning*.

Hamel, G., & Prahalad, C. K. (2005). Strategic intent. *Harvard Business Review, 83*(7), 148-161.

He, Z.-L., & Wong, P.-K. (2004). Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organization Science, 15*(4), 481-494.

Henderson, R., & Cockburn, I. (1996). Scale, scope, and spillovers: the determinants of research productivity in drug discovery. *The Rand journal of economics*, 32-59.

Hennart, J. F. (2012). Emerging market multinationals and the theory of the multinational enterprise. *Global Strategy Journal, 2*(3), 168-187.

Hillier, D., Marshall, A., McColgan, P., & Werema, S. (2007). Employee layoffs, shareholder wealth and firm performance: Evidence from the UK. *Journal of Business Finance & Accounting, 34*(3-4), 467-494.

Kumaraswamy, A., Mudambi, R., Saranga, H., & Tripathy, A. (2012). Catch-up strategies in the Indian auto components industry: Domestic firms' responses to market liberalization. *Journal of International Business Studies, 43*(4), 368-395.

Levinthal, D. A., & Wu, B. (2010). Opportunity costs and non-scale free capabilities: profit maximization, corporate scope, and profit margins. *Strategic Management Journal, 31*(7), 780-801.

Luo, Y., & Tung, R. L. (2007). International expansion of emerging market enterprises: A springboard perspective. *Journal of International Business Studies, 38*(4), 481-498.

Malerba, F., & Orsenigo, L. (1997). Technological regimes and sectoral patterns of innovative activities. *Industrial and Corporate Change, 6*(1), 83-118.

McGuckin, R. H., Nguyen, S. V., Reznek, A. P., & Census, U. S. B. o. t. (1995). *The impact of ownership change on employment, wages, and labor productivity in US manufacturing 1977-1987*: Bureau of the Census.

Miller, K. D., & Tsang, E. W. (2011). Testing management theories: critical realist philosophy and research methods. *Strategic Management Journal, 32*(2), 139-158.

Moatti, V., Ren, C. R., Anand, J., & Dussauge, P. (2015). Disentangling the performance effects of efficiency and bargaining power in horizontal growth strategies: An empirical investigation in the global retail industry. *Strategic Management Journal, 36*(5), 745-757.

Morosini, P., Shane, S., & Singh, H. (1998). National cultural distance and cross-border acquisition performance. *Journal of International Business Studies*, 137-158.

Mudambi, R. (2008). Location, control and innovation in knowledge-intensive industries. *Journal of Economic Geography, 8*(5), 699-725.

Nelson, & Winter. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.

OECD. (2016). *OECD Compendium of Productivity Indicators 2016*.

Owen, B. M., Sun, S., & Zheng, W. (2008). China's Competition Policy Reforms: The Antimonopoly Law and Beyond. *Antitrust Law Journal, 75*.

Pathak, S., Hoskisson, R. E., & Johnson, R. A. (2014). Settling up in CEO compensation: The impact of divestiture intensity and contextual factors in refocusing firms. *Strategic Management Journal, 35*(8), 1124-1143.

Peng, M. W. (2012). The global strategy of emerging multinationals from China. *Global Strategy Journal, 2*(2), 97-107.

Penrose, E. T. (1995). *The Theory of the Growth of the Firm*: Oxford university press.

Perez, C., & Soete, L. (1988). Catching up in technology: entry barriers and windows of opportunity. *Technical change and economic theory*, 458-479. doi:10.2139/ssrn.224582

Ravenscraft, D. J., & Scherer, F. M. (1987). Mergers. *Sell-offs, and Economic Efficiency (Brookings Institution, Washington, DC)*.

Romer, P. M. (1986). Increasing returns and long-run growth. *The journal of political economy*, 1002-1037.

Rui, H., & Yip, G. S. (2008). Foreign acquisitions by Chinese firms: A strategic intent perspective. *Journal of World Business, 43*(2), 213-226.

Salomon, R., & Jin, B. (2008). Does knowledge spill to leaders or laggards? Exploring industry heterogeneity in learning by exporting. *Journal of International Business Studies, 39*(1), 132-150.

Salomon, R., & Jin, B. (2010). Do leading or lagging firms learn more from exporting? *Strategic Management Journal, 31*(10), 1088-1113.

Seth, A. (1990). Sources of value creation in acquisitions: an empirical investigation. *Strategic Management Journal, 11*(6), 431-446.

Suarez, F. F., & Utterback, J. M. (1995). Dominant designs and the survival of firms. *Strategic Management Journal, 16*(6), 415-430.

Subramony, M., & Holtom, B. C. (2011). Customer Satisfaction as a Mediator of the Turnover-Performance Relationship. *Journal of Organizational Psychology, 11*(1), 49-62.

Sun, S. L., Peng, M. W., Ren, B., & Yan, D. (2012). A comparative ownership advantage framework for cross-border M&As: the rise of Chinese and Indian MNEs. *Journal of World Business, 47*(1), 4-16.

Syverson, C. (2011). What Determines Productivity? *Journal of Economic Literature, 49*(2), 326-365. doi:doi: 10.1257/jel.49.2.326

UNCTAD. (2015). *World Investment Report 2015*.

Valentini, G. (2012). Measuring the effect of M&A on patenting quantity and quality. *Strategic Management Journal, 33*(3), 336-346.

Wei, Y., & Liu, X. (2006). Productivity spillovers from R&D, exports and FDI in China's manufacturing sector. *Journal of International Business Studies, 37*(4), 544-557.

World Bank. (2015). Market capitalization of listed companies (% of GDP) Retrieved from http://data.worldbank.org/indicator/CM.MKT.LCAP.GD.ZS?order=wbapi_data_value_2012+wbapi_data_value+wbapi_data_value-last&sort=asc

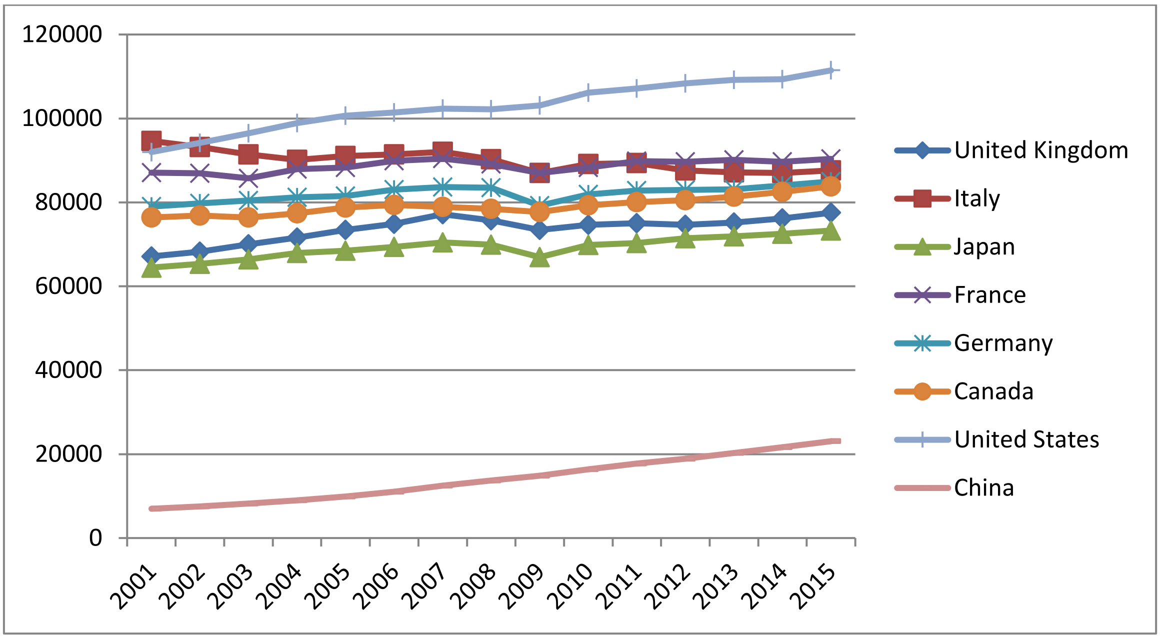
World Bank. (2016). GDP per person employed (constant 2011 PPP $). Retrieved from http://data.worldbank.org/indicator/SL.GDP.PCAP.EM.KD?end=2014&start=2002

Yu, X., Dosi, G., Lei, J., & Nuvolari, A. (2015). Institutional change and productivity growth in China’s manufacturing: the microeconomics of knowledge accumulation and “creative restructuring”. *Industrial and Corporate Change*, dtv011.

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review, 27*(2), 185-203.

Zhang, A., Zhang, Y., & Zhao, R. (2003). A study of the R&D efficiency and productivity of Chinese firms. *Journal of Comparative Economics, 31*(3), 444-464.

Figure 1. The comparison of labour productivity between China and G7 countries



Source: Data from World Bank (2016)

The World Bank defines labour productivity of a country as “GDP per person employed”. GDP captures “gross value-added in market prices” (OECD, 2016). Here, GDP is based on the constant 2011 Purchasing Power Parity (PPP) dollar, which makes the labour productivity comparable across different countries.

Figure 2. Average productivity of acquirers from four-year-before to four-year-after overseas M&A

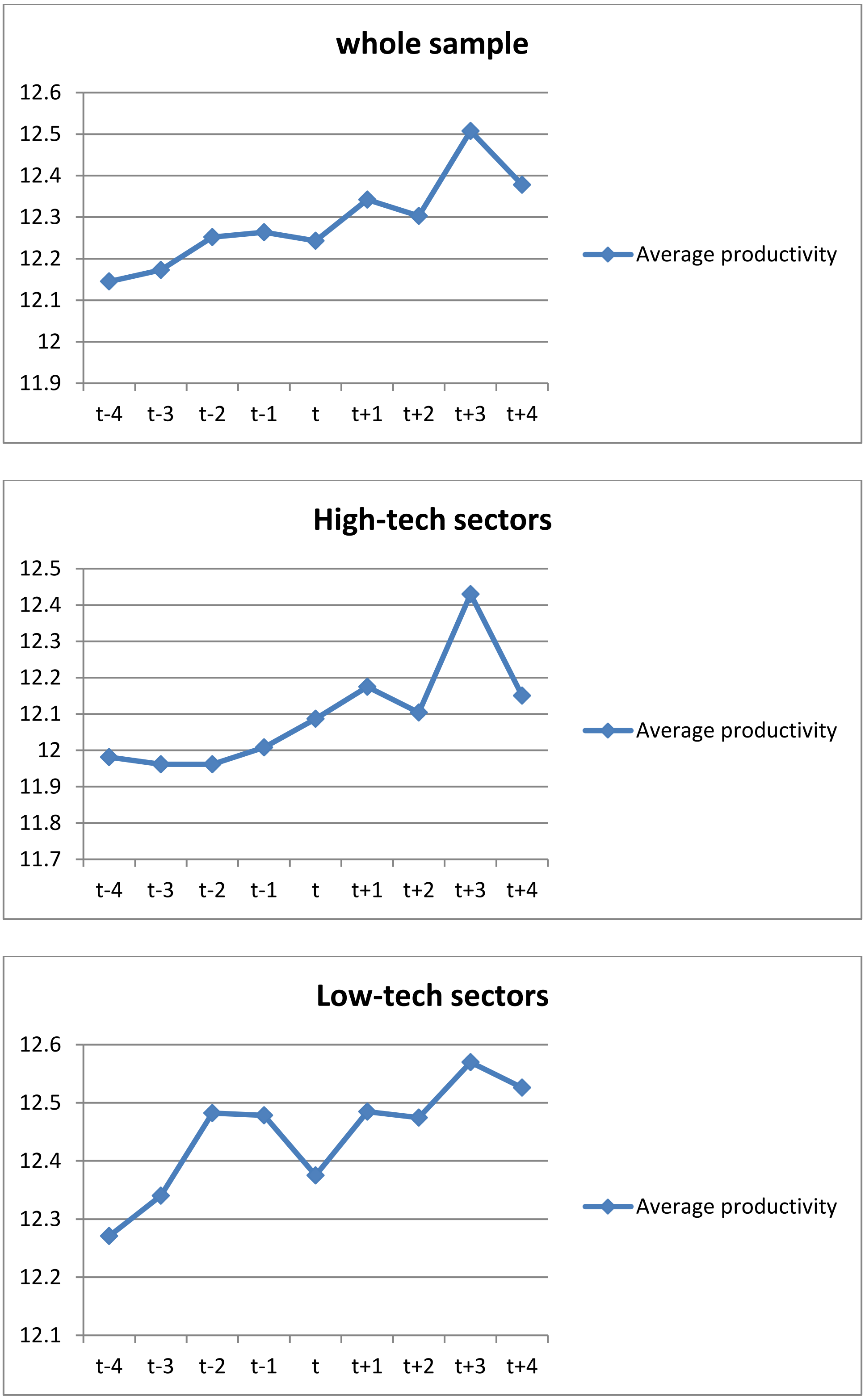


Figure 3. Average productivity of acquirers from four-year-before to four-year-after domestic M&A

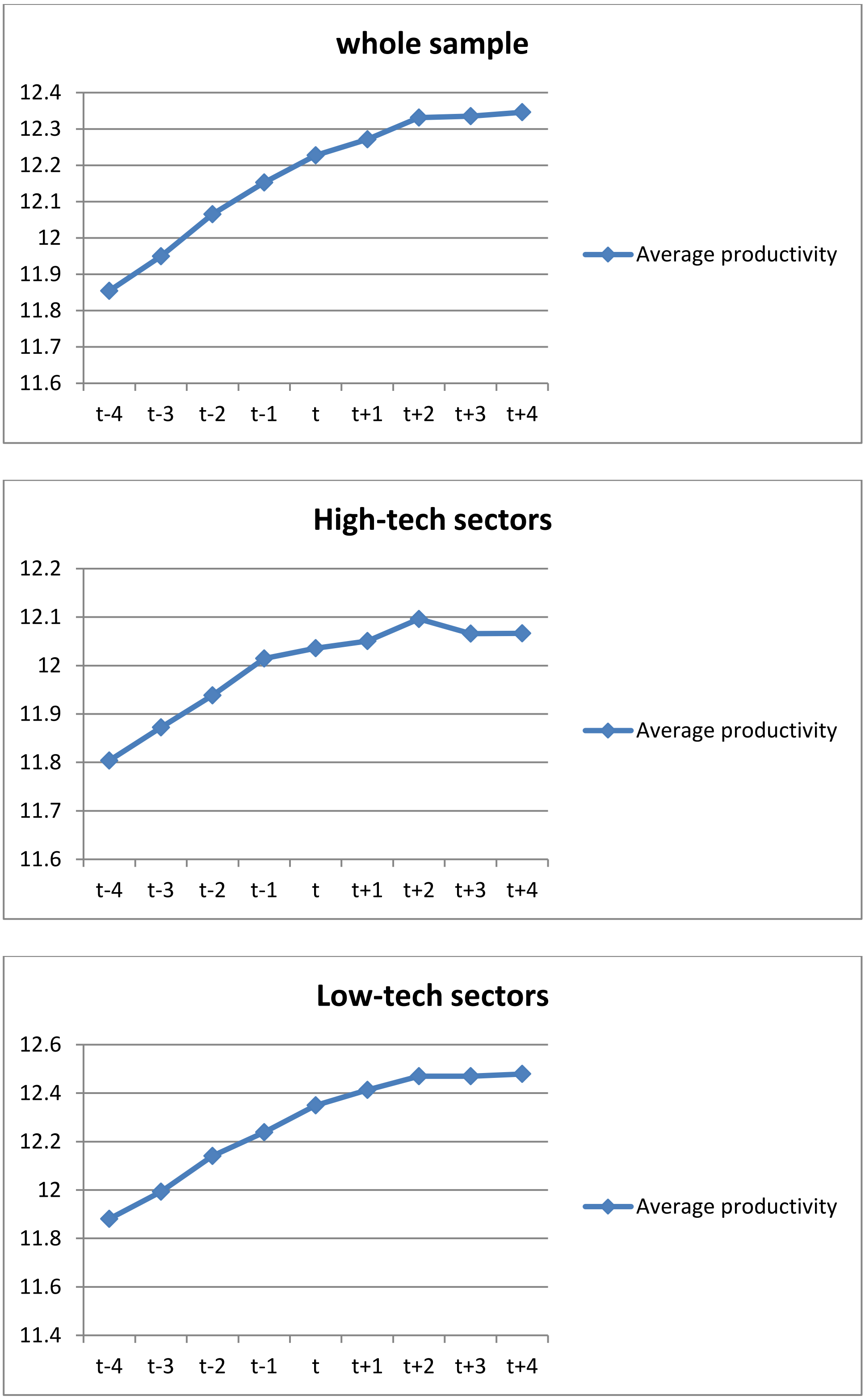


Table I. Sample description: number of cross-border/domestic M&A deals by year

	Number of cross-border deals	Number of domestic deals
2003	3	15
2004	8	49
2005	7	54
2006	4	85
2007	14	142
2008	12	163
2009	13	250
2010	8	276
2011	21	249
2012	31	256
2013	30	319
Total	151	1858

The sample includes only majority acquisitions (at least a 50 % stake acquired) conducted by the non-financial firms that are listed in the A-share market of the Shanghai Stock Exchange and the Shenzhen Stock Exchange.

Table II. Distribution of overseas M&A by host countries

Host country	Number	Percentage	Host country	Number	Percentage
GERMANY	22	14.57%	THAILAND	2	1.32%
HONG KONG	19	12.58%	CAYMAN ISLANDS	1	0.66%
US	19	12.58%	CHILE	1	0.66%
AUSTRALIA	9	5.96%	COLOMBIA	1	0.66%
CANADA	9	5.96%	CZECH REPUBLIC	1	0.66%
FRANCE	8	5.30%	DENMARK	1	0.66%
JAPAN	8	5.30%	HUNGARY	1	0.66%
UK	7	4.64%	ISRAEL	1	0.66%
SINGAPORE	4	2.65%	JAMAICA	1	0.66%
VIRGIN ISLANDS	4	2.65%	MONGOLIA	1	0.66%
BRAZIL	3	1.99%	NEW ZEALAND	1	0.66%
GABON	3	1.99%	NORWAY	1	0.66%
ITALY	3	1.99%	PERU	1	0.66%
NETHERLANDS	3	1.99%	POLAND	1	0.66%
BOLIVIA	2	1.32%	PORTUGAL	1	0.66%
INDIA	2	1.32%	RUSSIA	1	0.66%
SOUTH KOREA	2	1.32%	SPAIN	1	0.66%
SWEDEN	2	1.32%	TAJIKISTAN	1	0.66%
TAIWAN	2	1.32%	SRI LANKA	1	0.66%
Total	151	100.00%			

The sample also includes two Asian economies, Hong Kong and Taiwan, by following the prior literature (e.g., (Guo et al., 2016)).

Table III. Summary statistics and correlation table

		-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15
-1	Productivity	1														
-2	Overseas MA	0.02	1													
-3	Domestic MA	0.06	0.04	1												
-4	Overseas MA from high productivity country	0.02	0.63	0.05	1											
-5	Overseas MA from low productivity country	0.01	0.65	0.02	0	1										
-6	Within-region MA	0.04	0.01	0.7	0.03	0	1									
-7	Cross-region MA	0.05	0.04	0.66	0.04	0.01	0.07	1								
-8	Capital intensity	0.37	0.01	0.02	0	0	0.01	-0.01	1							
-9	Debt intensity	-0.07	0	0.01	0	0	0.01	0	0.18	1						
-10	Employees	-0.31	0.08	0.07	0.04	0.06	0.05	0.04	-0.12	0.07	1					
-11	Average wage	0.7	0.02	0.06	0.02	0.01	0.04	0.05	0.39	-0.08	-0.27	1				
-12	SOE	-0.01	0	-0.01	-0.01	0.01	0	-0.03	0.19	0.13	0.24	0.08	1			
-13	Operating Efficiency	-0.37	0	-0.01	-0.01	0.01	0	-0.03	0.04	0.16	0.12	-0.09	0.11	1		
-14	R&D Intensity	0	0	0	0	0	0.01	0	-0.05	-0.06	-0.02	0	-0.06	-0.09	1	
-15	Market Share	-0.06	0.03	0.01	0.01	0.02	0	0	0.1	0.11	0.23	-0.1	0.21	0.06	-0.06	1
	Mean	12	0.01	0.1	0	0	0.04	0.04	12.44	-1.18	7.4	11.02	0.52	0.74	0	0.4
	S.D.	1.18	0.1	0.38	0.06	0.06	0.24	0.23	1.23	1.49	1.42	0.84	0.5	0.25	0.03	0.39
	Min	2.14	0	0	0	0	0	0	-2.83	-11.26	0	4.87	0	-0.15	0	0
	Max	18.03	4	11	1	1	6	8	19.64	7.23	13.22	17.05	1	25.5	1.25	1

R&D intensity was calculated as R&D expenses divided by operating revenue. The R&D expenses were only available from 2007. Operating efficiency should be a non-negative number. However, a real estate firm ("Shanghai Jinfeng Investment Co., Ltd.") reported a negative operating expense in 2014, which caused the minimum value of this variable to be negative.

Table IV. Comparison between high-tech sectors and low-tech sectors

	(1)	(2)	(3)
VARIABLES	Whole sample	High-tech sectors	Low-tech sectors
Overseas MA (t-1)	0.020	0.025	0.018
	(0.037)	(0.073)	(0.043)
Overseas MA (t-2)	0.018	0.007	0.031
	(0.041)	(0.068)	(0.049)
Overseas MA (t-3)	0.049	0.125**	0.009
	(0.041)	(0.054)	(0.059)
Domestic MA (t-1)	0.022**	0.003	0.030**
	(0.010)	(0.016)	(0.013)
Domestic MA (t-2)	0.030**	0.030	0.029*
	(0.014)	(0.019)	(0.018)
Domestic MA (t-3)	0.024*	0.016	0.026
	(0.013)	(0.017)	(0.017)
Capital intensity	0.127***	0.137***	0.125***
	(0.024)	(0.034)	(0.029)
Debt intensity	-0.068***	-0.069***	-0.071***
	(0.011)	(0.014)	(0.015)
Average wage	0.834***	0.873***	0.820***
	(0.041)	(0.048)	(0.054)
Employees	-0.051	0.042	-0.089*
	(0.035)	(0.043)	(0.046)
SOE	-0.115	-0.181**	-0.080
	(0.075)	(0.084)	(0.101)
Observations	12,055	4,573	7,482
R-squared	0.433	0.451	0.432
Number of firms	2,135	909	1,226
Year fixed effects	Included	Included	Included
Firm fixed effects	Included	Included	Included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; the dependent variable is *Productivity*.

