Cultural proximity and local firms' catch-up with multinational enterprises (MNEs)

Abstract

Integrating and extending new growth theory and resource-based views, this paper provides a theoretical foundation for the catch-up hypothesis. It examines the role of technology gap, technological capability and cultural proximity in local firms' catch-up with MNEs. Hypotheses are developed and tested with a dynamic model on a large firm-level panel dataset from Chinese manufacturing. The results confirm that catch-up is positively related to technology gap and technological capability. Furthermore, in the presence of cultural proximity, the speed of local Chinese firms' catch-up with MNEs from Hong Kong, Macau and Taiwan is not significantly lower than that with other MNEs.

Keywords

Catch-up; China; Culture; New growth theory; Resource-based views; Technology gap hypothesis

INTRODUCTION

Catch-up has long been in the interests of managers, economists and policymakers. Any catch-up implies an increase in productivity in the lagging firm, or a rise in gross domestic product (GDP) and possibly social welfare in the backward economy, and the emergence of new economic power helps lift the entire global economy (Mandel, 2004). The catch-up hypothesis (CPH) developed by Gerschenkron (1962), Abramovitz (1986) and Maddison (1979), among others, suggests that a firm or country behind the world innovation frontier can grow faster by imitating technologies already developed in technologically more advanced economies. The larger the technology gap between the firm or country and the world innovation frontier, the faster the catch up. In this sense, CPH is also known as the technology gap hypothesis (TGH) (Hussler, 2004).

The traditional catch-up literature is descriptive, focusing on historical analysis of cross-country income convergence (Fagerberg, 1995). Recent literature contains econometric analysis of convergence or catch-up mainly at the macro level (e.g. Archibugi & Filippetti, 2011; Cameron, et al., 2005; Griffith, et al., 2009; Parente & Prescott, 1999), though there are a small number of micro level studies (e.g. Aiello, et al., 2011; Baily, et al., 1992; Bartelsman & Doms, 2000; Disney, et al., 2003; Lee, et al., 2012). Knowledge diffusion and imitation are essential for catch-up, but they are by no means automatic (Fagerberg, 1995). Following Ohkawa and Rosovsky (1973), Abramovitz (1994) adopts the concept of 'social capability' to explain catch-up, and a key element is technology. However, TGH is at its early stage, lacks a sound theoretical foundation for the determinants of social capability.

More recent economic literature attempts to apply new growth theory (NGT) to explain convergence or catch-up between countries by emphasizing the role of externalities from not only international trade and foreign direct investment (FDI), but also a country's own technological capability (TC) (Archibugi & Filippetti, 2011; Balasubramanyam, et al., 1996). The business or management literature also emphasizes TC. As argued by Dyker and Radošević (2001), whether the follower can catch-up depends on its ability to assimilate technology and brings its own knowledge stock up.

CUH developed in the existing literature is culture-free. While there are several studies of the role of national culture in technology diffusion (e.g. Hussler, 2004; Palich & Gomez-Mejia, 1999) and innovation (Boschma, 2005; Mattes, 2012), they do not directly link this to catch-up. In the same vein as Steensma et al.'s (2000) discussion of the creation of technology alliances, technology is diffused and assimilated in a societal context. Therefore, cultural values affect the efficiency of technology diffusion and the speed of catch-up. Among the exceptions, Palich and Gomez-Mejia (1999) and Hussler (2004) argue that technology diffusion is culture dependent, and greater efficiency of knowledge sharing is achieved between culturally related firms than unrelated ones, although their studies are yet to be firmly linked to theories.

This paper departs from the mainstream catch-up literature as it focuses on the micro-level study of productivity catch-up of local firms with multinational enterprises (MNEs) in the presence of international trade and FDI within one emerging economy rather than a macro-level study of cross-country or cross-region per capita income or productivity convergence. This paper addresses two important issues. First, is there any catch-up of local firms with MNEs in an emerging economy like China? This question will be answered by comparing the productivity growth pattern and technology gap of local Chinese firms with those of MNEs during the sample period. Second, if there is catch-up, what are its determinants? Particularly, what is the role of cultural proximity in the catch-up? The second research question will be answered by testing two hypotheses with the first focusing on the general economic and business determinants, and the second on cultural proximity.