Table V. Comparison between leaders and laggards

	(1)	(2)	(3)	(4)
	High-tech sectors		Low-tech sectors	
VARIABLES	Leaders	Laggards	Leaders	Laggards
Overseas MA (t-1)	0.133	-0.123	0.021	0.028
	(0.100)	(0.086)	(0.051)	(0.065)
Overseas MA (t-2)	0.105	-0.141	0.060	-0.088
	(0.086)	(0.087)	(0.053)	(0.078)
Overseas MA (t-3)	0.234***	0.003	0.059	-0.222*
	(0.067)	(0.050)	(0.062)	(0.117)
Domestic MA (t-1)	-0.004	0.013	0.022	0.044**
	(0.016)	(0.033)	(0.017)	(0.020)
Domestic MA (t-2)	0.005	0.071*	0.010	0.059**
	(0.019)	(0.039)	(0.024)	(0.023)
Domestic MA (t-3)	0.020	0.014	0.033	0.001
	(0.022)	(0.033)	(0.024)	(0.026)
Capital intensity	0.094***	0.179***	0.112***	0.142***
	(0.036)	(0.052)	(0.036)	(0.044)
Debt intensity	-0.062***	-0.068***	-0.097***	-0.047**
	(0.014)	(0.023)	(0.020)	(0.021)
Average wage	0.809***	0.959***	0.689***	0.983***
	(0.062)	(0.076)	(0.070)	(0.083)
Employees	-0.007	0.076	-0.148**	-0.068
	(0.057)	(0.062)	(0.063)	(0.064)
SOE	-0.123	-0.225*	-0.318**	0.128
	(0.099)	(0.126)	(0.157)	(0.123)
Observations	2,461	2,040	4,006	3,342
R-squared	0.530	0.413	0.466	0.419
Number of firms	508	390	669	536
Year fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; the dependent variable is *Productivity*.

Table VI. Comparison between overseas M&A from high productivity country and overseas M&A from low productivity country in high-tech sectors

VARIABLES	(1) High-tech sectors
Overseas MA from high productivity country (t-1)	0.051
	(0.099)
Overseas MA from high productivity country (t-2)	-0.017
	(0.109)
Overseas MA from high productivity country (t-3)	0.183**
	(0.082)
Overseas MA from low productivity country (t-1)	-0.027
	(0.108)
Overseas MA from low productivity country (t-2)	-0.009
	(0.099)
Overseas MA from low productivity country (t-3)	0.067
	(0.073)
Domestic MA (t-1)	0.004
	(0.017)
Domestic MA (t-2)	0.031*
	(0.019)
Domestic MA (t-3)	0.015
	(0.018)
Capital intensity	0.137***
	(0.034)
Debt intensity	-0.069***
	(0.014)
Average wage	0.874***
	(0.048)
Employees	0.043
	(0.043)
SOE	-0.180**
	(0.084)
Observations	4,573
Number of firms	909
R-squared	0.451
Year fixed effects	Included
Firm fixed effects	Included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; the dependent variable is *Productivity*.

Table VII. Comparison between within-region M&A and cross-region M&A in low-tech sectors

VARIABLES	(1) Low-tech sectors
Overseas MA (t-1)	0.020
	(0.043)
Overseas MA (t-2)	0.031
	(0.049)
Overseas MA (t-3)	0.011
	(0.059)
Within-region MA (t-1)	0.041**
	(0.020)
Within-region MA (t-2)	0.035
	(0.023)
Within-region MA (t-3)	0.035
	(0.023)
Cross-region MA (t-1)	0.030
	(0.026)
Cross-region MA (t-2)	0.049
	(0.031)
Cross-region MA (t-3)	0.037
	(0.034)
Capital intensity	0.125***
	(0.029)
Debt intensity	-0.071***
	(0.015)
Average wage	0.820***
	(0.054)
Employees	-0.089*
	(0.046)
SOE	-0.080
	(0.101)
Observations	7,482
Number of firms	1,226
R-squared	0.432
Year fixed effects	Included
Firm fixed effects	Included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; the dependent variable is *Productivity*.

Table VIII. Additional outcome variables: High-tech sectors

VARIABLES	(1) R&D Intensity	(2) Operating Efficiency	(3) Market Share
Overseas MA (t-1)	0.001	-0.001	-0.010
	(0.001)	(0.009)	(0.015)
Overseas MA (t-2)	0.003*	0.006	-0.014
	(0.002)	(0.010)	(0.017)
Overseas MA (t-3)	0.002	-0.007	-0.011
	(0.003)	(0.009)	(0.016)
Domestic MA (t-1)	0.000	0.000	0.003
	(0.001)	(0.003)	(0.003)
Domestic MA (t-2)	0.002*	-0.001	0.003
	(0.001)	(0.004)	(0.004)
Domestic MA (t-3)	0.001	0.003	0.000
	(0.001)	(0.004)	(0.004)
Employees	0.000	-0.001	0.035***
	(0.000)	(0.007)	(0.006)
SOE	0.000	0.033*	0.029
	(0.004)	(0.018)	(0.019)
Observations	4,980	5,448	5,454
R-squared	0.009	0.009	0.124
Number of firms	1,023	1,025	1,025
Year fixed effects	Included	Included	Included
Firm fixed effects	Included	Included	Included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table IX. Additional outcome variables: Low-tech sectors

VARIABLES	(1) R&D Intensity	(2) Operating Efficiency	(3) Market Share
Overseas MA (t-1)	0.000	-0.009	-0.015
	(0.000)	(0.008)	(0.009)
Overseas MA (t-2)	0.000	-0.005	-0.012
	(0.000)	(0.009)	(0.009)
Overseas MA (t-3)	0.000	0.003	-0.021
	(0.000)	(0.009)	(0.016)
Domestic MA (t-1)	0.000	-0.007***	0.008***
	(0.000)	(0.003)	(0.003)
Domestic MA (t-2)	0.000	-0.005	0.004
	(0.000)	(0.003)	(0.003)
Domestic MA (t-3)	-0.000	-0.008*	0.005*
	(0.000)	(0.004)	(0.003)
Employees	0.000	0.023	0.031***
	(0.000)	(0.020)	(0.005)
SOE	0.001	-0.013	-0.001
	(0.001)	(0.062)	(0.015)
Observations	7,672	8,776	8,784
R-squared	0.002	0.004	0.068
Number of firms	1,289	1,295	1,295
Year fixed effects	Included	Included	Included
Firm fixed effects	Included	Included	Included

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

As described by Moatti et al. (2015), operating efficiency was measured as operating expenses divided by operating revenue. Thus, a negative sign actually indicates a positive impact on real operating efficiency.

Table X. Coarsened exact matching for overseas M&A in high-tech sectors

VARIABLES	(1) Productivity (t-3)	(2) Productivity (t-2)	(3) Productivity (t-1)	(4) Productivity (t+1)	(5) Productivity (t+2)	(6) Productivity (t+3)
Overseas M&A	0.029	0.027	-0.015	0.045	0.026	0.333**
(treatment)	(0.108)	(0.106)	(0.086)	(0.091)	(0.110)	(0.152)
Capital intensity	0.291***	0.361***	0.305***	0.206***	0.148***	0.048
	(0.034)	(0.033)	(0.027)	(0.028)	(0.036)	(0.049)
Debt intensity	-0.063***	-0.098***	-0.100***	-0.074***	-0.054***	-0.061***
	(0.015)	(0.015)	(0.012)	(0.013)	(0.015)	(0.020)
Average wage	0.825***	0.878***	0.854***	0.882***	0.877***	0.848***
	(0.048)	(0.046)	(0.038)	(0.039)	(0.046)	(0.058)
Employees	0.159***	0.165***	0.124***	0.134***	0.142***	0.163***
	(0.018)	(0.017)	(0.014)	(0.015)	(0.019)	(0.025)
SOE	-0.202***	-0.270***	-0.251***	-0.282***	-0.279***	-0.239***
	(0.042)	(0.041)	(0.035)	(0.036)	(0.045)	(0.060)
Observations	1,303	1,454	1,598	1,706	1,374	1,086
R-squared	0.459	0.504	0.527	0.469	0.412	0.335
Year dummies	Included	Included	Included	Included	Included	Included
Industry dummies	Included	Included	Included	Included	Included	Included

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table XI. Coarsened exact matching for domestic M&A in low-tech sectors

VARIABLES	(1) Productivity (t-3)	(2) Productivity (t-2)	(3) Productivity (t-1)	(4) Productivity (t+1)	(5) Productivity (t+2)	(6) Productivity (t+3)
Domestic M&A	-0.075*	0.018	0.027	0.088***	0.099***	0.094**
(treatment)	(0.040)	(0.037)	(0.033)	(0.033)	(0.036)	(0.042)
Capital intensity	0.108***	0.094***	0.089***	0.077***	0.096***	0.082***
	(0.015)	(0.013)	(0.011)	(0.011)	(0.012)	(0.014)
Debt intensity	-0.027**	-0.023**	-0.049***	-0.022**	-0.028***	-0.014
	(0.012)	(0.010)	(0.009)	(0.009)	(0.010)	(0.011)
Average wage	0.745***	0.849***	0.885***	0.738***	0.581***	0.478***
	(0.023)	(0.020)	(0.018)	(0.017)	(0.018)	(0.021)
Employees	0.012	0.024**	0.005	-0.052***	-0.051***	-0.060***
	(0.012)	(0.010)	(0.009)	(0.009)	(0.010)	(0.011)
SOE	-0.073**	-0.112***	-0.122***	-0.094***	-0.081***	-0.056*
	(0.032)	(0.028)	(0.025)	(0.024)	(0.026)	(0.030)
Observations	5,872	6,718	7,498	8,138	6,998	5,891
R-squared	0.465	0.523	0.557	0.529	0.490	0.428
Year dummies	Included	Included	Included	Included	Included	Included
Industry dummies	Included	Included	Included	Included	Included	Included

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix. Descriptions of variables

Variable name	Description
Productivity	operating revenue minus operating expenses divided by number of employees (log-transformed)
Capital intensity	net fixed assets divided by number of employees (log-transformed)
Debt intensity	long-term debts plus short-term borrowings divided by total shareholder equity (log-transformed)
Average wage	cash paid to and on behalf of employees divided by number of employees (log-transformed)
Employees	the number of employees (log-transformed)
SOE	A dummy variable that indicates whether a firm is state-owned in a given year
Overseas MA	the number of overseas M&A conducted by a firm in a specific year
Domestic MA	the number of domestic M&A conducted by a firm in a specific year
Overseas MA from high productivity country	A dummy variable that indicates a firm conducted overseas M&A in a year, and the productivity of the host country is higher than (or equal to) the median productivity of all host countries
Overseas MA from low productivity country	A dummy variable that indicates a firm conducted overseas M&A in a year, and the productivity of the host country is lower than the median productivity of all host countries
Within-region MA	the number of domestic M&A conducted by a firm in a year, where the target firm is located in the same region as the acquirer
Cross-region MA	the number of domestic M&A conducted by a firm in a year, where the target firm is located in a different region from the acquirer
Operating efficiency	operating expenses divided by operating revenue
R&D intensity	R&D expenses divided by operating revenue
Market share	a firm's operating revenue divided by the sum of the operating revenues of all firms in the same industry and the same region, which could be a proxy for the firm's market power in the local market (Moses, 1987)

ESSAY 2. SEGMENTED MARKETS, GENERATIONAL TECHNOLOGICAL CHANGES, AND THE CATCHING-UP OF DOMESTIC FIRMS: A HISTORY-FRIENDLY MODEL OF CHINA'S MOBILE COMMUNICATIONS INDUSTRY[1]

ABSTRACT

This paper develops a history-friendly model of China's mobile communications industry to explain how the sectoral environments (e.g., segmented markets and generational technological changes) of the industry facilitated domestic firms' catching-up with respective to foreign multinationals. In a nutshell, segmented markets provided domestic firms with a nurturing ground in the peripheral (rural) market for surviving their infant ages, whereas generational technological changes opened windows of opportunities for domestic firms to catch-up with foreign multinationals in new product segments. Segmented markets, together with generational technological changes, allowed domestic firms to transform their initial comparative advantages in the rural market into rapid catching-up in the urban market. This paper mainly contributes to the literature on industry evolution by illuminating the role of market/technological regimes in the dynamic catching-up process.

Key words:

catch-up, industry evolution, mobile communications, market regime, technological regime

[1] The paper is co-authored with Gianluca Capone (IUSS–Istituto Universitario di Studi Superiori di Pavia) and Franco Malerba (Bocconi University).

1. INTRODUCTION

Prior literature has revealed successive changes of industrial leadership across countries in multiple industries (Lee & Malerba, 2014; Mowery, 1999). One recent development of such leadership changes is the rapid catching-up of Chinese telecom-equipment firms in both domestic and global markets. According to the "Telecommunications Equipment Vendor Leadership Scorecard" published by Infonetics Research[2] in 2013, Chinese firms Huawei and ZTE, were ranked No.1 and No.6 among the six largest global vendors of telecom-equipment[3]. In the segment of mobile handsets, Chinese firms increased their market share from negligible to 71% in the domestic market and to 25% in the global market within merely three decades[4].

Despite the rapid catching-up of Chinese firms, the telecom-equipment industry was historically dominated by a small number of established multinational enterprises (MNEs) from developed economies. The industry is characterized by high complexity of technologies and high demand for investments. This means that this industry represents a challenging environment for latecomers, at least at the first glance. So, it is an intriguing question to ask what explains Chinese firms' rapid catching-up in the communications equipment industry. Although scholars have provided different explanations for this question, ranging from industry environments to firm strategies (P. Fan, 2006; Mu & Lee, 2005), most of these explanations remain qualitative and static. The evolutionary process of the catching-up

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[2] a research and consulting firm that specializes in the telecom market

[3] The rest of the six top telecom-equipment vendors include Ericsson (No.2), Cisco (No.3), Nokia Siemens Networks (No.4), and Alcatel-Lucent (No.5).

[4] Here, market shares are calculated by retail volume in 2014 based on data from the Passport database. The domestic (global) market shares of major Chinese mobile phone producers are as following: Xiaomi 14.0% (3.9%); Lenovo 10.9% (5.3%), Huawei 10.0% (3.7%), Yulong 9.8% (2.6%), Vivo 6.7% (1.8%), ZTE 5.2% (2.4%), Oppo 4.7% (1.4%), Tianyu 4.3% (1.1%), Gionee 3.2% (1.1%), TCL 1.5% (1.2%), Meizu 0.9% (0.2%). (Source: Passport Database; last accessed on 9th November 2016)

dynamics still remains unclear. In this paper, we raise a specific question: what roles do the sectoral environments play in the process of Chinese firms' catching-up?

Theoretically speaking, we argue that the market regimes and the technological regimes of the mobile communications industry facilitated Chinese domestic firms' catching-up. To be more specific, we propose that: (1) segmented markets allowed domestic firms to survive their infant ages by leveraging on their comparative advantages in the peripheral market; (2) generational technological changes opened windows of opportunities for domestic firms to catch-up with foreign MNEs in new product segments. Segmented markets, together with generational technological changes, facilitated the catching-up of Chinese domestic firms with respective to foreign MNEs.

The contribution of this paper is three-fold: First, this paper contributes to the literature on industry evolution by demonstrating the evolution of a dynamic industry where the competition between domestic firms and foreign multinationals is shaped by the sectoral environments. Second, this paper contributes to the literature on the topic of "catch-up" by adopting a modeling approach to analyzing the role of market/technological regimes in the catching-up process. Third, the paper also has practical implications for the strategies of emerging market firms. Since segmented markets and generational technological changes play vital roles in latecomers' catching-up, emerging market firms with a strategic intent of "catch-up" should actively target such markets and product segments.

2. THE HISTORY TO BE EXPLAINED: THE G-STORY OF MOBILE COMMUNICATIONS INDUSTRY

Mobile communication technologies are one of the most wildly adopted applied-technologies in the world. Since Nikola Tesla first demonstrated the possibility of wireless communications with his high-frequency power experiment in 1893 (Giannini, Craninckx, &

Baschirotto, 2008), the number of mobile connections has reached 7.6 billion (GSMA Intelligence, 2016), surpassing the number of the global population.

Although consumers might have already been familiar with the end-user equipment such as mobile handsets, the whole picture of the mobile communications has a much broader scope. To enable end-to-end communications, we need a system which consists of the end-user equipment, the wireless access network, and the core network.

Since its inception, the mobile communications industry has witnessed four generations of technologies, which are called the first generation (1G), the second generation (2G), the third generation (3G), and the fourth generation (4G) of mobile communications respectively (Qualcomm, 2014). Each new generation of mobile communications significantly improved the previous state-of-the-art by adopting different technologies.

As Figure 1 illustrates, different generations of mobile communication systems differ from each other, not only in terms of the end-user equipment, but they also differ in terms of the wireless network and the core network. These differences will be further discussed below.

Insert Figure 1 about here

2.1 First generation (1G) mobile communications technologies

1G mobile communication systems provide users with analog voice services. The wireless access of 1G systems is based on the Frequency Division Multiple Access (FDMA) technology, which is a technology that separates different users by using different radio frequencies. This means that each radio channel can only support one user. To avoid interference between different users, 1G systems require a large frequency gap between two users. Because the frequency spectrum is a type of scarce resources, the cost of 1G communications is high. Additionally, 1G communications are based on analog technologies, and therefore, data services are not available in the 1G era.

China had a brief history of 1G communications in early 1990s, during which the country imported the Total Access Communication System (TACS) from foreign MNEs such as Motorola and Ericsson. However, all TACS networks were shut down in 1997, before domestic firms could enter the industry (Jin & Von Zedtwitz, 2008).

2.2 Second generation (2G) mobile communications technologies

Unlike the 1G mobile communication systems that rely on the analog technology, the 2G mobile communications are based on the digital technology. Although the main functionality of 2G systems is still to handle voice communications, 2G systems also provide users with limited data services such as Short Message Service (SMS). In the 2G era, there are mainly two wireless standards, the Europe-developed GSM and the US-developed CdmaOne. GSM systems adopt a wireless technology called Time Division Multiple Access (TDMA), which separates different users by using a different time slot for each user. In contrast, CdmaOne systems utilize a wireless technology called Code Division Multiple Access (CDMA), which separates different users by using a different code for each user.

There are incremental improvements within the 2G era. For example, the General Packet Radio Service (GPRS, the so-called 2.5G) and the Enhanced Data rates for GSM Evolution (EDGE, the so-called 2.75 G) enhanced the data handling capability of the existing GSM systems, which provided users with limited Internet access. However, the speed of 2G network is generally very low (e.g., data rates < 0.5 Mbps). Such low speed is insufficient for handling the increasing user demand for mobile Internet services.

In the 2G era, Chinese domestic firms started to enter the mobile communications industry. Although domestic firms had relatively weak technological capabilities compared with foreign MNEs, they tended to have some initial advantages (e.g., cheapness) in the peripheral (rural) market. Chinese domestic firms like Huawei and ZTE actively targeted the rural market, sending their engineers to remote rural areas (Long & Laestadius, 2015). However, the Chinese market was still largely dominated by foreign MNEs in this era. For example, before the government released the 3G licenses in 2009. Huawei's retail volume of mobile phones accounted for only about 4.2% of the Chinese domestic market in year 2008, much lower than the market share of foreign MNEs (e.g., Samsung had 16.9% of market share in the same period) (source: Passport database).

2.3 Third generation (3G) mobile communications technologies

Compared with 2G systems, 3G systems provide users with a much higher speed. Although the specific date rates of 3G systems depend on the specific wireless standards, the data rates are often higher than 2 Mbps (C.-X. Fan, Chen, & Lu, 2002), with some versions (e.g., WCDMA/HSPA+) reaching the data rates as high as 63 Mbps (Qualcomm, 2014).

In the 3G era, there are mainly three international wireless standards: WCDMA (developed in the Europe), CDMA2000 (developed in the US), and TD-SCDMA (developed in China). The main difference between TD-SCDMA and the other two standards resides in the duplexing mode, which differentiates how different systems transmit the uplink data (data from the end-user equipment to the base station) and the downlink data (data from the base station to the end-user equipment). TD-SCDMA adopts the Time Division Duplex (TDD) mode, which uses a single frequency bandwidth to handle both uplink data and downlink data. Instead, both WCDMA and CDMA2000 adopt the Frequency Division Duplex (FDD) mode, which needs a pair of frequency bandwidths to handle uplink data and downlink data separately. Interestingly, all of the three international 3G standards were commercialized in China.

Some Chinese domestic firms actively upgraded their technological capabilities in the

3G era. For example, one domestic firm Datang, developed the country's own 3G standard, TD-SCDMA, which was accepted by the International Telecommunications Union (ITU) as one of the international 3G standards in 2000 (Gao, 2014). Other Chinese firms like Huawei and ZTE, successfully developed products that follow the other two 3G standards (WCDMA and CDMA2000) by 2002 (Yearbook of China Communications, 2003). In this era, Chinese domestic firms also narrowed the market share gap between themselves and foreign MNEs. For example, before the government released the 4G licenses in 2013, Huawei's retail volume of mobile phones increased to about 10.0% of the Chinese market in year 2012. However, it was still lagging behind the market leader Samsung, which captured about 21.8% market share of the Chinese market in the same period (source: Passport database).

2.4 Fourth generation (4G) mobile communications technologies

Although 3G communication systems offered users much better data services compared with 2G systems, the speed of 3G systems is still not fast enough to support data-demanding applications, such as high-quality video streaming, online gaming, three-dimensional (3D) visuals, and so on (Rathore, Chaurasia, Mishra, & Kumar, 2012). 4G systems are designed to provide users with "high-speed" and "low-cost" mobile Internet, with the data rates as high as 300 Mbps (Qualcomm, 2014). 4G systems are optimized for data communications by combining different technologies, such as Orthogonal Frequency Division Multiple Access (OFDMA), Multiple Input Multiple Output (MIMO), and an all-IP based design. These technologies do not only provide users with much higher speed of the mobile Internet, but also provide users with better quality of services (e.g., lower latency). In the 4G era, different wireless standards converged to a unified standard, LTE, which can operate in both the FDD mode and the TDD mode.[5]

[5] although there is another potential 4G technology, Wi-Max, evolved from a different development path (IEEE standards).

The transition from 3G to 4G once again offered domestic firms an opportunity to catch-up with foreign multinationals in the new product segment. In this era, the retail volume of Huawei's mobile phones further increased to 14.7% of the Chinese market in year 2015, whereas the retail volume of Samsung's mobile phones decreased to 8.8% of the Chinese market in the same period (source: Passport database). Huawei, for the first time, surpassed Samsung and became one leading firm in the mobile handset segment.

A comparison of different generations of mobile communications is shown in Table I.

Insert Table I about here
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3. THEORIZING ON THE CATCHING-UP DYNAMICS

The prior literature on the topic of "catch-up" defines "catch-up" as a process by which latecomers narrow the gap between themselves and forerunners (Abramovitz, 1986). The gap could be measured either in terms of technological performance or in terms of market performance. However, technological catch-up and market catch-up are strongly related to each other. Market catch-up facilitates technological catch-up by providing firms with crucial resources for technological upgrading, whereas technological catch-up facilitates market catch-up by bringing firms better products (Lee & Lim, 2001). Ultimately, a firm should move up the value-chain through the process of catching-up, migrating from low-value-added activities to high-value-added activities (Gereffi, Humphrey, & Kaplinsky, 2001; Mudambi, 2008). To capture the two interrelated dimensions of catching-up, in this paper, we define domestic firms' catching-up as the increase of their market share in the urban market, a market that offers higher profits but also demands better quality products.

3.1 Market regime and horizontal upgrading

In the beginning of the 2G era, domestic firms have relatively weaker technological capabilities compared with foreign MNEs, but they also have some comparative advantages (e.g., cheapness) in the peripheral market. Such peripheral market (e.g., rural market) allowed domestic firms to survive their infant ages, and it provided domestic firms with crucial resources for upgrading their technological capabilities.

Segmented markets. Segmented markets refer to a market regime where customers of different groups have different preferences in terms of main attributes (e.g., price, quality) of products (Allon & Federgruen, 2009). Segmented markets would facilitate domestic firms' catching-up with respective to foreign MNEs. On the one hand, segmented markets would reduce the first mover advantages of incumbents, because segmented markets would make it difficult for incumbents to pre-empty the markets (Capone, Malerba, & Orsenigo, 2013). On the other hand, segmented markets allow domestic firms to survive their infant ages by leveraging on their comparative advantages (e.g., cheapness) in the rural market. This means that the rural market provided domestic firms with a "nurturing ground" to accumulate critical resources for upgrading their technological capabilities. With increasing technological capabilities, domestic firms can gradually catch-up with foreign multinationals in the urban market.

The market regime of China's mobile communications industry is characterized by such segmented markets because the country shows a high degree of regional disparity (S. Fan, Kanbur, & Zhang, 2008). Different regions of China tend to be different in terms of income levels, education levels, development levels, and so on. Eventually, these differences will be translated into different preferences for the price and the quality of mobile communications products. Generally speaking, urban markets (especially markets of coastal cities) are more developed than rural markets. As a result, customers in the urban markets tend to assign a higher weight to the quality[6] of products when making purchasing decisions, whereas customers in the rural markets tend to assign a higher weight to the cheapness of products when making purchasing decisions. Despite the rapid economic growth in the past decades, China still had a relatively large rural market. According to the data from the World Bank, the ratio of China's urban population was only about 40% (e.g., ranging from 37% in 2001 to 43% in 2005) in the early history of China's mobile communications industry.

Horizontal upgrading. In the early history of China's mobile communications industry, foreign MNEs somehow ignored the Chinese rural market, although the reasons for that are still debatable. One possible explanation is that, at that time, the Chinese urban markets *per se* are still large enough, and therefore, foreign MNEs do not have enough incentives to serve the rural markets that offer relatively low profit margins (Mu & Lee, 2005). Another possible explanation is that foreign MNEs might face the "liability of foreignness" (Zaheer, 1995) due to cultural and linguistic barriers, and such barriers prevented foreign MNEs from pre-empting the rural markets. Consequently, a large peripheral (rural) market allowed domestic firms, which do not have superior technologies at that time, to survive their infant ages by exploiting ordinary technologies in the peripheral market. For example, "Xiaolingtong" [7] (Yuan et al., 2006) is not a superior technology from the technological point of view. But some Chinese firms (e.g. ZTE) successfully exploited this technology in the rural markets, which helped these domestic firms to accumulate critical resources and experiences in their early stage of development.

Proposition 1. Market segmentation will facilitate domestic firms' catching-up, such that

[6] Here, "quality" is used as a general term to refer to a combination of design, performance, technology, functionality, and so on.

[7] The Xiaolingtong technology offers mobile services by connecting end users to existing fixed-line networks through micro-cell radio. This technology is based on the Personal Handy Phone System (PHS), a Japanese technology developed in 1995 (Yuan et al., 2006).

domestic firms are more likely to catch-up with foreign MNEs if there is a large peripheral (rural) market.

3.2 Technological regime and vertical upgrading

In the beginning of the 2G era, domestic firms have relatively weak technological capabilities in 2G products. However, generational technological changes provide domestic firms with windows of opportunities to catch-up with foreign MNEs in new product segments.

Generational technological changes. "Generational technological changes" (Lawless & Anderson, 1996) refers to big technological advances within a technological paradigm. In this sense, generational technological changes are neither "disruptive" (Christensen & Bower, 1996) nor "incremental" (Tushman & Anderson, 1986). With generational technological changes, many technologies will change across different generations. However, there is still a certain degree of relatedness between an old generation and a new generation of technologies. Different generations of technologies often coexist in the market (Lawless & Anderson, 1996).

Generational technological changes will facilitate domestic firms' catching-up with respective to foreign MNEs for two reasons. On the one hand, generational technological changes would open windows of opportunities for latecomers, because to some extent, every firm is a new comer in front of a new generation of technologies (Perez & Soete, 1988). On the other hand, generational technological changes are not so disruptive, so that the knowledge learned by latecomers in a previous generation of technologies can still serve as a stepping stone for latecomers' capability-building in a new generation of technologies.

The mobile communications industry is an industry characterized by such generational technological changes. Each new generation of mobile communications adopts different technologies, enables new services, and therefore, creates technological opportunities for the development of new products.

In some cases, it is relatively easy to see how the arrival of a new generation of communication technologies creates a new product segment. For example, because 3G communication systems significantly increased the data transmission capability of the previous generation of communication systems, the arrival of the 3G era introduced a group of products that offered computers with mobile Internet access. Figure 2 shows some of these products such as 3G mobile Wi-Fi and 3G mobile broadband modem.

Insert Figure 2 about here

In other cases, it is less clear whether the arrival of a new generation of communication technologies creates a new product segment or improves products within an existing product segment. For example, the mobile phones shown in Figure 3 are so different across different generations of mobile communications. Therefore, whether we should consider a new generation of mobile phones as a new product segment or as new products within an existing product segment seems to be a matter of personal judgment. Regardless of our judgment, the fact is that different generations of devices are significantly different in terms of “size”, “form”, “function”, and so on (Bangerter, Talwar, Arefi, & Stewart, 2014).

Insert Figure 3 about here

Above examples are mainly focused on the technological opportunities brought by generational technological changes on the end-user equipment side. But in fact, generational technological changes also bring technological opportunities on the network equipment side.

For example, the core network of GSM (2G) systems is mainly based on circuit-switch[8]; the core network of UMTS WCDMA (3G) systems is based on both circuit-switch and packet-switch; and the core network of LTE (4G) systems is solely based on packet-switch. The wireless access networks also differ across different generations of mobile communications.

Because each generation of communication technologies is associated with a set of new products that work together to comprise a mobile communication system, we consider these new products as belonging to a generation-specific product segment (e.g., 2G products, 3G products, 4G products). The history-friendly model developed in this paper aims to show how generational technological changes facilitated domestic firms' catching-up by opening windows of opportunities in these generation-specific product segments.

Vertical upgrading. Generational technological changes will open new product segments (e.g., 3G products, 4G products) that are associated with the new generations of technologies. Such new product segments would facilitate domestic firms' catching-up with respective to foreign MNEs, because both domestic firms and foreign MNEs are newcomers in these new product segments. More importantly, foreign MNEs that have developed strong technological capabilities in a previous generation of technologies might be reluctant to enter the new product segment because of the "locked-in" effect (Christensen & Bower, 1996; Tripsas & Gavetti, 2000), which means that a firm's existing capabilities in a previous generation of products may become a liability for its upgrading into a new generation of products (Leonard-Barton, 1992). Instead, domestic firms with sufficient (but not too strong) technological capabilities in a previous generation are more likely to embrace the opportunities brought by such generational technological changes.

In the past decades, the telecom-equipment industry has witnessed several rounds of

[8] although extensions of the GSM (e.g., GRPS) also utilize the packet-switched network to handle data services

generational technological changes from 2G to 4G. Each generational technological change opened a window of opportunities for latecomers to catch-up with foreign MNEs. Some Chinese firms seized the windows of opportunities associated with such generational technological changes, and these firms successfully reduced the technological gap between themselves and foreign MNEs in the new generation of technologies. For example, Huawei claimed that it held approximately 15% of all essential patents related to the LTE/EPC standard (a so-called 4G standard[9]), a much higher ratio compared with the 2% ratio related to the GSM standard (a 2G standard) and the 6% ratio related to the UMTS standard (a 3G standard) (Huawei, 2015). Since essential patents are patents that are “indispensable” for producing products conforming to a specific standard (Bekkers, Bongard, & Nuvolari, 2011), Huawei’s increasing share of essential patents in each new generation of technologies suggests a narrowing technological gap between Huawei and foreign MNEs. Increased technological capabilities would enable domestic firms to compete with foreign MNEs in the core (urban) market.

Proposition 2. Generational technological changes will facilitate domestic firms’ catching-up, such that domestic firms are more likely to catch-up with foreign MNEs in new product segments created by the generational technological changes.

4. METHODS: A “HISTORY-FRIENDLY MODEL” APPROACH

The “catch-up” process is an evolutionary process characterized by non-linear dynamics. Neither traditional econometric analyses nor formal mathematical models can adequately address such non-linear dynamics in the catching-up process. This study follows a “history-friendly model” approach, which is more capable of capturing the evolutionary process than

[9] Strictly speaking, LTE does not really meet the ITU requirements for 4G. But, it has often been advertised as a 4G technology by telecom operators.

econometrical models and more capable of testing mechanisms than verbal "appreciative theory" (Malerba, Nelson, Orsenigo, & Winter, 2016). History-friendly models are essentially simulation models that are developed to replicate some stylized facts of the history. The main steps of the history-friendly modeling approach include: First, researchers should extract the salient facts from the history based on their empirical observations, and identify the main mechanisms to be explained. Second, the researchers develop a simulation model to replicate the stylized facts of the history ("history-friendly simulation"). Third, the researchers change some of the parameters to see how the history might be different if some of the historical conditions would have been different ("history-divergent simulation"). The history-divergent simulation can serve as a test for the proposed mechanisms, because if the proposed mechanisms are correct, the researchers should observe that the results from the history-divergent simulation are consistent with their proposed mechanisms. Several prior studies have adopted history-friendly models to demonstrate the evolution of industries (C. W. Kim & Lee, 2003; Malerba, Nelson, Orsenigo, & Winter, 1999, 2008). We developed the simulation model through Java programming.

5. THE MODEL

5.1 Model overview

The model overview in Figure 4 captures the stylized facts of China's mobile communications industry. In the beginning of the 2G era, domestic firms tend to have relatively low technological capabilities compared with foreign MNEs. Although the products of domestic firms tend to have a lower quality than the products of foreign MNEs, they also tend to be cheaper than the products of foreign MNEs. Customers in the rural market value cheapness more than customers in the urban market do, whereas customers in the urban market value quality more than customers in the rural market do. The arrival of a new generation of mobile technologies will create a new product segment, but it will not obsolete existing product segments (Long & Laestadius, 2015). Firms can upgrade their technological capabilities by investing in R&D. Domestic firms' catching-up is defined as the increase of their market share in the urban market.

Insert Figure 4 about here

5.2 Market environment

Firms compete in segmented markets (urban vs. rural) based on the perceived merit of design (MOD) of their products in each market. The perceived MOD is a value that customers in a market assign to a product according to the quality and the cheapness of that product. Generally speaking, customers in the rural market care more about the cheapness of the product, whereas customers in the urban market care more about the quality of the product. As long as the quality and the cheapness meet the minimum requirements, the MOD is determined by a Cobb-Douglas function as specified in equation (1). However, if the quality is lower than the minimum quality required by a market, or the cheapness is lower than the minimum cheapness required by a market, the MOD of a product will be zero for that market.

$$MOD_{f,t,g,m} = \alpha * (q_{f,t,g} - Q_{g,m})^{\gamma_m^{quality}} * (ch_{f,t,g} - CH_{g,m})^{\gamma_m^{cheapness}} \quad (1)$$

The probability that a firm can sell its products in a market depends on the MOD of a firm's products relative to the MOD of all the competing products in that market. Mathematically, the probability of a firm's products being sold in a specific market is determined by equation (2).

$$prob_{f,t,g,m} = \frac{MOD_{f,t,g,m}}{\sum_{f=1}^{n} MOD_{f,t,g,m}} \quad (2)$$

The quality of a product ($q_{f,t,g}$) depends on a firm's technological capability ($r_{f,t,g}$) in that product segment, and it also depends on a segment-specific parameter which translates the technological capability into the quality.

$$q_{f,t,g} = \delta_g * r_{f,t,g} \qquad (3)$$

The price of a product ($p_{f,t,g}$) is determined by a production cost and a mark-up ratio.

$$p_{f,t,g} = c_{f,t,g} * (1 + markup_{f,t,g}) \qquad (4)$$

The production cost is the sum of a segment-specific baseline production cost that differs across different generations of products and a firm-specific component that increases with the quality of a firm's products. Generally speaking, a new generation of products tends to have a higher baseline production cost than an old generation of products (e.g., 3G products will cost more than 2G products). And, high quality products are more costly to produce than low quality products.

$$c_{f,t,g} = c_g + \lambda * q_{f,t,g} \qquad (5)$$

The cheapness is the inverse of the price, adjusted by a segment-specific parameter χ_g . The higher the price, the lower the cheapness value will be.

$$ch_{f,t,g} = \chi_g / p_{f,t,g} \qquad (6)$$

Firms will decide the markup ratio based on their market power in the industry. Here, $s_{f,t,g,rural}$ refers to a firm's market share in the rural market, whereas $s_{f,t,g,urban}$ refers to a firm's market share in the urban market. Generally speaking, the higher a firm's market share is, the greater its market power will be. Firms with greater market power will charge for a higher markup-up ratio. η_{rural} and η_{urban} represent the price elasticity of demand in the rural market and the price elasticity of demand in the urban market respectively. Firms decide the markup ratio of their products by jointly considering the two markets. Here, $\zeta_{f,t,g}$ and $(1-\zeta_{f,t,g})$ represent the weights for the rural and the urban markets respectively, when firms set their markup ratio. $\zeta_{f,t,g}$ equals to the percentage of product profits from the rural market, and $(1-\zeta_{f,t,g})$ equals to the percentage of product profits from the urban market.

$$markup_{f,t,g} = \zeta_{f,t,g} * \frac{s_{f,t,g,rural}}{\eta_{rural} - s_{f,t,g,rural}} + (1-\zeta_{f,t,g}) * \frac{s_{f,t,g,urban}}{\eta_{urban} - s_{f,t,g,urban}} \qquad (7)$$

Mathematically, a firm's market share in a market is calculated as a firm's sales volume in a market divided by the sum of all firms' sales volume in that market.

$$s_{f,t,g,m} = V_{f,t,g,m} / \sum_{f=1}^{n} V_{f,t,g,m} \qquad (8)$$

A firm's sales volume in a specific market is calculated as the probability that a firm can sell its products ($prob_{f,t,g,m}$) in a market multiplied by the number of active buyers in that market. The number of active buyers is drawn from the total number of potential customers in a market ($customers_m$) according to a normal distribution.

$$V_{f,t,g.m} = prob_{f,t,g,m} * F_1(customers_m) \qquad (9)$$

A firm's profit in a specific product segment (e.g., 2G) comes from both the rural market and the urban market. In each market, the profit is calculated as unit profit multiplied by the sales volume. And, a firm's total profit is the sum of profits from all the product segments and all the markets.

$$\pi_{f,t} = \sum_{g=2G}^{4G} \left[\sum_{m=rural}^{urban} (p_{f,t,g} - c_{f,t,g}) * V_{f,t,g,m} \right] \qquad (10)$$

A firm will exit the industry if the evaluation score ($E_{f,t}$) calculated from its profits is lower than a certain threshold (E_{exit}). The evaluation score takes into account both current performance and past performance, such that a firm is allowed to recover from a temporary poor performance. The parameter ω in equation (11) represents the weight of a firm's current profits in determining a firm's status of survival. We allow for the replacement of domestic firms, which means that once a domestic firm exited the industry, a new domestic firm will enter into the industry. This design is based on two considerations: First, domestic firms may face a high exit rate in the presence of intense competition. Second, entry and exit in an industry tend to be strongly correlated (Dunne, Roberts, & Samuelson, 1988). For example, as a new cohort of domestic firms (e.g., Oppo, Gionee, and Meizu) entered into the industry, some of the early domestic firms (e.g., Ningbo Bird and Amoi) exited the industry.

$$E_{f,t} = \omega * \pi_{f,t} + (1-\omega) * E_{f,t-1} \qquad (11)$$

5.3 Technological environment

To produce products of a specific product segment, a firm needs to develop technological capabilities in that product segment. This requires a firm to invest its R&D resources in that product segment. The relationship between firm R&D investments in a product segment and firm technological capabilities in that segment is captured by equation (12).

$$r_{f,t,g} = \begin{cases} F_2\left(\frac{B_{f,t,g}}{C_{R\&D}}\right), & \text{if } F_2\left(\frac{B_{f,t,g}}{C_{R\&D}}\right) > r_{f,t-1,g} \\ r_{f,t-1,g}, & \text{otherwise} \end{cases} \qquad (12)$$

Here, F_2 is a function which returns new values of technological capabilities through a number of R&D trials. The exact number of R&D trials is determined by the R&D budget ($B_{f,t,g}$) allocated to a product segment and the unit cost of doing R&D ($C_{R\&D}$). For simplicity, we assume that the unit cost of doing R&D is a constant, which is the same for all firms. The function F_2 is constructed by taking into consideration of firms' prior capabilities. Each time when a firm draws a new capability value from the R&D trial, it is drawing a random number from a normal distribution. The mean value of the normal distribution ($r_{f,t,g}{}^{*}$) is a weighted average of the firm's capabilities developed in the current generation and a previous generation of technologies (as specified in equation (13)). The larger the θ is, the more the capability development in the current segment (e.g., 3G) is related to a firm's existing capabilities in a previous product segment (e.g., 2G) [10].

$$r_{f,t,g}{}^{*} = \theta * r_{f,t,g-1} + (1-\theta) * r_{f,t,g} \qquad (13)$$

After a firm draws a new capability value through R&D trials, it will compare this value with its existing capability value. A firm will update its capability value only if the newly drawn capability value is greater than its existing capability value. In addition, there is an upper bound for firms' technological capabilities so that firms' technological capabilities cannot increase infinitely.

Generational technological changes will create new product segments (e.g., 3G products, 4G products). When the era of a new generation of technologies arrives, firms need to decide whether they would enter the new product segment or not. The details about how firms decide whether to enter a new product segment or not will be further discussed below.

5.4 Firms and their behaviors

There are two types of firms (domestic firms and foreign MNEs) in the industry, which differ in their initial level of technological capabilities ($r_{f,t,g}$). In the beginning of the 2G era, foreign MNEs had relatively greater technological capabilities compared with domestic firms.

Both types of firms face two strategic choices. The first choice is about what proportion of the total profits they should invest in R&D, and the second choice is about how they should

[10] Since our simulation starts from the 2G era, the rule of weight average does not apply for capability development in the 2G product segment.

allocate their limited R&D resources across different product segments.

$$B_{f,t} = \rho_f * \pi_{f,t} \qquad (14)$$

In this paper, we focus on the role of market/technological regimes on domestic firms' catching-up, instead of firm strategies *per se*. Therefore, we do not differentiate firms by their propensity to invest in R&D. We assume that all firms will invest all of their profits in R&D (ρ_f =1 for all firms).

The arrival of a new generation of mobile technologies will open a window of opportunities for firms to enter a new product segment (e.g., 3G products or 4G products). The probability of a firm entering into a new product segment is a function of its technological capabilities in the current generation of products. Firms with "too low" capabilities in the current generation of products may not be able to enter into a new generation of products, because of insufficient absorptive capacity (Cohen & Levinthal, 1990); whereas firms with "too high" capabilities in the current generation of products may also be reluctant to enter into a new generation of products, because of the "locked-in" effect (Christensen & Bower, 1996; Tripsas & Gavetti, 2000).

This is implemented by drawing a probability score from a beta distribution such that a firm's probability of upgrading into a new generation of technologies equals to the output of the probability density function (pdf) of the beta distribution. Here, the input of this pdf function is a firm's technological capability developed in a previous generation of technologies[11]. For simplicity, in the history-friendly setting, we assume the probability of upgrading will be related to a firm's capability in a previous generation in an inverted-U-shaped manner ($X \sim Beta(a, b)$ when both a and b equal to 2). In this case, the function can be

[11] The pdf function is scaled so that the maximum returned value is one.

simplified as the equation below:

$$ProbOfUpgrading = 4 * r_{f,t,g\text{-}1} * (1\text{-}r_{f,t,g\text{-}1}) \qquad (15)$$

However, by changing the two parameters (*a* and *b*) of the beta distribution, we can link a firm's probability of upgrading to the nature of the technological change. For example, if the technological change is competence-destroying, we can decease the value of the parameter *a*, so that the pdf function of the beta distribution would ensure that firms with lower capabilities in a previous generation of products would have a higher probability of upgrading (as discussed in section 6.2). Instead, if the technological change is competence-enhancing, we can decrease the value of the parameter *b*, so that the pdf function of the beta distribution would ensure that firms with higher capabilities in a previous generation of products would have a higher probability of upgrading (as discussed in section 6.2).

Once a firm decided to enter a new product segment, it would allocate R&D budget to the segment for increasing its technological capabilities in that segment. The exact amount of R&D budget being allocated to a new product segment depends on a firm's total R&D budget and its risk aversion (σ_f) toward the latest generation of products. Some firms might allocate a small proportion of total R&D budget to the latest generation of products, whereas other firms might allocate a large proportion. As mentioned earlier, because the focus of this paper is on market/technological regimes instead of firm strategies, we assume that firms' risk aversions are randomly drawn from a uniform distribution.

$$B_{f,t,g} = (1 - \sigma_f) * B_{f,t} \qquad (16)$$

After the R&D budget for the latest generation of products has been allocated, the rest of the R&D budget will be split among previous generation(s) of products by following the same rule above.

If a firm's prior capabilities do not allow it to enter a new generation of products, then no R&D budget will be allocated to the new generation of products. Instead, the total R&D budget will be directly distributed among previous generation(s) of products.

6. SIMULATION RUNS

In this section, we present the results from 1000 runs of a simulation model. First, we run the history-friendly simulation with the intention of replicating some stylized facts of the history. Then, we run the history-divergent simulation with the intention to see how the history might be different if the sectoral environments would have been different.

6.1 History-friendly simulation

The simulation starts from the 2G era (period 1 to period 50), and continues throughout the 3G era (period 51 to period 100), and the 4G era (period 101 to period 150). In the beginning of the 2G era, there are 10 domestic firms and 10 foreign MNEs. The difference between domestic firms and MNEs is that domestic firms have relatively low technological capabilities, whereas foreign MNEs have relatively high technological capabilities at the beginning.

Figure 5a shows the evolution of domestic firms' market share in the urban market. Here, the x-axis is the dimension of time, and the y-axis is the dimension of market share. The three curves in this figure represent three different product segments. As we can see, domestic firms have a relatively small market share (between 5.5 % and 8.6 %) in the 2G product segment. However, as generational technological changes open new product segments, domestic firms tend to increase their market shares in new product segments. For example, the market share of domestic firms in the 3G product segment grows rapidly, and it eventually exceeds the market share of domestic firms in the 2G product segment. Similarly, the growth rate of domestic firms' market share in the 4G product segment is even greater than the growth rate of domestic firms' market share in the 3G product segment, and domestic firms' 4G market share is eventually greater than their 3G market share. Since the catching-up of domestic firms is defined as the increase of domestic firms' market share in the urban market, the upward slope of these market share curves captures the speed of domestic firms' catching-up.

Insert Figure 5a about here

Figure 5b shows the average number of (initial) domestic firms alive in 1000 runs of the simulation. Initial domestic firms are the domestic firms that were in the industry since the beginning of the simulation. The number of initial domestic firms alive reflects the survive pressure for domestic firms in this industry. The interesting finding from Figure 5b is that there is a "shakeout" (Klepper, 1997) in the early periods. Many domestic firms cannot survive their infant ages. On average, more than half of the initial domestic firms were shaken out of the industry before the end of the simulation. This suggests that although the market share of domestic firms has been increasing at the aggregate level, the catching-up of domestic firms is actually driven by a small number of "star" firms. For example, over the past decades, there have been a few Chinese domestic firms that have been successful in terms of catching-up (e.g., Huawei, ZTE, to a less extent, also Datang). However, many other domestic firms (e.g., Ningbo Bird, Amoi) eventually exited (or almost exited) the industry.