China provides an ideal context for addressing these questions. Since its economic reform and opening up in 1978, Chinese foreign trade has grown by approximately 15% per year, and FDI into China is now more than US$ 80 billion a year (Lau & Bruton, 2008). China has already become a major destination for FDI in the world and a trading nation of global rank (OECD, 2008). There are two main sources of China's inward FDI: MNEs from Hong Kong, Macau and Taiwan (HMT-MNEs), and other MNEs mainly from OECD countries (Other-MNEs). Local Chinese firms have a greater technology gap with Other-MNEs than HMT-MNEs (Liu, et al., 2009; Wei & Liu, 2001; Wei & Liu, 2006), but enjoy cultural proximity with the latter. In addition, China is emerging as a significant player in R&D and innovation, and increasingly becoming integrated in the global system of knowledge creation, diffusion and adoption (OECD, 2008). This provides local Chinese firms with great opportunities for learning from advanced economies and developing their own TC. This context enables us to develop and test novel hypotheses regarding local firms' catch-up with different types of MNEs.

This paper contributes to our understanding of catch-up in the following ways. First, it tries to ground CUH on a combination of new growth theory (NGT) and resource-based views (RBV). While NGT is sometimes used in previous macro-level studies, we argue that both NGT and RBV focus on TC, and their combination provides a better theoretical framework for CUH when this topic is researched at the firm level. Second, we explicitly incorporate cultural proximity into CUH. In our analytical framework, cultural proximity is seen as a special resource to facilitate technology spillovers. We not only incorporate a cultural determinant, but 'identify how this change affects the accepted relationships between the variables' (Whetten, 1989, p. 492), i.e. how the addition of cultural proximity affects the accepted relationship between technology gap and catch-up as specified by the traditional TGH. The consideration of cultural proximity in this context should be a legitimate, value added contribution to theory development (Whetten, 1989). Third, different from many existing studies which deal with cross-country or cross-region catch up, we compare the speeds of local firms' catch up with culturally-close and culturally-distant MNEs in an emerging economy based on a very large firm-level panel dataset for the first time, and should contribute to the empirical literature.

The next section deals with theory and hypothesis development, integrating and extending NGT and RBV to explain CUH. Cultural proximity is incorporated into the analytical framework as a special resource facilitating technology diffusion and catch-up. We then discuss the data, model, measurement, estimation methods and empirical results. The final section concludes.

THEORY AND HYPOTHESES

In the simple form, CUH suggests that 'being backward in level of productivity carries a potential for rapid advance' (Abramovitz, 1986, p. 386). The extent to which catch-up occurs depends not only on technology gap, but also social capability which involves 'various efforts and capabilities that developing countries have to develop in order to catch-up, such as improving education, infrastructures, and, more generally technological capabilities' (Fagerberg & Godinho, 2005, p. 523). Technical capabilities (TC) are needed by catch-up countries in order to absorb the knowledge and technology developed elsewhere (Archibugi & Filippetti, 2011; Castellacci, 2008), and the scope for catch-up is determined by the scope for technology diffusion from the advanced countries to the catch-up countries (Dyker & Radošević, 2001).

New growth theory (NGT) suggests that globalization is a key means for technology diffusion. As Romer (2010) argues, globalization is driven by the gains from reuse of ideas, and flows of ideas are the part of globalization that matters for catch-up. Globalization offers latecomer firms the opportunity to access external knowledge sources through technological transfer or more active technological learning (Wu & Zhang, 2010). The main channels for superior technological knowledge diffusion identified in the literature are FDI and international trade. Balasubramanyam, et al. (1996) suggest that skill gaps between developed and developing countries can be bridged through FDI carried out by MNEs. Knowledge created in developed countries is often transferred by MNEs to their foreign subsidiaries. Such knowledge can spill over to local firms in host countries via labor training and indigenous management and through links between MNEs and local consumers and suppliers. Increased competition forces local firms to seek new technologies and improve efficiency. Through MNEs' demonstration effects, local firms can also benefit from learn-by-watching and learning-by-doing. FDI is a very important mechanism for international (from home-country MNEs to their foreign subsidiaries) and intra-national (from foreign subsidiaries to local firms in host countries) knowledge diffusion. Given its important role in knowledge diffusion, Balasubramanyam, et al. (1996) argue that many of the growth promoting factors identified by NGT can be nurtured to promote productivity growth through FDI. FDI in an emerging economy provides much better opportunities for local firms to learn advanced knowledge from MNEs. FDI facilitates technology spillovers from MNEs to local firms as it turns a mode of technology diffusion from international to intra-national.

NGT suggests that international trade is another vital mechanism for knowledge transfer and diffusion. Local firms can benefit from exports in terms of more efficient use of resources, greater capacity utilization and gains of scale effects associated with large international markets (Bhagwati, 1978). To obtain low-cost, better-quality products from main exporters, foreign buyers may transmit tacit and occasionally proprietary knowledge (World Bank, 1993). Furthermore, participating in exports enables firms to access international best practices and learning, and to be acquainted with the availability and absorption of advanced technologies (James & Romijn, 1997; World Bank, 1997). International competition provides firms with incentives to adopt and foster advanced technologies (Hejazi & Safarian, 1999). International trade and FDI together with other international activities such as scientific exchanges and technological collaborations enable backward countries to exploit the technological opportunities offered by the most developed countries (Archibugi & Filippetti, 2011; Perez & Soete, 1988).