Insert Figure 5b about here

6.2 History-divergent simulation

Case 1: A small rural market. The history friendly model allows us to conduct some counterfactual thinking regarding how the history might be different if some of the historical conditions would have been different. If domestic Chinese firms really benefited from a relatively large peripheral (rural) market in their catching-up process, we may expect to see that Chinese firms would be less likely to catch-up with foreign MNEs, if the size of the rural market is small.

Figure 6a and Figure 6b show the results from 1000 runs of such "history-divergent" simulation. In the "history-divergent" simulation, we kept everything else the same, except that we reduced the size of the rural market. As expected, results from Figure 6a and Figure 6b show that, without a large rural market to provide domestic firms with an initial "nurturing ground", most of the domestic firms could not survive their infant ages. Almost all of the initial ten domestic firms exited the market in the 2G era, soon after the beginning of the simulation. In this case, there is a high rate of exit and entry of domestic firms. However, the new entrants have relatively low technological capabilities, and therefore, they cannot enter the urban market.

Insert Figure 6a and 6b about here

Case 2: no technological relatedness. To explore the role of generational technological changes in the catching-up process, we also conduct a "history-divergent" simulation in which we assume that there is no technological relatedness between a new generation of technologies and an old generation of technologies. In this case, we kept everything else the same as in the history-friendly setting, but we make the θ (the relatedness parameter) in equation (13) equal to zero, and we change the value of parameter a of the beta distribution from 2 to 1. This represents a technological regime under which the technological changes are "competence-destroying" (Tushman & Anderson, 1986), because the capability development for the new generation of technologies is unrelated to firm capabilities in an old generation of technologies. The results are shown in Figure 7a and Figure 7b. From Figure 7a to Figure 7b, we can see that under such a technological regime, domestic firms could not develop adequate technological capabilities to produce good enough (3G and 4G) products that can be accepted by the urban market. There is no “catching-up” happening.

This result seems to be surprising at the first glance, because the prior literature on competence-destroying technological changes (Anderson & Tushman, 1990; Tushman & Anderson, 1986) suggests that such technological changes would favor new entrants instead of incumbents. However, we should notice that this stream of literature was originally developed in the context of developed economies, in which “new entrants” are often technologically advanced firms that enter an industry with “competence-destroying innovations”. However, “latecomer firms” in the context of emerging economies are different from “new entrants” in the context of advanced economies, because “latecomer firms” are often “resource-poor” firms that lack advanced technologies (Mathews, 2002). It is unlikely for such “latecomer firms” to enter an industry with “competence-destroying innovations”. Instead, the catching-up process is a learning process through which latecomers gradually transform themselves from imitators to innovators (L. Kim, 1997). If the technological change is competence-destroying, it does not only obsolete the existing capabilities of incumbents, it also disrupts the learning process of latecomer firms. In fact, even if both types of firms have to develop new capabilities from scratch, established MNEs might develop capabilities faster than domestic firms, because established MNEs have more resources (e.g., higher R&D expenditures) to combat such technological changes.

Insert Figure 7a and 7b about here

Case 3: strong technological relatedness. We further explore how the history might be different if the capability-building for a new generation of products is strongly related to a firm's capability in an old generation of products. In this case, we kept everything else the same as in the history-friendly setting, but we make the θ (the relatedness parameter) in equation (13) equal to one, and we change the value of parameter b of the beta distribution from 2 to 1. This represents a technological regime under which the technological changes are "competence-enhancing" (Tushman & Anderson, 1986), because the development of capabilities in a new generation of products largely depends on firm capabilities in an old generation of products. The results are shown in Figure 8a to Figure 8b. Like what happened in the history-friendly setting, domestic firms can upgrade into new product segments (3G or 4G) under this setting, and they are catching-up with foreign MNEs in terms of market shares in the urban market.

This result is consistent with our explanations in the previous case. Although the traditional view on the "competence-enhancing" technological changes suggests that such technological changes would favor incumbents instead of new entrants (Tushman & Anderson, 1986), the technological regime under such a setting also represents an environment that ensures the continuity for the learning and capability-building process within latecomer firms. Under such a technological regime, latecomer firms might achieve an extraordinary performance by making a good composition of reasonably good quality and relatively competitive price (Luo & Child, 2015).

Insert Figure 8a and 8b about here
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7. DISCUSSIONS

This paper examines the role of sectoral environments (market regimes and technological regimes) in the process of domestic firms' catching-up. The environment of China's mobile communications industry is characterized by segmented markets and generational technological changes. Both of the characteristics facilitated domestic firms' catching-up with foreign MNEs.

The "history-friendly" simulation demonstrates that, domestic firms tend to catch-up with foreign MNEs in new product segments following generational technological changes. The "history-divergent" simulation suggests that, without a large peripheral market to provide domestic firms with an initial "nurturing ground", domestic firms cannot survive their infant ages, not mentioning catching-up with MNEs. Additionally, certain degree of relatedness between a new generation and an old generation of technologies is necessary for domestic firms' catching-up, because such relatedness ensures the continuity of latecomers' capability-building process.

In this paper, we mainly operationalized "peripheral market" as the "rural market" and operationalized "core market" as the "urban market". However, such "from the countryside to cities" metaphor can also be applied to explain Chinese firms' international expansion. When Chinese telecom equipment firms started to internationalize, they tended to start from other emerging markets in which they had competitive advantages (or at least less disadvantages) against established MNEs. For example, both Huawei and ZTE actively targeted other emerging markets such as countries in Asia, Latin America, and Africa. And, this strategy has been consistently adopted even when Huawei started to expand into the more advanced western European and the North American markets. In these markets, Huawei has been actively targeting small-and-medium-sized telecom operators. Because these small-and-medium-sized operators are more resource constrained compared with top tier operators, they often have a different evaluation on the quality and the price of telecom products. Chinese firms like Huawei and ZTE seem to be capable of providing good enough products at competitive prices for these small-and-medium-sized operators. The existence of such peripheral markets within advanced economies provided emerging-market firms with an opportunity to enter these advanced-economy markets.

At the same time, generational technological changes provided domestic firms with the windows of opportunities for catching-up with foreign MNEs in new product segments. Unlike the common understanding in the literature on technological discontinuities (Tushman & Anderson, 1986), the history-divergent simulations show that if the generational technological changes are too radical, domestic firms actually cannot catch-up. This is because “latecomer firms” in the context of emerging economies are different from “new entrants” in the context of advanced economies. New entrants in the context of advanced economies tend to be technologically advanced firms that enter into an industry with competence-destroying innovations (Tushman & Anderson, 1986). However, latecomer firms in the context of emerging economies are often laggards in an industry whose backwardness is caused by the historical conditions of the home country (Mathews, 2002). If the technological changes are too radical, latecomer firms may face more challenges in terms of developing new capabilities from scratch compared with foreign MNEs, because latecomer firms are often more resource constrained.

To sum up, this paper demonstrates that, segmented markets together with generational technological changes, facilitated Chinese firms’ catching-up in the mobile communications industry.

7.1 Contributions

The contribution of this paper is three-fold: First, this paper contributes to the literature on industry evolution by demonstrating the evolution of a dynamic industry where the competition between domestic firms and foreign multinationals is shaped by the market/technological regimes. Although prior studies on industry evolution have examined the life cycle of products (Abernathy & Utterback, 1978; Suarez & Utterback, 1995) and the competition of firms within an industry (e.g., (Klepper, 2002)), much of such theorization is based on single-product industries. The question that is less clear is what happens when one product life cycle ends (Malerba et al., 2016). This paper sheds light on this question by showing the competition between domestic firms and foreign multinationals in a dynamic industry that constantly renews itself through generational technological changes.

Second, this paper contributes to the literature on the topic of "catch-up". Although early research on the topic of "catch-up" was mainly focused on the country-level (Abramovitz, 1986), there have been increasing voices calling for a better understanding of the micro-foundations of the catching-up process (Fagerberg, Mowery, & Nelson, 2006). Prior studies that attempted to address the antecedents of firm-level catching-up have suggested that certain types of industrial environment might promote successful catching-up. For example, Perez and Soete (1988) conceptually argued that technological changes might open the "windows of opportunities" for latecomers. Using US patent data, Park and Lee (2006) empirically tested the relationship between technological regimes and the occurrence/speed of catching-up. This paper contributes to this stream of literature by modeling the micro dynamics of the catching-up process. The history-friendly modeling approach is an appropriate approach to studying the catching-up process, not only because it has the ability to demonstrate some stylized facts of the history, but also because it helps us to conduct divergent thinking regarding the counterfactual situations.

Lastly, although this paper is focused on how certain sectoral environments (market/technological regimes) might facilitate domestic firms' catching-up, it also has implications for the catch-up strategies of firms (Awate, Larsen, & Mudambi, 2012; Kumaraswamy, Mudambi, Saranga, & Tripathy, 2012). Since peripheral markets play a vital role in domestic firms' catching-up, emerging market firms should actively target those markets, not only domestically but also internationally. Additionally, emerging market firms with a strategic intent of catching-up should actively search opportunities in new product segments created by generational technological changes.

7.2 Limitations and future research

One limitation of this study is that the study does not explicitly model different firm strategies. In this paper, the heterogeneity of firms is treated as a result of random variations. We made this choice because the main purpose of this paper is to demonstrate the role of the market and technological regimes on domestic firms' catching-up. However, we acknowledge that not all firms can equally benefit from such sectoral environments. Future research can further explore the role of firm strategies in the catching-up process of emerging-market firms under such sectoral environments.

Additionally, this paper does not address the role of institutions (e.g., governments, public research institutions) in the catching-up process of domestic firms. Governments might facilitate domestic firms' catching-up by using different policy tools (e.g., procurement policies or standards policies), whereas public research institutions might facilitate domestic firms' catching-up by reducing technological uncertainty. Future research can further investigate how different institutions played their roles in the catching-up process of domestic firms under the sectoral environments that we described in this paper.

8. CONCLUSIONS

This paper develops a history-friendly model of China's mobile communications industry. The model demonstrates that segmented markets, together with generational technological changes, facilitated domestic firms' catching-up with respective to foreign multinationals. Segmented markets allowed domestic firms to survive their infant ages by leveraging on their comparative advantages in the rural market, whereas generational technological changes opened up windows of opportunities for latecomers to catch-up with foreign multinationals in new product segments. The model sheds light on a better understanding of the dynamic catching-up process through which latecomers climb up the ladder of the value chain.

REFERENCES

Abernathy, W. J., & Utterback, J. M. (1978). Patterns of industrial innovation. *Technology review, 64*, 254-228.
Abramovitz, M. (1986). Catching up. forging ahead, and falling behind. *Journal of Economic History, 46*(2), 385-406.
Adachi, F. (2001). Wireless Past and Future--Evolving Mobile Communications Systems. *IEICE transactions on fundamentals of electronics, communications and computer sciences, 84*(1), 55-60.
Allon, G., & Federgruen, A. (2009). Competition in service industries with segmented markets. *Management Science, 55*(4), 619-634.
Anderson, P., & Tushman, M. L. (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. *Administrative Science Quarterly*, 604-633.
Awate, S., Larsen, M. M., & Mudambi, R. (2012). EMNE catch-up strategies in the wind turbine industry: Is there a trade-off between output and innovation capabilities? *Global Strategy Journal, 2*(3), 205-223.
Bangerter, B., Talwar, S., Arefi, R., & Stewart, K. (2014). Networks and devices for the 5G era. *Communications Magazine, IEEE, 52*(2), 90-96.
Bekkers, R., Bongard, R., & Nuvolari, A. (2011). An empirical study on the determinants of essential patent claims in compatibility standards. *Research Policy, 40*(7), 1001-1015.
Capone, G., Malerba, F., & Orsenigo, L. (2013). Are Switching Costs Always Effective in Creating First-Mover Advantage? The Moderating Role of Demand and Technological Regimes. *Long Range Planning, 46*(4), 348-368.
Christensen, C. M., & Bower, J. L. (1996). Customer power, strategic investment, and the failure of leading firms. *Strategic Management Journal, 17*(3), 197-218.
Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 128-152.
Dunne, T., Roberts, M. J., & Samuelson, L. (1988). Patterns of firm entry and exit in US manufacturing industries. *The Rand journal of economics*, 495-515.
Fagerberg, J., Mowery, D. C., & Nelson, R. R. (2006). *The Oxford handbook of innovation*: Oxford Handbooks Online.
Fan, C.-X., Chen, H., & Lu, W. (2002). China’s perspectives on 3G mobile communications and beyond: TD-SCDMA technology. *IEEE Wireless Commun, 9*, 48-59.
Fan, P. (2006). Catching up through developing innovation capability: evidence from China's telecom-equipment industry. *Technovation, 26*(3), 359-368.
Fan, S., Kanbur, R., & Zhang, X. (2008). Regional inequality in China: An overview. *China’s Regional Disparities: Experience and Policies*.
Gao, X. (2014). A latecomer's strategy to promote a technology standard: The case of Datang and TD-SCDMA. *Research Policy, 43*(3), 597-607.
Gereffi, G., Humphrey, J., & Kaplinsky, R. (2001). Introduction: Globalisation, value chains and development. *IDS bulletin, 32*(3), 1-8.
Giannini, V., Craninckx, J., & Baschirotto, A. (2008). *Baseband analog circuits for software defined radio*: Springer Science & Business Media.
GSMA Intelligence. (2016). Definitive data and analysis for the mobile industry. Retrieved from https://gsmaintelligence.com/
Huawei. (2015). Radio Communication Standards. Retrieved from http://m.huawei.com/enmobile/industry/standards-contributions/hw-u_167829.htm
Jin, J., & Von Zedtwitz, M. (2008). Technological capability development in China's mobile

phone industry. *Technovation, 28*(6), 327-334.
Kim, C. W., & Lee, K. (2003). Innovation, technological regimes and organizational selection in industry evolution: a 'history friendly model' of the DRAM industry. *Industrial and Corporate Change, 12*(6), 1195-1221. doi:10.1093/icc/12.6.1195
Kim, L. (1997). *Imitation to innovation: The dynamics of Korea's technological learning*: Harvard Business Press.
Klepper, S. (1997). Industry Life Cycles. *Industrial and Corporate Change, 6*(1), 145-182. doi:10.1093/icc/6.1.145
Klepper, S. (2002). The capabilities of new firms and the evolution of the US automobile industry. *Industrial and Corporate Change, 11*(4), 645-666.
Kumaraswamy, A., Mudambi, R., Saranga, H., & Tripathy, A. (2012). Catch-up strategies in the Indian auto components industry: Domestic firms' responses to market liberalization. *Journal of International Business Studies, 43*(4), 368-395.
Lawless, M. W., & Anderson, P. C. (1996). Generational technological change: Effects of innovation and local rivalry on performance. *Academy of Management Journal, 39*(5), 1185-1217.
Lee, K., & Lim, C. (2001). Technological regimes, catching-up and leapfrogging: findings from the Korean industries. *Research Policy, 30*(3), 459-483. doi:10.1016/s0048-7333(00)00088-3
Lee, K., & Malerba, F. (2014). *Changes in Industry Leadership and Catch-up by the Latecomers: Toward a theory of catch-up cycles.* Paper presented at the Future perspective on innovation and governance in development, UNU-MERIT/MGSoG Conference, 26e.
Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal, 13*(S1), 111-125.
Long, V., & Laestadius, S. (2015). An Indigenous Innovation: An Example from Mobile Communication Technology. *Oxford Development Studies*, 1-21.
Luo, Y., & Child, J. (2015). A composition-based view of firm growth. *Management and Organization Review, 11*(03), 379-411.
Malerba, F., Nelson, R., Orsenigo, L., & Winter, S. (1999). 'History-friendly'models of industry evolution: the computer industry. *Industrial and Corporate Change, 8*(1), 3-40.
Malerba, F., Nelson, R., Orsenigo, L., & Winter, S. (2008). Vertical integration and disintegration of computer firms: a history-friendly model of the coevolution of the computer and semiconductor industries. *Industrial and Corporate Change, 17*(2), 197-231.
Malerba, F., Nelson, R., Orsenigo, L., & Winter, S. (2016). *Innovation and the evolution of industries: History friendly models*: Cambridge: Cambridge University Press.
Mathews, J. (2002). Competitive Advantages of the Latecomer Firm: A Resource-Based Account of Industiral Catch-up Strategies. *Asia Pacific Journal of Management, 19*, 467-488.
Mowery, D. C. (1999). *Sources of industrial leadership: studies of seven industries*: Cambridge University Press.
Mu, Q., & Lee, K. (2005). Knowledge diffusion, market segmentation and technological catch-up: The case of the telecommunication industry in China. *Research Policy, 34*(6), 759-783. doi:10.1016/j.respol.2005.02.007
Mudambi, R. (2008). Location, control and innovation in knowledge-intensive industries. *Journal of Economic Geography, 8*(5), 699-725.

Nohrborg, M. (2016). LTE. Retrieved from http://www.3gpp.org/technologies/keywords-acronyms/98-lte

Park, K.-H., & Lee, K. (2006). Linking the technological regime to the technological catch-up: analyzing Korea and Taiwan using the US patent data. *Industrial and Corporate Change, 15*(4), 715-753. doi:10.1093/icc/dtl016

Perez, C., & Soete, L. (1988). Catching up in technology: entry barriers and windows of opportunity. *Technical change and economic theory*, 458-479. doi:10.2139/ssrn.224582

Qualcomm. (2014). *The Evolution of Mobile Technologies*. Retrieved from https://www.qualcomm.com/documents/evolution-mobile-technologies-1g-2g-3g-4g-lte

Rathore, A., Chaurasia, R., Mishra, R., & Kumar, H. (2012). Road Map and Challenges in 4G Wireless System. *J Elec Electron, 1*(2).

Suarez, F. F., & Utterback, J. M. (1995). Dominant designs and the survival of firms. *Strategic Management Journal, 16*(6), 415-430.

Telesystem Innovations. (2010). LTE in a Nutshell: The Physical Layer. *White paper.*

Tripsas, M., & Gavetti, G. (2000). Capabilities, cognition, and inertia: Evidence from digital imaging. *Strategic Management Journal, 21*(10-11), 1147-1161.

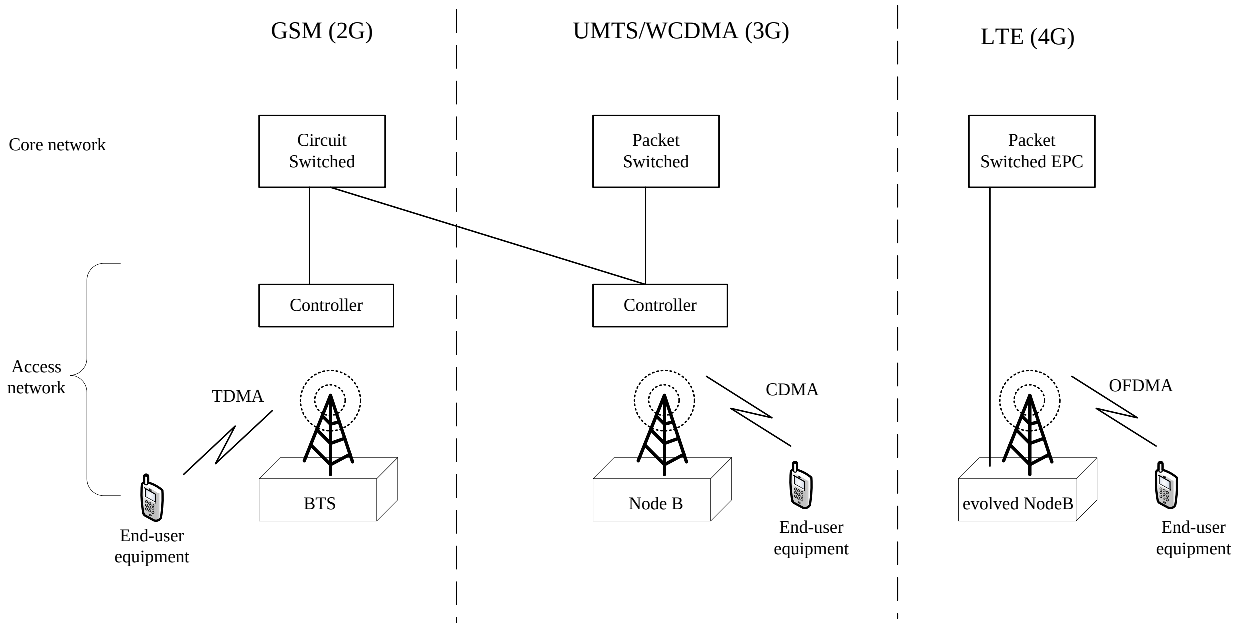
Tushman, M. L., & Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative Science Quarterly*, 439-465.

Yearbook of China Communications. (2003).

Yuan, Y., Zheng, W., Wang, Y., Xu, Z., Yang, Q., & Gao, Y. (2006). Xiaolingtong versus 3G in China: Which will be the winner? *Telecommunications Policy, 30*(5), 297-313.

Zaheer, S. (1995). Overcoming the liability of foreignness. *Academy of Management Journal, 38*(2), 341-363.

Figure 1. An illustration of different generations of mobile communication systems



Source: modified from Nohrborg (2016)'s figure published on the 3GPP official site. GPRS, an extension of GSM (the so-called 2.5 G), is dropped for the purpose of this study.

Figure 2. New products in the 3G era

3G Mobile Wi-Fi[12] 3G mobile broadband modem[13]

[12] A Mobile Wi-Fi is a device that converts 3G signals to Wi-Fi signals.

[13] A 3G mobile broadband modem is a device that provides computers with Internet access based on 3G signals.

Figure 3. Different generations of mobile phones

1G phone 2G phone 3G phone 4G phone

Figure 4. The model overview

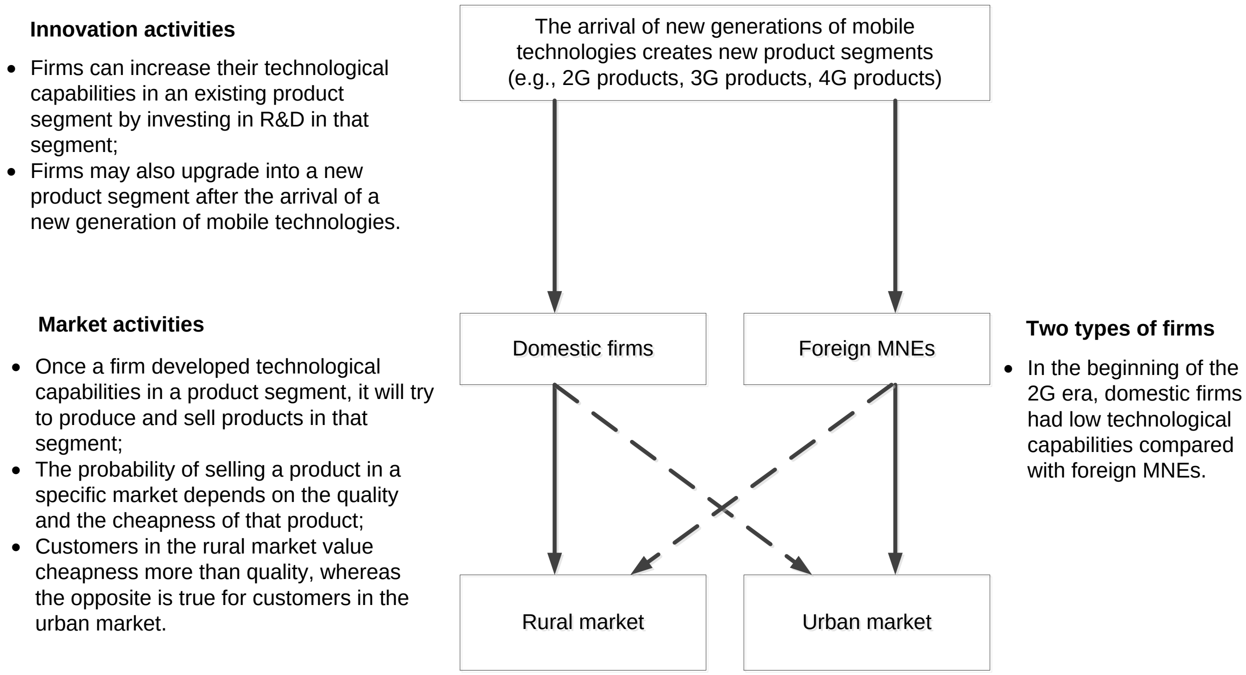


Figure 5a. History-friendly simulation: Domestic firms' market share in the urban market

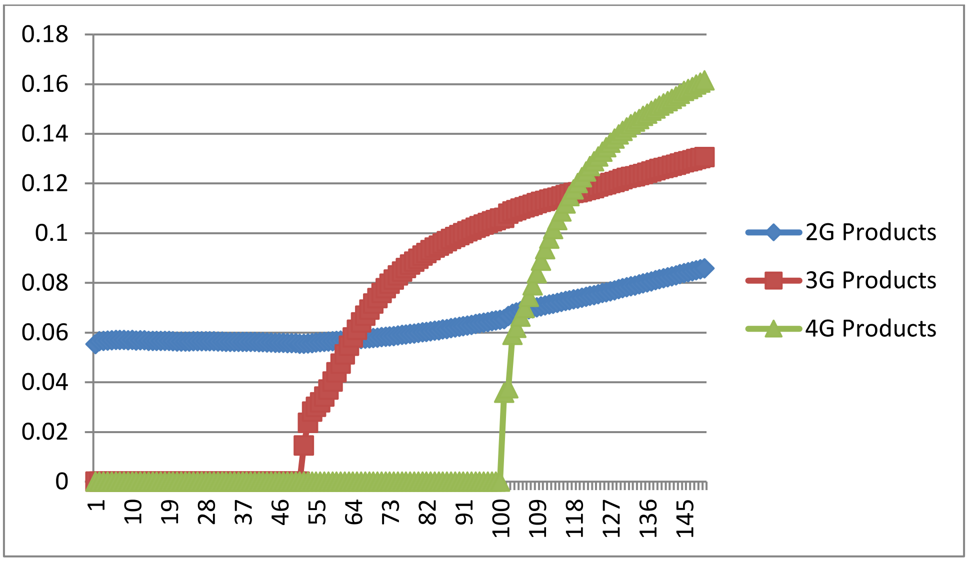


Figure 5b. History-friendly simulation: Average number of (initial) domestic firms alive

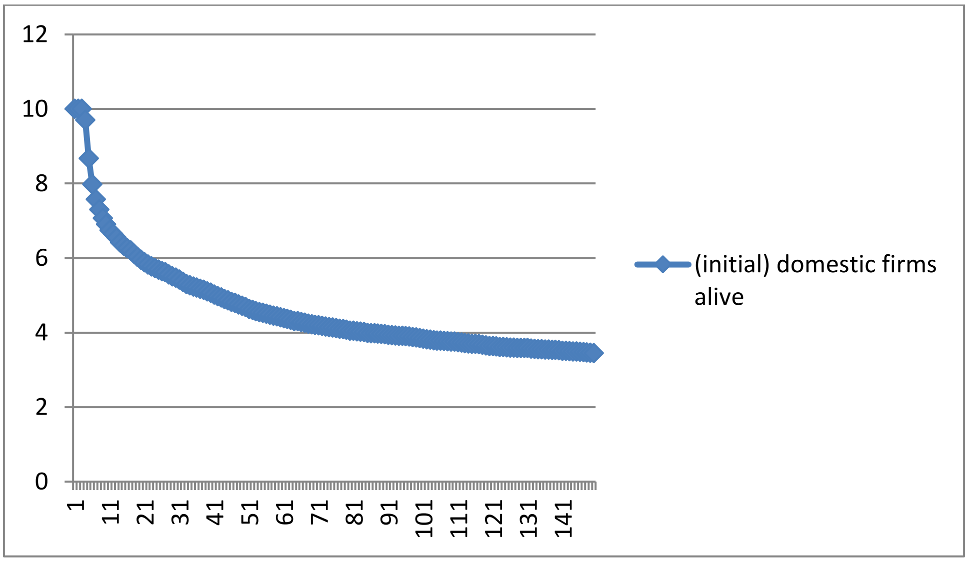


Figure 6a. History-divergent simulation (small rural market): Domestic firms' market share in the urban market

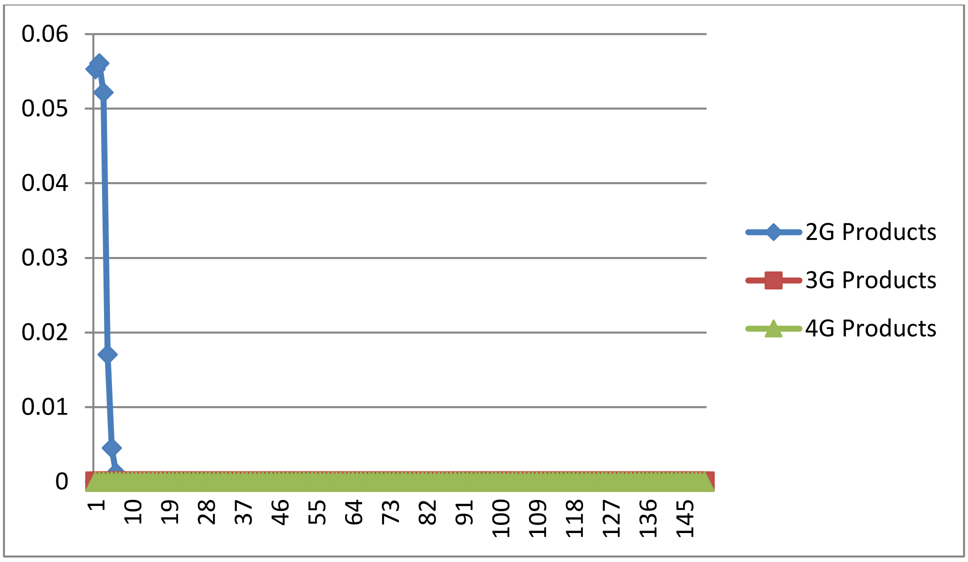


Figure 6b. History-divergent simulation (small rural market): Average number of (initial) domestic firms alive

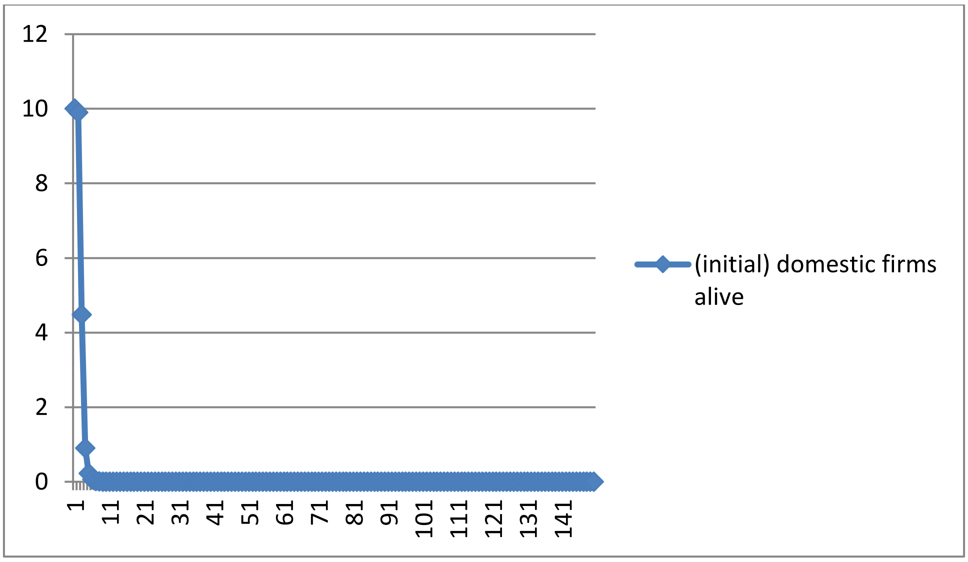


Figure 7a. History-divergent simulation (no technological relatedness): Domestic firms' market share in the urban market

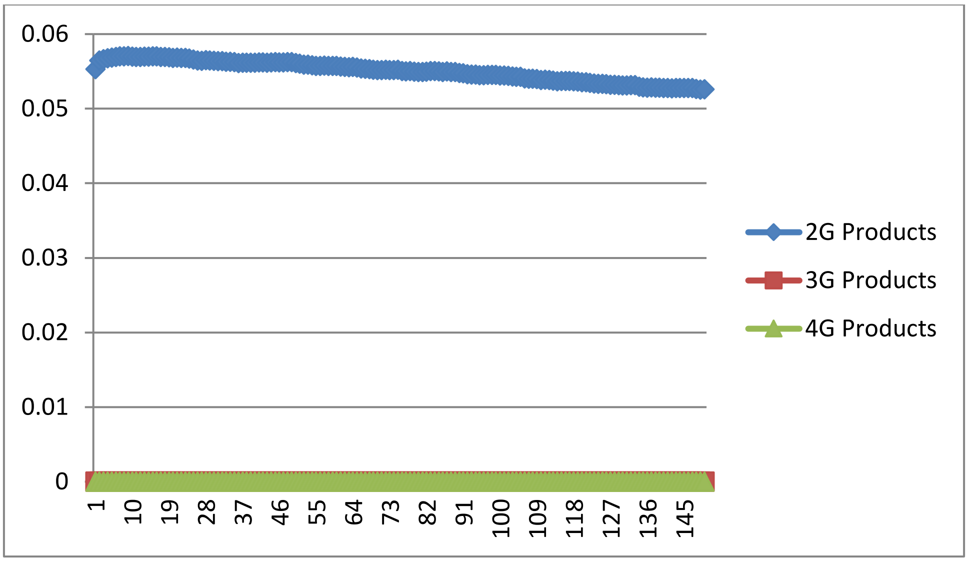


Figure 7b. History-divergent simulation (no technological relatedness): Average number of (initial) domestic firms alive

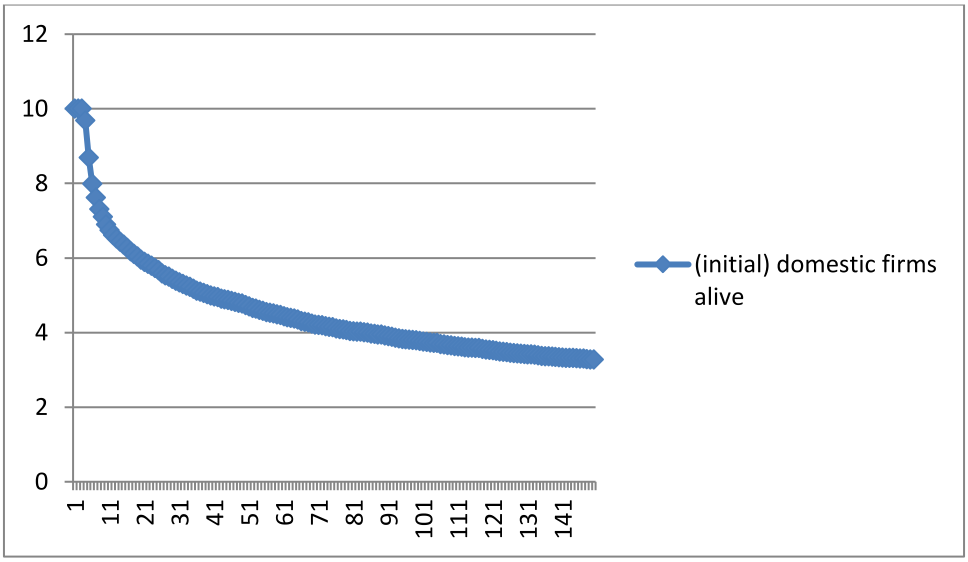


Figure 8a. History-divergent simulation (strong technological relatedness): Domestic firms' market share in the urban market:

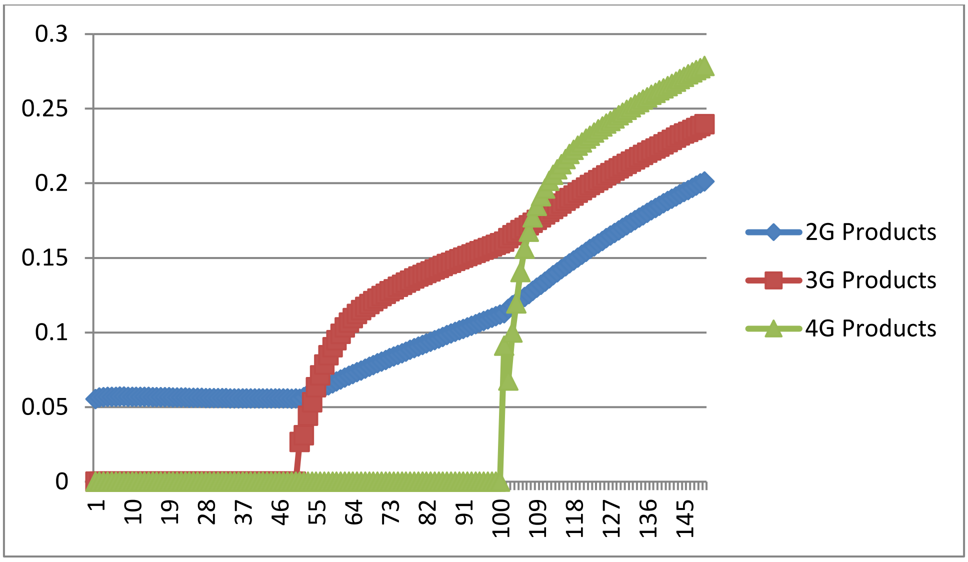


Figure 8b. History-divergent simulation (strong technological relatedness): Average number of (initial) domestic firms alive

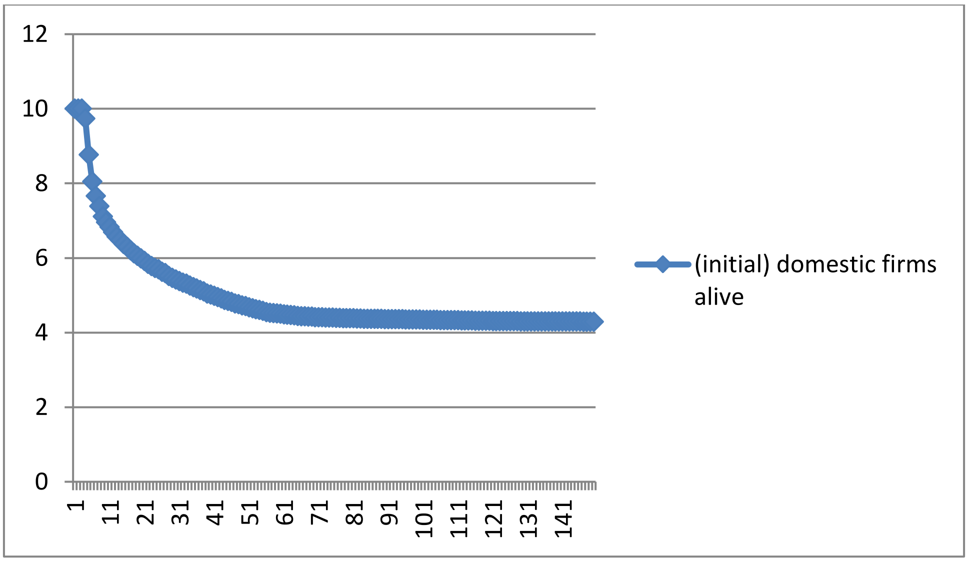


Table I. Comparison of different generations of mobile communications technologies

Generation	1G	2G	3G	4G
End-user equipment	Analog mobile cell phones	Feature phones	Smart phones, mobile broadband modem, tablets, etc.	Smart phones, mobile broadband modem, tablets, etc.
Wireless Access	FDMA	TDMA, CDMA	CDMA	OFDMA, MIMO
Core network	Circuit-based	Circuit-based	Circuit-based & Packet-based	Packet-based (fully IP-based)
Standards	AMPS, TACS, NMT	GSM, CdmaOne	WCDMA, CDMA2000, TD-SCDMA	LTE (including TDD and FDD modes)
Major Services	(analog) Voice	Voice	Voice	Voice over IP
	No data service	Limited Internet	Internet	High speed Internet

Sources: modified from Table 1 of Adachi (2001) with additional information from Qualcomm (2014) and Telesystem Innovations (2010)

APPENDIX 1: INDEX OF SYMBOLS

Symbol	Meaning	Value / Range
t	index for time	[1,150]
f	index for firm	$\mathbb{R}+$
g	index for generation-specific product segment	$\{2G, 3G, 4G\}$
m	index for market	$\{rural, urban\}$
$prob_{f,t,g,m}$	probability of selling	[0,1]
$MOD_{f,t,g,m}$	perceived merit of design	$\mathbb{R}$
$q_{f,t,g}$	quality of a firm's product at time *t* in product segment *g*	$[0, \delta_g]$
$Q_{g,m}$	minimum required quality in product segment *g* and market *m*	$\{1, 5,10,25,40\}$
$\gamma_m^{quality}$	weight assigned for quality by customers in market *m*	$\{0.2,0.8\}$
$r_{f,t,g}$	technological capability of a firm at time *t* in product segment *g*	[0,1]
δ_g	a parameter that translates a firm's technological capability into the quality of its products	$\{100,500,1000\}$
$p_{f,t,g}$	price of a firm's product at time *t* in product segment *g*	$\mathbb{R}+$
χ_g	a parameter that translates price into cheapness	$\{500,1000,1500\}$
$ch_{f,t,g}$	cheapness of a firm's product at time *t* in product segment *g*	$\mathbb{R}+$
$CH_{g,m}$	minimum required cheapness in product segment *g* and market *m*	$\{5,10,20,40\}$
$\gamma_m^{cheapness}$	weight assigned for cheapness by customers in market *m*	$\{0.2,0.8\}$
c_g	generation-specific baseline production cost	$\{10,15,20\}$
$c_{f,t,g}$	firm-specific production costs	$\mathbb{R}+$
$markup_{f,t,g}$	mark-up ratio of firm *f* at time *t* in product segment *g*	$[0, \frac{1}{\eta_m - 1}]$
$s_{f,t,g,m}$	market share of firm *f* at time *t* in product segment *g* and market *m*	[0,1]
$\pi_{f,t}$	total profit of a firm *f* at time *t*	$\mathbb{R}$
$E_{f,t}$	an evaluation score that determines whether a firm will exit the industry or not	$\mathbb{R}$
E_{exit}	a threshold evaluation score	200
ω	weight for current profits in evaluating firms' status of survival	0.75
$\zeta_{f,t,g}$	weight for the rural market when firms decide the markup ratio	[0,1]

$V_{f,t,g,m}$	the sales volume of a firm *f* at time *t* in product segment *g* and market *m*	$\mathbb{R}$
$customers_m$	the number of customers in market *m*	$customers_{urban}$ always = 20000; $customers_{rural}$ = 30000 (history-friendly setting), $customers_{rural}$ = 10000 (history-divergent setting)
$B_{f,t,g}$	R&D budget of a firm *f* at time *t* in product segment *g*	$\mathbb{R}$
$B_{f,t}$	total R&D budget of a firm *f* at time *t*	$\mathbb{R}$
$C_{R\&D}$	cost of doing R&D	100
θ	weight assigned for a firm's technological capability in a previous product segment (technological relatedness parameter)	0.05 (history-friendly setting); 0 or 1 (history-divergent settings)
ρ_f	a firm specific parameter that determines the proportion of profits being allocated as total R&D budget	1
σ_f	a firm specific parameter that determines a firm's risk aversion towards the latest generation of technologies	[0,1]
η_m	elasticity of demand in market *m*	{1.25,1.5}
α	a constant in equation (1)	1000
λ	structural parameter	0.08

APPENDIX 2: A LIST OF ABBREVIATIONS

1G	First generation (mobile communications)
2G	Second generation (mobile communications)
3G	Third generation (mobile communications)
4G	Fourth generation (mobile communications)
FDMA	Frequency Division Multiple Access
TDMA	Time Division Multiple Access
CDMA	Code Division Multiple Access
OFDMA	Orthogonal Frequency Division Multiple Access
GPRS	General Packet Radio Service
EDGE	Enhanced Data rates for GSM Evolution
TACS	Total Access Communication System
TD-SCDMA	Time Division - Synchronous Code Division Multiple Access
SMS	Short Message Service
GSM	Global System for Mobile Communications
TDD	Time Division Duplex
FDD	Frequency Division Duplex
WCDMA	Wideband Code Division Multiple Access
AMPS	Advanced Mobile Phone System
NMT	Nordic Mobile Telephony
MIMO	Multiple Input Multiple Output
BTS	Base Transceiver Station
EPC	Evolved Packet Core
LTE	Long Term Evolution
UMTS	Universal Mobile Telecommunications System
HSPA+	Evolved High-Speed Packet Access
Mbps	Megabits per Second

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ESSAY 3. IS A PROTECTIVE FDI POLICY GOOD (OR BAD) FOR DOMESTIC FIRMS' PRODUCTIVITY CATCH-UP? A COMPARISON OF FIRMS UNDER DIFFERENT FDI POLICIES[1]

ABSTRACT

The role of FDI policies on latecomer's catch-up is controversial. On the one hand, policy makers often consider FDI policies (e.g., forced IJV arrangements) as a tool for promoting knowledge transfer. On the other hand, such policies may also impede competition between domestic and foreign firms, leading to an inefficient industry. China adopted different FDI policies in two industries in the post-WTO era. In the automobile industry, the country implemented a protective FDI policy, which specifies that foreign multinationals can only enter the industry through forming joint ventures with local partners. In the telecom-equipment industry, the country implemented a non-protective FDI policy, which allows foreign multinationals to enter the industry through establishing foreign-owned enterprises. After analyzing data from the Annual Industrial Survey between 1998 and 2007, we find that although there is no evidence of knowledge transfer under a protective FDI policy, there is in fact increasing competition under such a policy.

Keywords:

government policy, FDI, knowledge transfer, competition, productivity

[1] This essay comes as an outcome of my visit to China Institute for Science and Technology Policy at Tsinghua University, where I was working under Prof. Zheng LIANG's guidance.

INTRODUCTION

There is a huge debate on the relationship between policy protection and latecomers' catch-up. The debate dates back to the age of Adam Smith, Friedrich List and Alexander Hamilton. Although Smith's emphasis on the importance of free trade for economic development implies that governments should reduce their interventions in economic activities, Hamilton (Secretary of the US Treasury) and List (German economist) argue that government interventions (e.g., "infant industry protection") are actually needed for promoting US and Germany's catching-up with respect to the British Empire at that time (Fagerberg, Mowery, & Nelson, 2006; Lundvall, 2008). H.-J. Chang (2002) further argues that many of today's developed countries have adopted certain types of policy protections on their domestic firms in the history of their development. What these leading countries are promoting today (e.g., the so-called "Washington Consensus") is nothing but "kicking away the ladders they once used" (H.-J. Chang, 2002).