TC is studied at the macro-level as in the case of mainstream NGT discussed above, but also at the micro-level as in the case of the resource based view (RBV) (Wernerfelt, 1984), According to RBV, a firm's valuable, rare, inimitable, and non-substitutable resources (including capabilities) determine its competitiveness (Wernerfelt, 1984). Based on this theory, TC is a firm's 'ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies' (Kim, 1997). Therefore, TC involves not only developing new technologies, but also searching, adapting and utilizing advanced ones. A similar concept is absorptive capacity or capability. Cohen and Levinthal (1990) suggest that absorptive capacity is a firm's 'ability to recognize the value of new information, assimilate it, and apply it to commercial ends'. Absorptive capacity depends largely on prior related knowledge and diversity of background. A firm needs to invest in R&D to develop absorptive capacity. This helps the firm develop new technology, generate product and process innovation, create differentiation advantage and achieve superior performance (Ju, et al., 2013; Zhou & Wu, 2010).

The above discussion shows that NGT and RBV seek both internal (e.g. own R&D) and external sources for TC. However, by comparison, NGT is an aggregate theory of growth, focusing on technological capabilities and catch-up at the macroeconomic- rather than firm-level. On the other hand, RBV concentrates on the micro-level analysis of TC, and is more suitable for the study of catch-up at the firm level. Another difference between the two theories appears that NGT pays much more attention than RBV to international trade and FDI as important knowledge sources. Furthermore, TGH suggests a positive relationship between technology gap and catch-up. The rate at which new technology is diffused is an increasing function of technology gap because a large gap allows great potential for catch-up (Findlay, 1978). Based on NGT's notion of (conditional) β-convergence, long-run economic growth follows a steady-state balanced path. In the short run, countries that have not reached their steady state demonstrate higher growth rates than those closer to the steady state. The theory therefore endorses catch-up at the macroeconomic level. TGH is particularly emphasized in NGT, although not in RBV. However, at the microeconomic level, RBV emphasizes the importance of absorptive capability for a firm's superior performance. In sum, the two theories are complementary to each other, but neither of them alone may be used to satisfactorily analyze the phenomenon of local firms' catch-up with MNEs. We combine the ideas of the two theories together and discuss at the firm level the relationship between technological knowledge diffusion from various channels and technical capability development using both internal and external sources, and may be able to offer a better explanation of catch-up of latecomer firms.

The above discussion shows that the greater the technology gap between the leading and follower countries, the greater potential for catch-up. In addition, the higher the degree of international trade and inward FDI and the greater the follower's own R&D efforts, the more likely the follower is to catch up. It is clear that technological knowledge from trade and FDI is from external sources, while that from own R&D efforts is from internal sources. Knowledge from both sources contributes to the development of TC for catch-up. Therefore, hypothesis 1 (H1) can be established:

H1: The bigger the technology gap between local firms and MNEs, the higher the levels of international trade and inward FDI, and the greater the local firms' own R&D efforts, the more likely the local firms are to catch up with MNEs.

So far we have based CUH on a theoretical foundation integrating NGT and RBV, and have developed a general hypothesis. However, catch-up occurs in a certain social context so that cultural values will affect technology diffusion and catch-up. Hofstede (2001) defines culture as "the collective programming of the mind that distinguishes the members of one group or category of people from another" (p. 9). If people live in the same community, they have a common system of opinions, and hence, a common culture (Hussler, 2004). Technology can be most easily transferred between countries of a same or similar culture and development (Kedia & Bhagat, 1988). Cultural proximity promotes knowledge exchange since cultural compatibilities between firms in countries with similar or shared values can act as a bond to technology or knowledge transfer (Keller & Chinta, 1990). People of a same culture 'share the same tacit background and ideology, they adopt similar ways of thinking, behaving, deciding and do not need to communicate a lot to explain their opinion to other members of their culture since the whole community grounds its knowledge on the same pre-existing and accumulated know-how, know-why, know-what, and know-who' (Hussler, 2004). Conducting business with culturally close partners lowers uncertainty, and facilitates acquiring and sharing tacit knowledge (Schmitt & Van Biesebroeck, 2013). In other words, people of a same or similar culture can communicate and diffuse knowledge efficiently. Culture together with local formal institutions such as a law system securing ownership and intellectual property rights provides a basis for economic coordination and interactive learning, and facilitate knowledge exchange, collaboration, and innovation (Boschma, 2005; Maskell & Malmberg, 1999; Shearmur, 2011). However, it must be recognized that cultural proximity does not always promote knowledge diffusion and creation. Recent literature suggests that too much cultural proximity is unfavorable for new ideas and innovations as it obstructs awareness of new possibilities (lock-in) and impedes the required institutional readjustment (inertia) (Ben Letaifa & Rabeau, 2013; Boschma, 2005). As discussed earlier, RBV suggests that a firm's sustainable competitive advantage is achieved through unique resources it holds, and these resources cannot be easily bought, transferred, or imitated. They are also valuable to the firm while being rare. Cultural proximity is a unique resource for all firms with the same or similar culture. While it is not firm-specific, it is a culture-specific advantage for a specific group of firms. 'The intrinsic cultural features of a population might influence its capability to absorb external knowledge' (Hussler, 2004), and this adds value to this group of firms. National culture can influence organizational culture which is firm-specific. In addition, culture evolves very slowly. Therefore, cultural proximity creates a strong competitive barrier for firms from a different culture. In short, cultural proximity can be regarded as a specific resource which enables firms of the same or similar culture to absorb, use and internally diffuse external knowledge efficiently.