Although there are different policies being adopted by different governments to promote the development of domestic firms, the policy that we study in this paper is China's FDI policies in the post-WTO era. Foreign Direct Investments (FDI), as a means through which multinational enterprises (MNEs) expand their presence into other countries, have long been studied in terms of their impacts on the host economies (Blomström & Kokko, 1998; Caves, 1971, 1974). Generally speaking, there are two types of impacts that FDI might have on host economies. First, MNEs often possess firm-specific advantages (e.g., superior technologies) that would enable them to overcome the "liabilities of foreignness" in host countries (Zaheer, 1995). This means that FDI might bring domestic firms previous unknown knowledge/technologies through the "knowledge spillover effect" (Blomström & Kokko, 1998). Second, FDI might also reshape the competition landscape in the host economies through the “competition effect” (Caves, 1974).

Many emerging-economy governments established FDI policies that are intended to harness foreign knowledge, but at the same time, to protect domestic firms from being crowded out by foreign competitors. Historically, China adopted protective FDI policies in many of its industries (e.g., require MNEs to form IJVs with local firms). However, as the country prepared itself for joining the WTO, China relaxed its restrictions on FDI in some industries, although it kept the same policy restrictions in other so-called “strategic industries”, such as the steel industry and the automobile industry (Chang, Chung, & Moon, 2013).

Despite similar requirements on IJV formation have also been adopted by other emerging economies, the policy implications of such practices are far from clear. First, although policy makers often expect to promote knowledge transfer through making such forced IJV arrangements, such IJV arrangements might actually discourage foreign firms from bringing advanced knowledge to the IJV establishments (Kokko & Blomström, 1995). Second, although such IJV arrangements might provide domestic firms with necessary “infant industry protection” (Hamilton, 1791), the same IJV arrangements might also eliminate competition between domestic firms and foreign firms, thereby reducing domestic firms’ incentives for conducting innovation (Lenway, Morck, & Yeung, 1996).

In this paper, we examine the two potential consequences of China’s FDI policies: (1) we investigate whether a protective FDI policy can promote knowledge transfer through the deliberate IJV arrangements; (2) we investigate whether a protective FDI policy will lead to an inefficient industry because of reduced competition. We examine the two questions by making a comparison of two industries (Automobile and Telecom-equipment) that are under different policy regimes in the post-WTO era. Telecom-equipment and automobiles industries represent an interesting setting to examine the impacts of FDI policies on latecomers' (productivity) catching-up. First, the two sectors have witnessed different FDI policies in China's post-WTO era. Second, these two sectors have often been compared in the context of latecomers' catching-up (Lee & Lim, 2001; Malerba & Nelson, 2011). Third, Chinese firms have been catching-up in both sectors (although with varying degrees of success).

After comparing the labor productivity of automobile firms and telecom firms, we find that unlike what the policy makers expected, requiring foreign MNEs to form international joint ventures (IJVs) with domestic firms does not necessarily make them transfer foreign knowledge to domestic firms. For example, in the automobile industry, we find no evidence that IJVs are more productive than non-IJV enterprises. Instead, in the telecom sector (a sector where forming IJVs is not required), IJVs tend to be more productive than non-IJV enterprises. This means that the IJV could still be a conduit for knowledge transfer when it is formed as a result of firm choices instead of policy interventions. On the other hand, we also find no evidence that a protective FDI policy leads to an inefficient industry. In fact, the productivity growth in the automobile sector is faster than the productivity growth in the telecom sector following China's accession to the WTO. The competition pressure (as captured by the decreasing Herfindahl index) in the automobile industry also systematically increased after China's accession to the WTO. This decreasing Herfindahl index in the automobile industry is not driven by a large number of entrants. Instead, it is driven by the entry of a few MNEs that formed different Sino-foreign coalitions with local partners, which subsequently reshaped the competition landscape in the industry.

This paper contributes to the debate on the role of government policies in the process of latecomers' catching-up. The results suggest that although a protective FDI policy may not achieve the intended effect of promoting knowledge transfer, it also may not induce an inefficient industry.

THEORY

Policies, as one type of “social technologies”, have been increasingly argued as a driving force for economic growth (Aghion, David, & Foray, 2009; Mazzoleni & Nelson, 2005). One type of policies, which might be critical for latecomers’ catching-up, is government protection against foreign competition (Hamilton, 1791; List, 1841). However, implications of government protection for latecomers’ catching-up are highly debatable. On the one hand, government protection might increase domestic firms’ chances to survive their infant ages, making future catching-up possible (Hamilton, 1791). On the other hand, government protection might distort the market selection, inducing inefficient domestic industries (Mazzoleni & Nelson, 2005). Nevertheless, understanding the impacts of government protection on domestic firms remains an important issue for both scholars and policy makers.

This paper is focused on one type of policies that is critical for emerging market economies, the FDI policy that regulates FDI into one country. Generally speaking, FDI have two types of effects on host-country firms. First, FDI might bring domestic firms foreign knowledge through the “knowledge spillover effect” (Blomström & Kokko, 1998). Second, FDI might reshape the competition landscape in the host country through the “competition effect” (Caves, 1974). As China’s accession to the WTO integrated the country into the global economy, the inward FDI to China have significantly increased in the post-WTO era. Foreign firms increase their FDI in China, not only for serving the Chinese market, but also for capitalizing on the country’s low-cost labor to serve the global market.

Insert Figure 1 about here

A protective FDI policy that requires foreign firms to form IJVs with domestic partners has often been observed in major emerging economies such as China and India (Mohr & Puck, 2007). In China, before the country's accession to the WTO, FDI were largely restricted to the formation of IJVs. However, such restrictions on FDI were relaxed in some industries as the country prepared itself for joining the WTO (Chang et al., 2013). The telecom industry is an industry under a non-protective FDI policy in the post-WTO era, where foreign firms are allowed to operate in China through wholly-owned subsidiaries. Instead, the automobile industry is an industry under a protective FDI policy in the post-WTO era, where FDI are still restricted to forming joint ventures with local partners. For example, according to the Article 48 of the official document, "Policy on Development of Automotive Industry", foreign entrants are required to form IJVs with local partners, in which foreign firms' equity shares should not exceed 50%, and each foreign firm can establish no more than two IJVs for each product category. As a result, the number of IJVs in the automobile sector increased rapidly in the post-WTO era, whereas the number of foreign owned enterprises (FOEs) in the telecom sector increased rapidly in the post-WTO era.

Insert Figure 2 about here

A protective FDI policy may have repercussions on both the knowledge spillover effect and the competition effect of FDI. In terms of the knowledge spillover effect, although policy makers often expect such IJV arrangements would reveal foreign firms' advanced technologies to domestic firms, such a policy might also discourage foreign firms from bringing advanced technologies to the IJV establishments. In terms of the competition effect, although such IJV arrangements might reduce direct competition between domestic firms and foreign firms, they might also introduce another type of competition that is the competition among different Sino-foreign coalitions. This paper analyzes how China's FDI policy impacts domestic firm productivity by focusing on the two effects of FDI respectively. First, we discuss whether a protective FDI policy can promote knowledge transfer through the IJV arrangements. Second, we discuss whether a protective FDI policy will lead to an inefficient industry because of reduced competition. The relationships between FDI policies and their impacts on knowledge transfer and competition will be further discussed below.

FDI policies and knowledge transfer

FDI have long been known as a conduit through which MNEs might bring advanced foreign knowledge to local firms (Caves, 1971, 1974). One main reason that many emerging-economy governments require foreign firms to form IJVs with domestic firms is that policy makers expect that such policy arrangements would reveal foreign MNEs' knowledge to domestic firms, thereby facilitating knowledge transfer (Beamish, 1987; Kokko & Blomström, 1995). Foreign multinationals often possess firm-specific advantages (e.g., superior technologies) that allow them to overcome their liability of foreignness in a host country (Blomström & Kokko, 1998). And, the IJV partnership might provide domestic firms with an opportunity to access superior foreign technologies from their foreign partners (Blomström & Sjöholm, 1999). Beyond that, the IJV arrangements may create additional value because of the resource complementarity between foreign firms and domestic partners. By combining the technology-related resources from foreign partners and local knowledge-related resources from domestic firms, IJVs may create more value than what can be achieved by domestic firms or foreign firms alone (Beamish & Banks, 1987; Choi & Beamish, 2013).

Despite the prevalence of the IJVs in developing countries, the drawbacks of such policy arrangements also deserve attentions. First, under such "forced" IJV arrangements, foreign firms may anticipate the risks of potential opportunistic behaviors (e.g., leakage of proprietary knowledge) from their local partners (Williamson, 1981). As a result, they may adopt "old" and “less advanced” technologies in the IJV establishments, instead of bringing “new” and “more advanced” technologies (Kokko & Blomström, 1995). Second, the capability development in the automobile industry is an evolutionary process characterized by “trials and errors” (Fujimoto, 1999). In this sense, the forced IJV arrangements may also disrupt the capability-building process of domestic firms, because domestic firms might substitute indigenous innovation with imported (outdated) technologies (Lu & Feng, 2005). In fact, prior case studies (Buckley, Clegg, & Tan, 2004; Lu & Feng, 2005) suggest that under the “forced” IJV arrangements, foreign firms are unwilling to engage in knowledge transfer, and domestic firms are unlikely to develop their own capabilities.

Given the pros and cons of the IJV arrangements, we compare the productivity of IJVs and the productivity of non-IJV enterprises within each of the two industries, for better understanding whether a protective FDI policy can promote knowledge transfer through the IJV arrangements or not. If such IJV arrangements can really facilitate knowledge transfer, we may expect that IJVs tend to be more productive than non-IJV enterprises in the automobile industry.

FDI policies and competition

Another question that is critical for evaluating China’s FDI policies is whether a protective FDI policy would lead to an inefficient industry or not.

On the one hand, foreign FDI in developing countries might bring competition into an industry, removing the “monopolistic distortion” in the industry (Caves, 1974). Such competition would force domestic firms to improve their productivity either by making better use of their existing resources or by searching for new technologies, so that they can cope with the increasing level of competition introduced by FDI (Blomström & Sjöholm, 1999). A policy that restricts the mode of foreign entry to be IJVs (or simply called as “a protective FDI policy") might lead to an inefficient industry, because it eliminates the potential competition between domestic firms and foreign firms, thereby reducing domestic firms' incentives to innovate (Lenway et al., 1996). In other words, although from a latecomer's perspective, a protective FDI policy might be beneficial because it shelters domestic firms from foreign competition, such "sheltering behavior" is not cost-free at the industry level (Boddewyn & Brewer, 1994).

On the other hand, the government might consider the FDI policy as a tool for reshaping the competition landscape in an industry. For example, the government may expect to reduce monopoly power and introduce (more balanced) competition in an industry by arranging a "marriage" between a weak domestic firm and a strong foreign firm. Such pro-competition objective can be found in the "Policy on Development of Automotive Industry", a guiding document for FDI approval in the automobile industry. In Article 13 of this document, it is written, "the state encourages the development of groups of automobile enterprises to form a new competition landscape"[2]. If this is the case, it means that the reduced competition between domestic firms and foreign firms will be replaced by another type of competition, the competition among different Sino-foreign coalitions.

To understand whether a protective FDI policy will lead to an inefficient industry or not, we compare how the productivity and the competition pressure change in the two industries following the country's accession to the WTO.

DATA

We collected data for this study from the Annual Industrial Survey (Chang et al., 2013) database. The Annual Industrial Survey (1998-2007) is conducted by the National Bureau of Statistics, which covers all industrial enterprises above the designated size (sales > 5 million

[2] translated from the original Chinese version

RMB). The database has been confirmed to be statically valid by Chow (1993), and it has been widely used in China-related studies (Brandt, Van Biesebroeck, & Zhang, 2012; Chang et al., 2013; Yu, Dosi, Lei, & Nuvolari, 2015).[3] We obtained the data from a Chinese data company called "RESSET".

Here, the automobile industry is defined by the Chinese industry classification code "3721". This code represents "integrated automobiles", which is a sector under the protective FDI policy.[4] The telecom equipment industry is defined by the following codes: "4011 (Transmitting Equipment)", "4012 (Switching equipment)", "4013 (End-user equipment)", and "4014 (Mobile communications and end-user equipment)". Since China's industry classification codes have been revised in 2003, adjustments have been made according to the concordance provided by Brandt et al. (2012). Firms' ownership types are defined by their registration codes by following Yu et al. (2015). Foreign Owned Enterprises (FOEs)[5] include firms with registration codes "230 (Hong Kong, Macao, Taiwan- wholly owned enterprises)" and "330 (foreign wholly-owned enterprises)". And finally, International Joint Ventures (IJVs)[6] include firms with registration codes "210 (Hong Kong, Macao, Taiwan- invested joint ventures)", "220 (Hong Kong, Macao, Taiwan- invested cooperatives)", "240 (Hong Kong, Macao, Taiwan- invested shareholding companies)", "310 (foreign invested joint ventures)", "320 (foreign invested cooperatives)", and "340 (foreign invested shareholding companies)". We consider the period of "1998-2001" as the pre-WTO period, and the period of "2002-2007" as the post-WTO period.

[3] Data of year 2004 have missing values for several key variables (e.g., value-added, sales revenue). Following Yu et al (2015), we do not use the 2004 data in the analyses below.

[4] Instead, the "automobile components" sector is not subject to the protective FDI policy.

[5] Here, we also include Hong Kong, Macao, or Taiwan owned enterprises in this category for the purpose of this study.

[6] Here, we also include joint ventures with partners from Hong Kong, Macao, and Taiwan in this category for the purpose of this study.

Table I shows the summary statistics of enterprises in each industry by ownership types. Table I (a) and Table I (b) show the summary statistics of enterprises in the automobile industry, whereas Table I (c) to Table I (e) show the summary statistics of enterprises in the telecom industry. “N” in Table I represents the number of available firm-year observations for each variable. In the automobile industry, the number of observations for domestic firms is approximately four times the number of observations for IJVs. In the telecom industry, the number of observations for FOEs is slightly smaller than the number of observations for IJVs. And, the number of observations for domestic firms is approximately three times the number of observations for FOEs or IJVs.

Insert Table I about here

From Table I (a) and Table I (b), we can see that in the automobile industry, IJVs seem to be more productive than domestic firms. Compared with domestic firms, IJVs also tend to be more capital intensive, less financially constrained, larger in size, and higher in wages paid. Table I (c) and Table I (d) suggest that in the telecom industry, IJVs also tend to be more productive than domestic firms. Interestingly, although MNEs are allowed to operate as FOEs in the telecom industry, FOEs are not much more productive than domestic firms in terms of value-added based productivity (as shown in Table I (c) and Table I (e)). Additionally, FOEs tend to be less productive than IJVs in the telecom industry (as shown in Table I (d) and Table I (e)).

CAN A PROTECTIVE FDI POLICY PROMOTE KNOWLEDGE TRANSFER THROUGH IJVS?

To understand whether a protective FDI policy can promote knowledge transfer through the IJV arrangements, we estimate the effect of “being an IJV” on labor productivity. If a protective FDI policy can promote knowledge transfer, we expect to see that IJVs in the automobile industry should be more productive than other non-IJV enterprises. First, we run the following regression in the full sample. The dependent variable ($Productivity_{it}$) is the labor productivity of an enterprise, measured as the logarithm of value-added per employee (Bertrand & Capron, 2014). The independent variable (IJV_{it}) is a dummy variable that indicates whether the ownership type of a firm-year observation is an IJV or not. We also control for a set of variables that might affect firm productivity, including capital intensity, debt intensity, average wage, number of employees, SOE, and year dummies (for a full description of variables, see the Appendix 1).

$$Productivity_{it} = \beta_0 + \beta_1 * IJV_{it} + \beta_2 * X_{it} + \rho_t + \mu_{it}$$

Then, we conduct split-sample analyses (Golovko & Valentini, 2014; Salomon & Jin, 2008) by running the above regression in the automobile industry and in the telecom industry separately. What we find is that, under a protective FDI policy (automobile industry), being an IJV is not significantly correlated with a higher level of productivity compared with non-IJV enterprises. We interpret the results as a lack of knowledge transfer from foreign firms to the IJV establishments in the automobile industry. Interestingly, we find that under a non-protective FDI policy (telecom industry), IJVs tend to be more productive than other non-IJV enterprises (column 3 of Table II). For example, in the telecom industry, other things being equal, labor productivity will be approximately 20% (calculated as ($e^{0.183}$-1)) higher for the IJVs than for the non-IJV enterprises. And, the association is significant at 5% level. Here, the non-IJV enterprises include both domestic firms and FOEs.

In column (4) of Table II, we excluded FOEs from the comparison group (the non-IJV enterprises) to make direct comparison between IJVs and domestic firms. The association between the variable "*IJV*" and the dependent variable "*Productivity*" actually became insignificant after the removal of FOEs. This result is surprising at the first glance, because FOEs are supposed to be productive firms with firm-specific advantages. Therefore, removing them from the comparison group should only make the positive association between "*IJV*" and "*Productivity*" stronger. However, this seems not to be the case in the telecom industry. From the summary statistics (Table I (c) and Table I (e)), we already see that FOEs are not much more productive than domestic firms in terms of (value-added based) productivity. And generally speaking, FOEs tend to be less productive than IJVs. Because FOEs constitute a large proportion of the enterprises that are less productive than IJVs, removing these FOEs from the comparison group actually makes the association insignificant. This explanation is consistent with prior studies (e.g., (Fan, 2006)) that suggest foreign subsidiaries in China are mainly responsible for low-value-added activities, such as sales and local customizations. Most of the high-value-added activities (e.g., R&D) by MNEs are still concentrated in advanced economies (Blomström & Kokko, 1996).

Insert Table II about here

Although labor productivity is mostly measured as the logarithm of value-added per employee (Arnold & Javorcik, 2009; Bertrand & Capron, 2014), prior studies have also used the logarithm of sales per employee as a proxy for labor productivity (Datta, Guthrie, & Wright, 2005). The difference between the two measures is that sales-based productivity does not reflect costs for production, whereas the value-added based productivity takes into account the costs of intermediate materials. We also used sales-based productivity as the dependent variable to test the robustness of the results above.

Table III shows the results when we use the sales-based productivity measure (*Productivity2*) as the dependent variable, which are similar to the results from using value-added based productivity. The only difference is that, here even if we exclude FOEs from the comparison group, IJVs are still significantly more productive than non-IJV enterprises. This is because FOEs are relatively productive in terms of sales-based productivity. Therefore, removing FOEs from the comparison group would not largely attenuate the positive association between the variable *IJV* and the dependent variable sales-based labor productivity (*Productivity2*).

Insert Table III about here

To sum up, the empirical results here are consistent with the results found in prior case studies (Buckley et al., 2004; Lu & Feng, 2005). Generally speaking, there is no significant association between “being an IJV” and higher labor productivity in the automobile industry. This implies that foreign firms might be reluctant to transfer knowledge to the IJV establishments under an “arranged marriage”. On the contrary, IJVs tend to be more productive than non-IJV enterprises in the telecom industry, where there are no formal requirements on the formation of IJVs.

WILL A PROTECTIVE FDI POLICY LEAD TO AN INEFFICIENT INDUSTRY?

To understand whether a protective FDI policy will lead to an inefficient industry, we first compared the mean productivity of the two industries at the industry-level for the period of 1998 to 2007. Figure 3 gives us an intuition about how the industry-level labor productivity of the two industries changes relatively in the post-WTO era. As we can see, before China’s accession to the WTO, the mean productivity of automobile firms is systematically lower than the mean productivity of telecom firms. However, after China’s accession to the WTO, the mean productivity of automobile firms increased faster than the mean productivity of telecom firms. This casts doubts on the traditional wisdom that a protective FDI policy would lead to an inefficient industry because of limited competition. In fact, firms under a protective FDI policy (automobile industry), achieved a faster productivity growth in the post-WTO era as compared with firms under a non-protective FDI policy (telecom industry).

Insert Figure 3 about here

Then, we conducted a "difference-in-differences" type of regressions, which is a common tool for evaluating the impact of policy changes (Angrist & Pischke, 2008). The "difference-in-differences" regressions allow us to control for additional variables that might affect firm productivity, including capital intensity, debt intensity, average wage, number of employees, and SOE. We estimated the equation below:

$$Productivity_{ijt} = \beta_0 + \beta_1 * PostWTO_t + \beta_2 * Automobile_j + \beta_3 * (PostWTO_t * Automobile_j) + \beta_4 * X_{ijt} + \mu_{ijt}$$

Here, the dependent variable, $Productivity_{ijt}$, is (value-added based) productivity of enterprise i from industry j in year t. Unlike the previous section in which the comparison is made within each industry (e.g., compare the IJVs and non-IJV enterprises within the automobile industry), this section is focused on the comparison across different industries. Therefore, we included the industry subscript j into the notation to highlight this difference. The variable $PostWTO_t$ indicates whether an observation belongs to the Post-WTO era. Before China's accession to the WTO, the institutional barrier for MNEs to make FDI in China was relatively high. And, the entry mode of FDI was largely restricted to the IJVs. However, as the country joined the WTO, China relaxed its restrictions on FDI in most industries (e.g., telecom-equipment industry), although the restrictions remain unchanged in some strategic industries (e.g., automobile industry) (Chang et al., 2013). Therefore, the variable $PostWTO_t$ can be considered as a proxy for the policy change. The variable

$Automobile_j$ indicates whether an observation belongs to the automobile industry or not. And, the interaction term $PostWTO_t * Automobile_j$ is essentially a difference-in-differences estimator that indicates whether the productivity-enhancing effect of joining the WTO will be stronger for the automobile firms than for the telecom firms. One assumption underlying the difference-in-differences estimation is the common trend assumption, which assumes that without the treatment (e.g., accession to the WTO), the trend of productivity changes will be the same in the two industries. We acknowledge that this might be a strong assumption, and therefore, we do not claim causal identification in this study. Nevertheless, it would be interesting to see whether the regression results would be consistent with the general pattern that we have observed in Figure 3.

The regression results are shown in Table IV, which confirmed the general pattern in Figure 3. The coefficient of the variable "PostWTO" is positive and significant. This suggests that, other things being equal, the labor productivity of firms will be higher in the post-WTO era. The coefficient of the variable "Automobile" is negative and significant, which suggests that other things being equal, the productivity of automobile firms will be lower than the productivity of telecom firms. However, the coefficient of the interaction term $Post\mathrm{WTO} * Automobile$ is positive and significant, which suggests that the positive effect of joining the WTO will be stronger for automobile firms than for telecom firms. This implies that firms under a protective FDI policy (automobile firms) tend to obtain a greater productivity gain in the post-WTO era, compared with firms under a non-protective FDI policy (telecom firms).

As a robustness check, we also run the same regression in the sample that excludes FOEs (column 2 of Table IV) and the sample that excludes both FOEs and IJVs (column 3 of Table IV). The results remain qualitatively the same. We conduct such a robustness check because if the relatively faster productivity growth in the automobile industry is explained by the increasing competition pressure in an industry, then it should apply to all firms in the industry including domestic firms without foreign ownership.

Insert Table IV about here

To better understand how the competition pressure in the two industries changes in the post-WTO era, we checked the Herfindahl index of the two industries in the post-WTO era. Prior literature (Blomström, 1986) suggests that there is no accepted theory on how to measure competition, and the concentration ratio measured as the Herfindahl index is the best single indicator to capture the competition pressure in an industry. The Herfindahl index is calculated as the sum of the squared market share of all firms in an industry. Here, the market share is defined as a firm's sales revenue divided by the total sales revenue of all firms in the same year and the same industry. Generally speaking, a decreasing Herfindahl index implies decreasing concentration in an industry and increasing competition in that industry (Carbó, Humphrey, Maudos, & Molyneux, 2009; Petersen & Rajan, 1995).

Results in Figure 4 suggest that the competition pressure in the automobile industry increased systematically in the post-WTO era. Unlike the traditional wisdom that suggests a protective FDI policy would reduce competition in an industry, the Chinese automobile industry under a protective FDI policy in fact witnessed intensifying competition in the post-WTO era. Although the protective FDI policy might eliminate competition between foreign multinationals and domestic firms, it might also intensify the competition among different Sino-foreign coalitions. The increasing competition might be an explanation for the relatively rapid productivity growth in the automobile industry after China's accession to the WTO.

Insert Figure 4 about here

To further understand how the competition landscape evolves in the two industries, we plotted the market shares of the top 8 enterprises in each industry by year. The results of the two industries are shown in Figure 5 and Figure 6 respectively.

Insert Figure 5 & Figure 6 about here

What we can see from Figure 5 is that, the market shares of the top 8 automobile enterprises are becoming more and more equally distributed. However, this is not the case in the telecom industry (as shown in Figure 6), where the market shares of the top two enterprises remain much higher than the market shares of the rest six enterprises. One potential explanation for such results is that, under a protective FDI policy, the government can stimulate competition in an industry by making deliberate IJV arrangements. For example, the government can introduce (more balanced) competition (and thereby, reduce monopoly power) by arranging a "marriage" between a relatively weak domestic firm (e.g., Guangzhou Automobile Group Co., Ltd.) and a relatively strong foreign firm (e.g., Toyota). The pro-competition intention is reflected in the government document, "Policy on Development of Automotive Industry", which is a guiding document for FDI approval in the automobile industry. In this sense, although the protective FDI policy adopted in China's automobile industry might reduce competition between domestic firms and foreign firms, it might also introduce another type of competition that is the competition among different Sino-foreign coalitions.

To sum up, the results indicate that there is no evidence of an inefficient industry under a protective FDI policy. In fact, the competition in the automobile industry, an industry under the protective FDI policy, is becoming more and more intense in the post-WTO era.

CONCLUSIONS

This study investigates the impacts of China's FDI policies on the productivity of domestic firms. The results show that in an industry under a protective FDI policy (automobile industry), the labor productivity is not significantly higher for IJVs than for non-IJV enterprises. Instead, in an industry under a non-protective FDI policy (telecom industry), the labor productivity tends to be significantly higher for IJVs than for non-IJV enterprises. This implies that the protective FDI policy that forces MNEs to form IJVs with local partners may not achieve the intended effect of promoting knowledge transfer. Nevertheless, the IJVs may still be a conduit for knowledge transfer when they are formed as a result of firm choices instead of policy interventions.

Although a protective FDI policy may not have the intended impact of promoting knowledge transfer, it also may not lead to an inefficient industry. This is because the eliminated competition between domestic firms and foreign firms is replaced by another type of competition, the competition among different Sino-foreign coalitions.

LIMITATIONS AND FUTURE RESEARCH

This paper has two major limitations. First, we do not have a direct measure of knowledge transfer. We make the assumption that knowledge transfer can be reflected on firm labor productivity, which is an assumption that has often been made in the literature on knowledge spillovers (e.g., (Blalock & Gertler, 2009)). However, we acknowledge that there are other unobserved factors which might have impacts on firm labor productivity. For example, the resource complementarity between two partners could be a factor that leads to a higher labor productivity among the joint venture enterprises. Future research can further examine different value-creation mechanisms behind the Sino-foreign joint ventures by using more fine-grained data.

Second, the paper might suffer from endogeneity problems. Although we observed that the labor productivity of automobile firms tended to increase faster than the labor productivity of telecom firms in the post-WTO era, we cannot rule out other possible explanations for this phenomenon. One might argue that such relative productivity changes are not a result of implementing different FDI policies in the post-WTO era, but a result of other external changes happened during this period. For example, the relative productivity changes might be a result of technological changes occurred in the post-WTO era. However, the frequency of technological changes tends to be higher in the telecom industry than in the automobile industry. Assuming that technological changes will enhance firm productivity in general, we might expect to see that the productivity of telecom firms increased faster than the productivity of automobile firms. But, this is not the case. So, technological changes cannot be an alternative explanation for what we have observed in this study. Nevertheless, there might still be other unknown explanations for the observed phenomenon. Future research can further explore alternative explanations by using different data and methods (e.g., qualitative interviews with industry experts and policy makers).

REFERENCES

Aghion, P., David, P. A., & Foray, D. (2009). Science, technology and innovation for economic growth: linking policy research and practice in 'STIG Systems'. *Research Policy, 38*(4), 681-693.

Angrist, J. D., & Pischke, J.-S. (2008). *Mostly harmless econometrics: An empiricist's companion*: Princeton University Press.

Arnold, & Javorcik. (2009). Gifted kids or pushy parents? Foreign direct investment and plant productivity in Indonesia. *Journal of International Economics, 79*, 42-53.

Beamish, P. W. (1987). Joint ventures in LDCs: Partner selection and performance. *Management International Review*, 23-37.

Beamish, P. W., & Banks, J. C. (1987). Equity joint ventures and the theory of the multinational enterprise. *Journal of International Business Studies, 18*(2), 1-16.

Bertrand, O., & Capron, L. (2014). Productivity enhancement at home via cross-border acquisitions: The roles of learning and contemporaneous domestic investments. *Strategic Management Journal*, n/a-n/a. doi:10.1002/smj.2256

Blalock, G., & Gertler, P. J. (2009). How firm capabilities affect who benefits from foreign technology. *Journal of Development Economics, 90*(2), 192-199.

Blomström, M. (1986). Foreign investment and productive efficiency: the case of Mexico. *The Journal of Industrial Economics*, 97-110.

Blomström, M., & Kokko, A. (1996). The impact of foreign investment on host countries: a review of the empirical evidence. *Policy Research Working Paper, 1745*.

Blomström, M., & Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic surveys, 12*(3), 247-277.

Blomström, M., & Sjöholm, F. (1999). Technology transfer and spillovers: does local participation with multinationals matter? *European economic review, 43*(4), 915-923.

Boddewyn, J. J., & Brewer, T. L. (1994). International-business political behavior: New theoretical directions. *Academy of Management Review, 19*(1), 119-143.

Brandt, L., Van Biesebroeck, J., & Zhang, Y. (2012). Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. *Journal of Development Economics, 97*(2), 339-351.

Buckley, P., Clegg, J., & Tan, H. (2004). Knowledge transfer to China: policy lessons from foreign affiliates. *Transnational Corporations, 13*, 31-72.

Carbó, S., Humphrey, D., Maudos, J., & Molyneux, P. (2009). Cross-country comparisons of competition and pricing power in European banking. *Journal of International Money and Finance, 28*(1), 115-134.

Caves, R. E. (1971). International corporations: The industrial economics of foreign investment. *Economica, 38*(149), 1-27.

Caves, R. E. (1974). Multinational firms, competition, and productivity in host-country markets. *Economica, 41*(162), 176-193.

Chang, Chung, & Moon. (2013). When do wholly owned subsidiaries perform better than joint ventures? *Strategic Management Journal, 34*, 317-337.

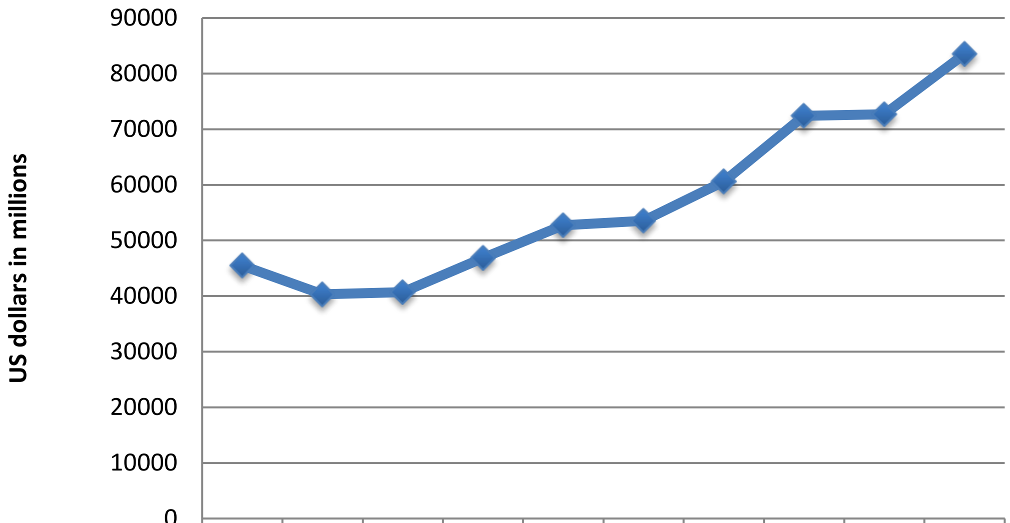
Chang, H.-J. (2002). *Kicking away the ladder: development strategy in historical perspective*: Anthem Press.

Choi, C.-B., & Beamish, P. W. (2013). Resource complementarity and international joint venture performance in Korea. *Asia Pacific Journal of Management, 30*(2), 561-576.

Datta, D. K., Guthrie, J. P., & Wright, P. M. (2005). Human resource management and labor productivity: does industry matter? *Academy of Management Journal, 48*(1), 135-145.

Fagerberg, J., Mowery, D. C., & Nelson, R. R. (2006). *The Oxford handbook of innovation*: Oxford Handbooks Online.
Fan, P. (2006). Catching up through developing innovation capability: evidence from China's telecom-equipment industry. *Technovation, 26*(3), 359-368.
Fujimoto, T. (1999). *The evolution of a manufacturing system at Toyota*: Oxford university press.
Golovko, E., & Valentini, G. (2014). Selective Learning-by-Exporting: Firm Size and Product Versus Process Innovation. *Global Strategy Journal, 4*(3), 161-180.
Hamilton, A. (1791). Report on Manufactures, reprinted in: The Reports of Alexander Hamilton: Harper Torch-back, New York.
Kokko, A., & Blomström, M. (1995). Policies to encourage inflows of technology through foreign multinationals. *World Development, 23*(3), 459-468.
Lee, K., & Lim, C. (2001). Technological regimes, catching-up and leapfrogging: findings from the Korean industries. *Research Policy, 30*(3), 459-483. doi:10.1016/s0048-7333(00)00088-3
Lenway, S., Morck, R., & Yeung, B. (1996). Rent seeking, protectionism and innovation in the American steel industry. *The Economic Journal*, 410-421.
List, F. (1841). *National Systems of Political Economy*. London.
Lu, F., & Feng, K. (2005). The Policy Choice of Developing Indigenous IPR Chinese Automobile Industry: Beijing, Peking University Press.
Lundvall, B.-Å. (2008). Innovation system research: where it came from and where it might go.
Malerba, F., & Nelson, R. (2011). Learning and catching up in different sectoral systems: evidence from six industries. *Industrial and Corporate Change, 20*(6), 1645-1675.
Mazzoleni, R., & Nelson, R. R. (2005). The roles of research at universities and public labs in economic catch-up. *Laboratory of Economics and Management (LEM) Working Paper Series, Pisa*.
Mohr, A. T., & Puck, J. F. (2007). Role conflict, general manager job satisfaction and stress and the performance of IJVs. *European Management Journal, 25*(1), 25-35.
Petersen, M. A., & Rajan, R. G. (1995). The effect of credit market competition on lending relationships. *The Quarterly Journal of Economics*, 407-443.
Salomon, R., & Jin, B. (2008). Does knowledge spill to leaders or laggards? Exploring industry heterogeneity in learning by exporting. *Journal of International Business Studies, 39*(1), 132-150.
Williamson. (1981). The Economics of Organization: The Transaction Cost Approach. *American Journal of Sociology, 87*(3), 548-577.
Yu, X., Dosi, G., Lei, J., & Nuvolari, A. (2015). Institutional change and productivity growth in China's manufacturing: the microeconomics of knowledge accumulation and "creative restructuring". *Industrial and Corporate Change*, dtv011.
Zaheer, S. (1995). Overcoming the liability of foreignness. *Academy of Management Journal, 38*(2), 341-363.

Figure 1. Inward FDI in China during 1998-2007



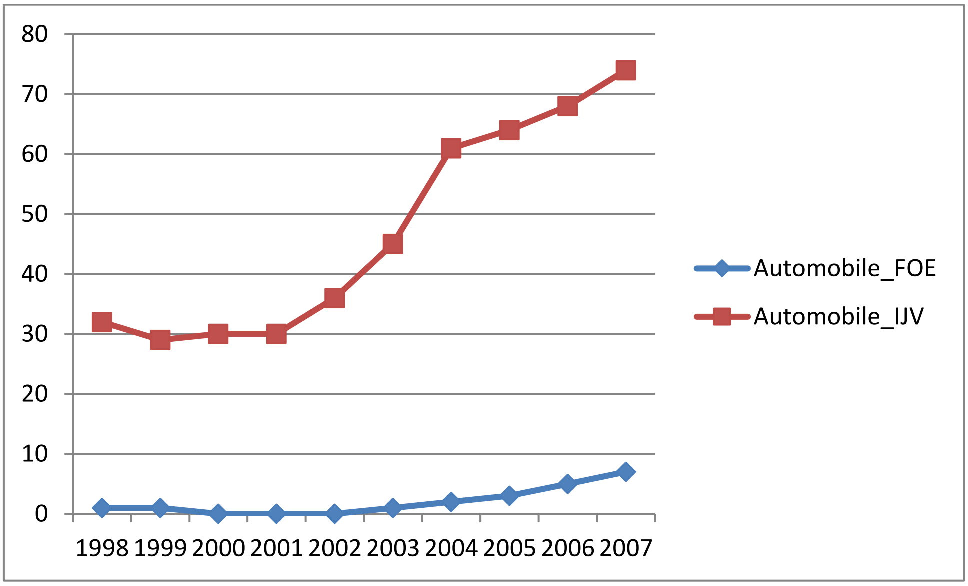
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Inward FDI	45463	40319	40715	46878	52743	53505	60630	72406	72715	83521

Source: UNCTAD database [accessed on 7 June, 2016]

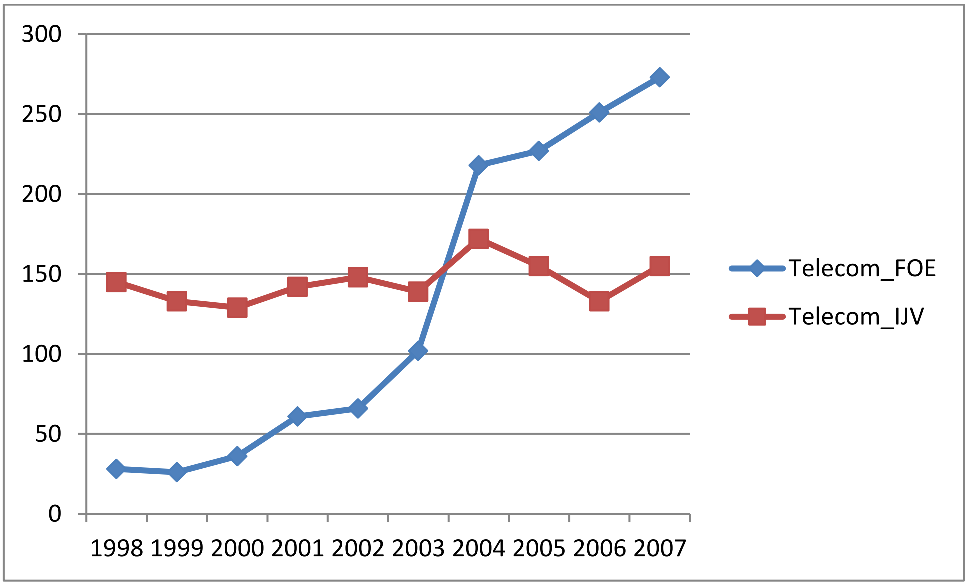
Note: FDI is calculated based on current price and current exchange rates

Figure 2. The number of FOEs and IJVs by year

(a) The number of FOEs and IJVs in the automobile industry

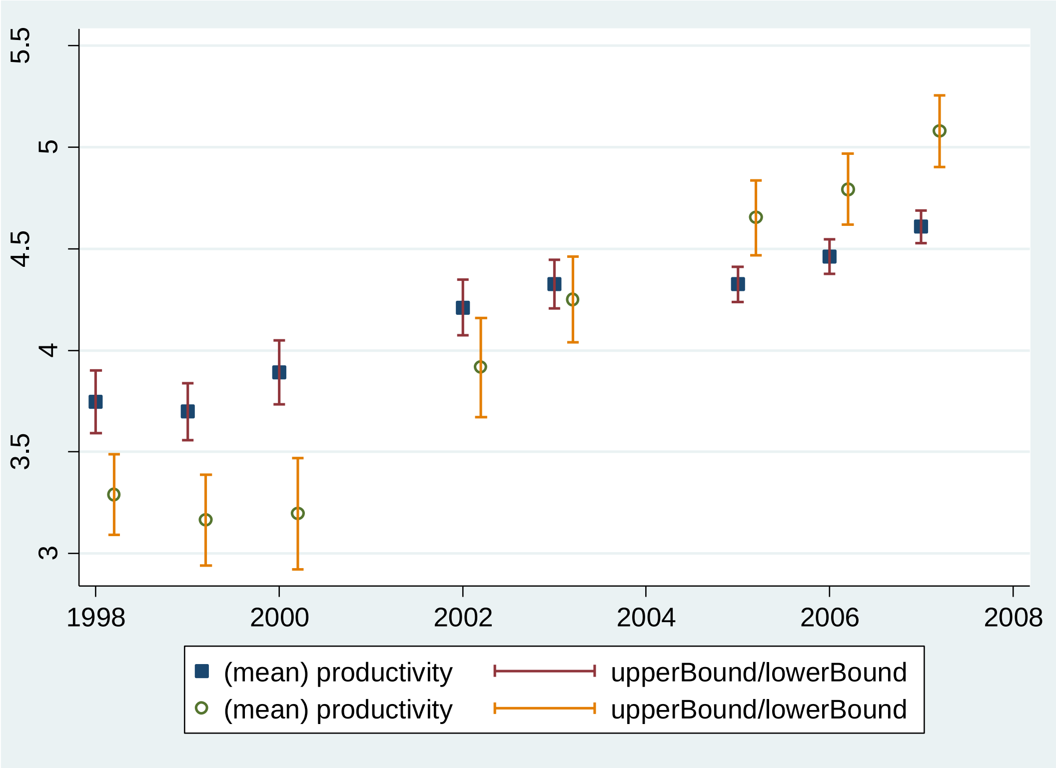


(b) The number of FOEs and IJVs in the telecom industry



Note: FOE stands for Foreign Owned Enterprise, IJV stands for International Joint Venture

Figure 3. The average productivity of automobile firms and telecom firms (1998-2007)

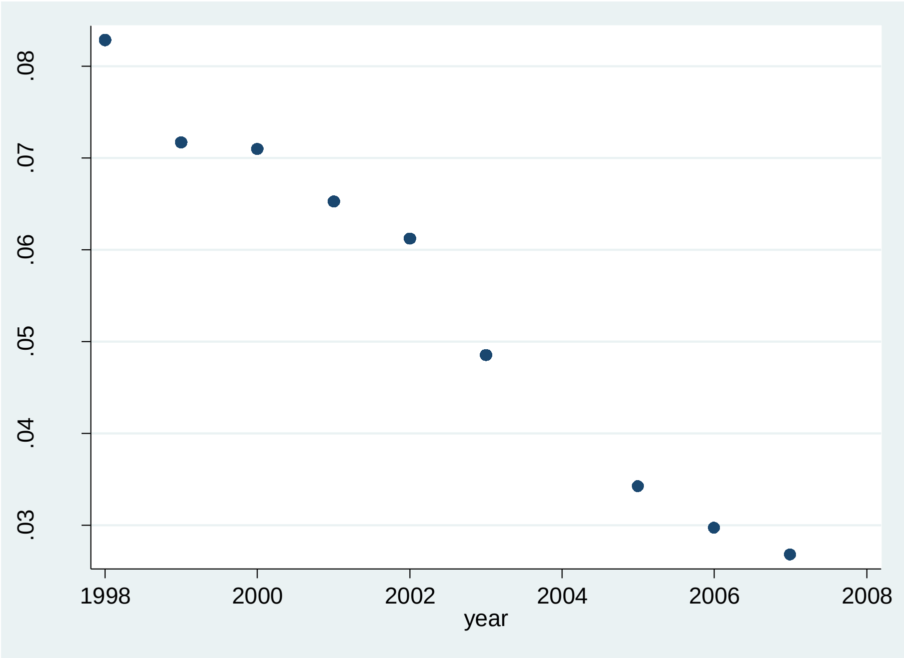


Note: The squares in the above figure represent the mean productivity of telecom firms, and the circles in the above figure represent the mean productivity of automobile firms. The vertical lines represent the range of the 95% confidence interval.

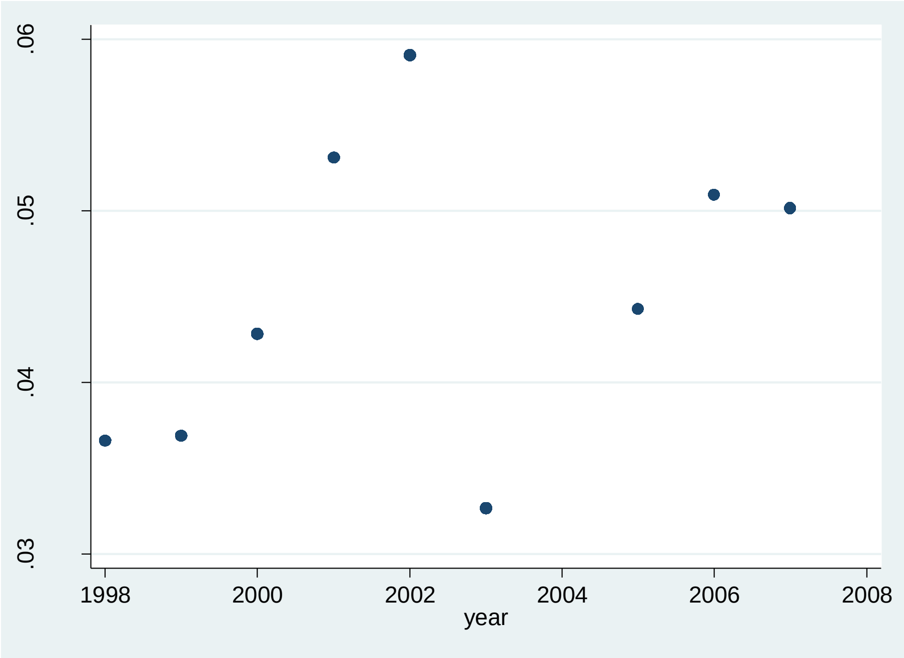
Figure 3 shows the general pattern at the industry level, which means that firms in this figure include different types of firms (domestic firms, IJVs, and FOEs). In the regression analyses (Table IV) that complement this figure, we also checked the robustness of the above pattern by excluding FOEs and IJVs.

Figure 4. Herfindahl index by year

(a) Herfindahl index in the automobile industry

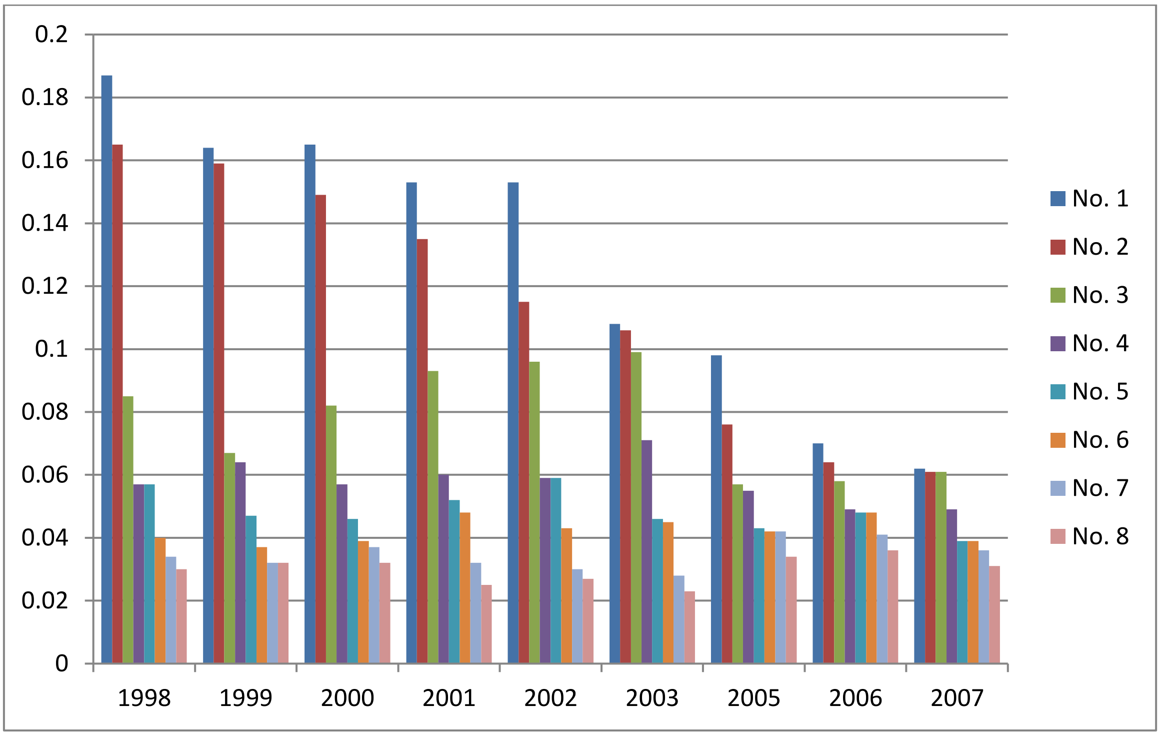


(b) Herfindahl index in the telecom industry



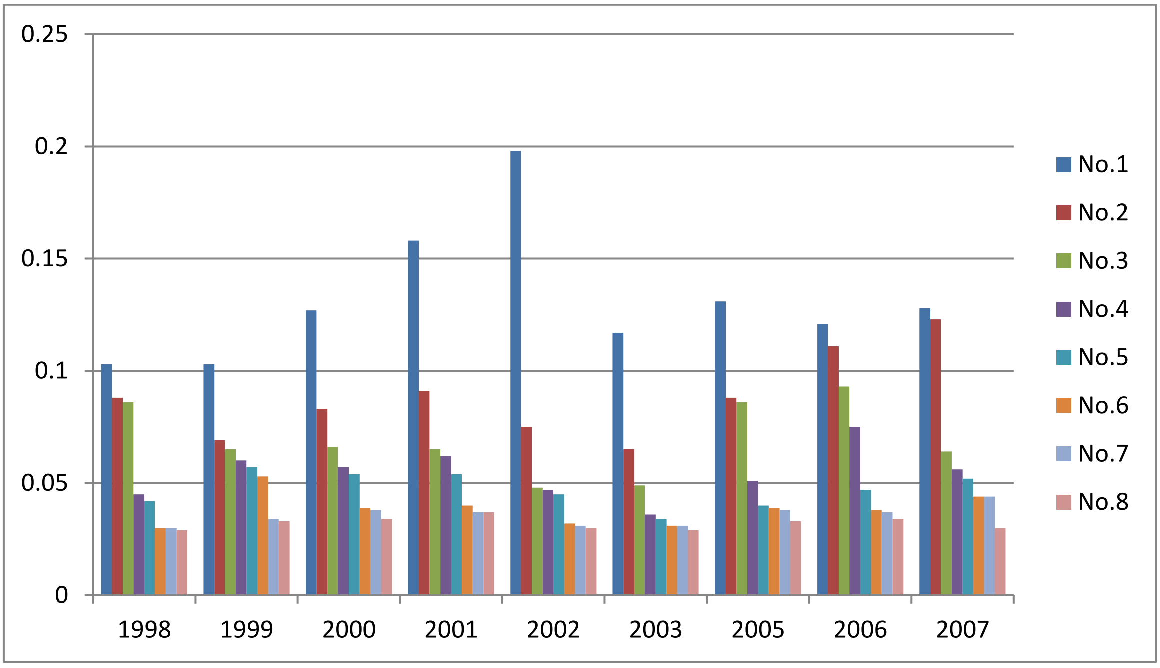
Note: Following Yu et al (2015), data of 2004 are not used due to missing values.

Figure 5. Market share of the top 8 enterprises by year (Automobile industry)



Note: For the names of the top 8 enterprises, see Appendix 2.

Figure 6. Market share of the top 8 enterprises by year (Telecom industry)



Note: For the names of the top 8 enterprises, see Appendix 3.

Table I. Summary statistics

Table I (a). Summary statistics (Automobile industry: domestic firms)

		N	Mean	S.D.	-1	-2	-3	-4	-5	-6
-1	Productivity	1309	3.866	1.559	1					
-2	Productivity2	1630	5.236	1.53	0.82	1				
-3	Capital intensity	1636	4.124	1.326	0.24	0.22	1			
-4	Debt intensity	1657	-0.462	0.567	-0.21	-0.17	-0.12	1		
-5	Employees	1663	6.216	1.604	-0.02	0.03	0.23	0.1	1	
-6	Average wage	1592	2.293	0.91	0.55	0.62	0.26	-0.12	0.09	1

Table I (b). Summary statistics (Automobile industry: IJVs)

		N	Mean	S.D.	-1	-2	-3	-4	-5	-6
-1	Productivity	341	5.192	1.715	1					
-2	Productivity2	396	6.533	1.555	0.89	1				
-3	Capital intensity	394	5.344	1.269	0.59	0.56	1			
-4	Debt intensity	403	-0.633	0.54	-0.28	-0.23	-0.21	1		
-5	Employees	399	7.097	1.34	0.22	0.27	0.24	0.06	1	
-6	Average wage	380	3.224	0.809	0.54	0.63	0.45	-0.14	0.18	1

Productivity is labor productivity measured as the logarithm of value-added per employee, whereas *Productivity2* is labor productivity measured as the logarithm of sales per employee. Because value-added is not reported in 2001, the variable *Productivity* has fewer observations than the variable *Productivity2*.

In principle, there should be no FOEs in the automobile industry under the current regulation. In reality, there are 18 firm-year observations in the dataset that are registered as FOEs in the automobile industry. These observations are mainly “automobile components” enterprises that misrepresented themselves as “integrated automobiles” enterprises. By default, I excluded these observations from the automobile industry in all of the regressions, although including these observations would produce qualitatively the same results.

Table I (c). Summary statistics (Telecom industry: domestic firms)

		N	Mean	S.D.	-1	-2	-3	-4	-5	-6
-1	Productivity	2834	4.119	1.367	1					
-2	Productivity2	3270	5.294	1.319	0.79	1				
-3	Capital intensity	3245	3.463	1.367	0.21	0.2	1			
-4	Debt intensity	3293	-0.687	0.675	-0.15	-0.14	-0.07	1		
-5	Employees	3306	4.912	1.345	-0.17	-0.19	0.07	0.11	1	
-6	Average wage	3128	2.677	0.879	0.43	0.52	0.18	-0.12	-0.1	1

Table I (d). Summary statistics (Telecom industry: IJVs)

		N	Mean	S.D.	-1	-2	-3	-4	-5	-6
-1	Productivity	1036	4.678	1.536	1					
-2	Productivity2	1254	6.087	1.505	0.84	1				
-3	Capital intensity	1247	3.975	1.386	0.43	0.46	1			
-4	Debt intensity	1258	-0.681	0.656	0.12	0.21	-0.03	1		
-5	Employees	1263	5.323	1.377	0.01	0.07	-0.01	0.15	1	
-6	Average wage	1220	3.133	0.977	0.49	0.52	0.35	0.06	-0.07	1

Table I (e). Summary statistics (Telecom industry: FOEs)

		N	Mean	S.D.	-1	-2	-3	-4	-5	-6
-1	Productivity	967	4.227	1.327	1					
-2	Productivity2	1055	5.677	1.233	0.82	1				
-3	Capital intensity	1052	3.749	1.247	0.32	0.38	1			
-4	Debt intensity	1058	-0.801	0.878	0.08	0.13	-0.01	1		
-5	Employees	1060	5.605	1.473	-0.11	-0.08	-0.05	0.12	1	
-6	Average wage	1037	3.018	0.861	0.5	0.53	0.18	0.05	-0.15	1

Table II. Estimate the effect of being an IJV on (value-added based) labor productivity

VARIABLES	(1) Full sample	(2) Automobile	(3) Telecom	(4) Telecom (exclude FOEs)
IJV	0.184***	0.035	0.183**	0.093
	(0.063)	(0.136)	(0.072)	(0.076)
Capital intensity	0.233***	0.212***	0.216***	0.220***
	(0.018)	(0.038)	(0.022)	(0.024)
Debt intensity	-0.026	-0.322***	0.025	-0.025
	(0.033)	(0.079)	(0.035)	(0.042)
Employees	-0.044***	-0.004	-0.077***	-0.057**
	(0.016)	(0.029)	(0.019)	(0.023)
Average wage	0.612***	0.719***	0.582***	0.570***
	(0.030)	(0.060)	(0.035)	(0.040)
SOE	-0.676***	-0.700***	-0.647***	-0.738***
	(0.074)	(0.122)	(0.092)	(0.096)
Observations	6,203	1,590	4,613	3,671
R-squared	0.343	0.464	0.299	0.308
Year dummies	included	included	included	included

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is *Productivity*, which is defined as the logarithm of value-added per employee.

Table III. Estimate the effect of being an IJV on (sales based) labor productivity

VARIABLES	(1) Full sample	(2) Automobile	(3) Telecom	(4) Telecom (exclude FOEs)
IJV	0.198***	-0.058	0.258***	0.216***
	(0.061)	(0.118)	(0.072)	(0.075)
Capital intensity	0.225***	0.153***	0.222***	0.218***
	(0.017)	(0.035)	(0.020)	(0.023)
Debt intensity	0.082***	-0.121*	0.111***	0.087**
	(0.030)	(0.072)	(0.033)	(0.039)
Employees	0.021	0.061**	-0.024	-0.018
	(0.015)	(0.025)	(0.019)	(0.023)
Average wage	0.651***	0.810***	0.618***	0.620***
	(0.032)	(0.070)	(0.036)	(0.043)
SOE	-0.873***	-0.777***	-0.932***	-0.968***
	(0.070)	(0.110)	(0.089)	(0.092)
Observations	7,283	1,956	5,327	4,300
R-squared	0.434	0.527	0.405	0.415
Year dummies	included	included	included	included

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is *Productivity2*, which is defined as the logarithm of sales per employee.

Table IV. Difference-in-differences estimation

VARIABLES	(1) Full sample	(2) Sample excluding FOEs	(3) Sample excluding FOEs and IJVs
PostWTO	0.127**	0.172***	0.192***
	(0.054)	(0.057)	(0.067)
Automobile	-0.222***	-0.264***	-0.168*
	(0.084)	(0.086)	(0.092)
PostWTO*Automobile	0.454***	0.400***	0.345***
	(0.092)	(0.094)	(0.103)
Capital intensity	0.229***	0.227***	0.168***
	(0.019)	(0.021)	(0.022)
Debt intensity	-0.031	-0.091**	-0.157***
	(0.034)	(0.038)	(0.042)
Employees	-0.046***	-0.028	-0.054***
	(0.016)	(0.017)	(0.020)
Average wage	0.638***	0.630***	0.604***
	(0.030)	(0.033)	(0.036)
SOE	-0.735***	-0.783***	-0.705***
	(0.072)	(0.073)	(0.076)
Observations	6,203	5,261	3,939
R-squared	0.344	0.359	0.326

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is *Productivity*, which is defined as the logarithm of value-added per employee.

Appendix 1. Description of the variables

Variable	Definition
Productivity	the labor productivity of a firm, which is measured as value-added[7] divided by the number of employees (Bertrand & Capron, 2014; Yu et al., 2015). The variable is log-transformed.
Productivity2	an alternative measure of the labor productivity of a firm, as sales per employee (Datta et al., 2005). The variable is log-transformed.
IJV	a dummy variable that indicates whether a firm-year observation is an international joint venture or not
Employees	number of employees is measured by the variable "number of labors" in the AIS database, except for year 1999 and year 2003. In these two years, the variable "number of labors" is not available. Instead, the variable "staff and workers number" and the variable "number of labor at the end of the year" are used respectively. The variable is log-transformed.
Capital intensity	capital intensity is measured as average balance of net fixed asset divided by the number of employees. The variable is log-transformed.
Debt intensity	debt intensity is measured as total liability divided by total assets. The variable is log-transformed.
Average wage	average wage is measured as "main business gross pay" divided by the number of employees. The variable is log-transformed.
SOE	a dummy variable that indicates whether a firm-year observation is a state-owned enterprise or not
PostWTO	a dummy variable which equals to 1 in the post-WTO era (year>=2002) and equals to 0 in the pre-WTO era (year<2002)
Automobile	a dummy variable that indicates whether a firm belongs to the automobile industry or not. If a firm belongs to the automobile industry, the variable is set to 1. Instead, if a firm belongs to the telecom industry, the variable is set to 0.
$Post\mathrm{WTO} * Automobile$	a difference-in-differences estimator, which shows us how the productivity of automobile firms changes relative to the productivity of telecom firms in the post-WTO era.

[7] The AIS data from RESSET did not report "value-added" for year 2001 and 2004. Therefore, labor productivity for these two years cannot be calculated.

Appendix 2. Names of the top 8 enterprises by year (Automobile industry)

	1998	1999	2000	2001	2002	2003	2005	2006	2007
No. 1	Shanghai Volkswagen Automotive Co., Ltd	Shanghai Volkswagen Automotive Co., Ltd	China FAW Group Corporation	China FAW Group Corporation	China FAW Group Corporation	China FAW Group Corporation	China FAW Group Corporation	Shanghai General Motors Co., Ltd	Shanghai General Motors Co., Ltd
No. 2	China FAW Group Corporation	China FAW Group Corporation	Shanghai Volkswagen Automotive Co., Ltd	Shanghai Volkswagen Automotive Co., Ltd	Shanghai Volkswagen Automotive Co., Ltd	Shanghai Volkswagen Automotive Co., Ltd	Shanghai General Motors Co., Ltd	China FAW Group Corporation	FAW-Volkswagen Automotive Co., Ltd.
No. 3	Dongfeng Motor Corporation	FAW-Volkswagen Automotive Co., Ltd.	FAW-Volkswagen Automotive Co., Ltd.	FAW-Volkswagen Automotive Co., Ltd.	FAW-Volkswagen Automotive Co., Ltd.	FAW-Volkswagen Automotive Co., Ltd.	Guangzhou Honda Automobile Co., Ltd.	FAW-Volkswagen Automotive Co., Ltd.	China FAW Group Corporation
No. 4	Tianjin Automotive Industry (Group) Co., Ltd.	Dongfeng Motor Corporation	Dongfeng Motor Corporation	Dongfeng Motor Corporation	Dongfeng Motor Corporation Ltd	Shanghai General Motors Co., Ltd	FAW-Volkswagen Automotive Co., Ltd.	Shanghai Volkswagen Automotive Co., Ltd	Shanghai Volkswagen Automotive Co., Ltd
No. 5	FAW-Volkswagen Automotive Co., Ltd.	Tianjin Automotive Industry (Group) Co., Ltd.	Shanghai General Motors Co., Ltd	Guangzhou Honda Automobile Co., Ltd.	Shanghai General Motors Co., Ltd	Dongfeng Motor Corporation	Passenger Vehicle Company, Dongfeng Motor Co., Ltd.	Guangzhou Honda Automobile Co., Ltd.	Guangzhou Honda Automobile Co., Ltd.
No. 6	Yuejin Motor Group	Shanghai General Motors Co., Ltd	Guangzhou Honda Automobile Co., Ltd.	Shanghai General Motors Co., Ltd	Guangzhou Honda Automobile Co., Ltd.	Guangzhou Honda Automobile Co., Ltd.	Shanghai Volkswagen Automotive Co., Ltd	Dongfeng Automobile Co., Ltd. (Shiyan Region)	Tianjin FAW Toyota Motor Co., Ltd.
No. 7	China National Heavy Duty Truck Group Corporation	Yuejin Motor Group	FAW Jinbei Automobile Co., Ltd.	Jinbei Automobile Co., Ltd.	Dongfeng Peugeot Citroen Automobile Co., Ltd.	Beijing Foton Motor Co., Ltd.	Beijing Hyundai Motor Co., Ltd.	Tianjin FAW Toyota Motor Co., Ltd.	China National Heavy Duty Truck Group Co., Ltd.
No. 8	Qingling Motors (Group) Co., Ltd.	FAW Jinbei Automobile Co., Ltd.	Dongfeng Peugeot Citroen Automobile Co., Ltd.	Dongfeng Peugeot Citroen Automobile Co., Ltd.	Jinbei Automobile Co., Ltd.	Guangzhou Fengshen Motor Co., Ltd.	Tianjin FAW Toyota Motor Co., Ltd.	Beijing Hyundai Motor Co., Ltd.	Guangzhou Toyota Motor Co., Ltd.

Appendix 3. Names of the top 8 enterprises by year (Telecom industry)

	1998	1999	2000	2001	2002	2003	2005	2006	2007
No.1	Shenzhen Huawei Technologies Co., Ltd.	Shenzhen Huawei Technologies Co., Ltd.	Shenzhen Huawei Technologies Co., Ltd.	Motorola (China) Electronics Co., Ltd.	Motorola (China) Electronics Co., Ltd.	Motorola (China) Electronics Co., Ltd.	Motorola (China) Electronics Co., Ltd.	Motorola (China) Electronics Co., Ltd.	Nokia Telecommunications Ltd.
No.2	Shanghai Bell Telephone Equipment Manufacturing Co., Ltd.	Shanghai Bell Co., Ltd.	Nanjing Ericsson Panda Communication Co., Ltd.	Beijing Nokia Mobile Telecommunications Co., Ltd.	Huawei Technologies Co., Ltd	Huawei Technologies Co., Ltd	Nokia Capitel Telecommunications Co., Ltd.	Nokia Capitel Telecommunications Co., Ltd.	Huawei Technologies Co., Ltd
No.3	Zhejiang Eastern Communications Group Co., Ltd.	Nanjing Ericsson Communication Co., Ltd.	Siemens Shanghai Mobile Communications Co., Ltd.	Huawei Technologies Co., Ltd	Shenzhen ZTE Corporation	Shenzhen ZTE Corporation	Huawei Technologies Co., Ltd	Huawei Technologies Co., Ltd	Motorola (China) Electronics Co., Ltd.
No.4	Shanghai Bell Alcatel Mobile Communication System Co., Ltd.	Zhejiang Eastern Communications Group Co., Ltd.	Dongguan Nokia Mobile Phones Ltd.	Siemens Shanghai Mobile Communications Co., Ltd.	Siemens Shanghai Mobile Communications Co., Ltd.	Beijing Capitel Nokia Mobile Telecommunications Co., Ltd.	Daye (shanghai) Computer Science And Technology Co., Ltd.	Shenzhen Futaihong Precision Industrial Co., Ltd.	Shenzhen Futaihong Precision Industrial Co., Ltd.
No.5	Beijing International Switching System Co., Ltd.	Dongguan Nokia Mobile Phones Ltd.	Shanghai Bell Co., Ltd.	Nanjing Ericsson Panda Communication Co., Ltd.	Dongguan Nokia Mobile Phones Ltd.	UT Starcom (Hangzhou) Co., Ltd.	Beijing SE Putian Mobile Communications Co., Ltd.	Hangzhou Motorola Cellular Equipment Co., Ltd.	Tianjin Samsung Telecom Technology Co., Ltd.
No.6	Woori Electronics (Shenzhen) Co., Ltd.	Siemens Shanghai Mobile Communications Co., Ltd.	Zhejiang Eastern Communications Group Co., Ltd.	Dongguan Nokia Mobile Phones Ltd.	Alcatel Shanghai Bell Co., Ltd.	Siemens Shanghai Mobile Communications Co., Ltd.	ZTE Corporation	Beijing SE Putian Mobile Communications Co., Ltd.	ZTE Corporation
No.7	Siemens Shanghai Mobile Communications Co., Ltd.	Beijing Nokia Hangxing Telecommunications Systems Co., Ltd.	Shenzhen Zhongxing Communication Equipment Co., Ltd.	Shenzhen ZTE Corporation	UT Starcom (Hangzhou) Co., Ltd.	Ningbo Bird Co., Ltd.	Tianjin Samsung Telecom Technology Co., Ltd.	Tianjin Samsung Telecom Technology Co., Ltd.	Beijing SE Putian Mobile Communications Co., Ltd.
No.8	Dongguan Nokia Mobile Phones Ltd.	Fujian Start Computer Group Co., Ltd.	Guangdong Nortel Telecommunications Equipment Co., Ltd.	Shanghai Bell Co., Ltd.	Huizhou TCL Mobile Communication Co., Ltd.	Dongguan Nokia Mobile Phones Ltd.	Shenzhen Futaihong Precision Industrial Co., Ltd.	ZTE Corporation	Hangzhou Motorola Cellular Equipment Co., Ltd.

CONCLUDING REMARKS

Guided by the Sectoral Systems of Innovation framework, I developed three essays at the intersection between “Sectoral Systems of Innovation” and “catching-up”. Firms need to take sectoral differences into account when they formulate their catch-up strategies. Sectoral environments (market/technological regimes) are important for explaining domestic firms’ catching-up. Government policies also have an impact on domestic firms during the catching-up process. The three essays of the dissertation address the role of firm strategies, the role of sectoral environments, and the role of government policies in the catching-up process of Chinese firms respectively.

In the first essay, I find that in the high-tech sectors, overseas acquisitions tend to be an appropriate catch-up strategy for enhancing firm productivity; whereas in the low-tech sectors, domestic acquisitions tend to be an appropriate catch-up strategy for enhancing firm productivity. In the second essay, I find that segmented markets, together with generational technological changes, facilitated Chinese firms’ catching-up in the mobile communications industry. In the third essay, I find that although a protective FDI policy may not be able to facilitate knowledge transfer through forced IJV arrangements, it also may not lead to an inefficient industry.

Catching-up with established multinational enterprises is always a challenging task for emerging market firms. And, deliberate efforts are needed from various actors within an innovation system to promote latecomers’ catching-up. The three essays developed in this dissertation marked the beginning of my endeavor to understand the factors and mechanisms behind the complex catching-up phenomenon. Future research will continue along this line of thinking.