NGT recognizes the role of institutions in economic growth, and institutions include formal rules such as laws and regulations, and informal constraints such as customs, norms and cultures (North, 1990). Among the institutions, NGT emphasizes the importance of government policy and regulations, education, intellectual property right protection, and corruption for economic growth, but seems to be short of assessing the role of cultural proximity in technology spillover. This can be supplemented by our discussion of the relationship between cultural proximity and technology absorption from the angle of RBV as follows.

As mentioned earlier, there are two main types of foreign investors in China: overseas Chinese from Hong Kong, Macau and Taiwan (HMT-MNEs), and foreign firms from the rest of the world, mainly from developed economies (Other-MNEs). Their average shares in China's total inward FDI flows between 2000 and 2008 were 40% and 60% respectively (PRC National Bureau of Statistics, various years). Other-MNEs often possess intangible assets such as leading-edge technology, brand names, and efficient international marketing networks. By comparison, HMT-MNEs are not on world frontiers of technology and organizational sophistication, although they are good at adapting mature technologies to more labor-intensive contexts and to local raw materials (Chiu, 1995; Yang, 1997; Zhang, 2005).

The relative positions of TC possessed by HMT-MNEs and Other-MNEs in Chinese manufacturing offer an opportunity for testing TGH at the firm level. Following TGH and without considering cultural proximity, we argue that local firms can experience faster catch-up with Other-MNEs than with HMT-MNEs. The reason is that, since HMT-MNEs are behind Other-MNEs in terms of technology, the technological gap of local Chinese firms with HMT-MNEs is smaller than that with Other-MNEs. Therefore, it is expected that local firms experience a higher speed of catch-up with Other-MNEs than with HMT-MNEs, as a larger technology gap implies a greater opportunity for local firms to learn, and therefore offers greater potential for a large leap.

On the other hand, since local Chinese firms share a similar culture with HMT-MNEs, knowledge from HMT-MNEs can be more efficiently diffused and absorbed by local Chinese firms than that from Other-MNEs, if their cultural proximity is not too close. Therefore, there is an offsetting effect on the prediction of TGH that local Chinese firms catch up with Other-MNEs more quickly than with HMT-MNEs. As a result, our hypothesis 2 (H2) is as follows:

H2: Cultural proximity enables local Chinese firms to catch up with HMT-MNEs at a speed not significantly lower than that with Other-MNEs.

In summary, the discussion in this section shows that NGT and RBV can and need to be integrated and extended to explain TGH at the firm level. NGT endorses catch-up at the macroeconomic level, and both NGT and RBV emphasize the importance of TC for catch-up. Both NGT and RBV need to be extended to explain the role of cultural proximity in knowledge diffusion, absorption and catch-up. Although NGT and RBV are similar in focusing on TC, they are complementary in discussing the external knowledge sources and the role of technology gap. If we combine and extend both theories by incorporating cultural factors into an analytical framework, it can be argued that the simple positive relationship between technology gap and catch-up as predicted by the traditional TGH may need to be modified due to the presence of cultural proximity. Such an analytical framework may be more suitable for the catch-up of latecomer firms with MNEs in an emerging economy.

DATA, MODEL, MEASUREMENT AND ESTIMATION METHODS

The main data source for the empirical study is the Annual Industrial Survey Database of the Chinese National Bureau of Statistics (NBS). This database covers all firms in Chinese manufacturing, with annual sales of at least RMB 5 million in the year prior to the survey. The full sample is an unbalanced panel data set covering on average 200,000 firms in each year for successive 10 years (1998-2007). The same firms can be identified based on their identifiers. The data set was carefully checked. A number of incorrect entries (such as wrong firm identity, ownership and industry codes and negative values of employees) were identified and either removed or corrected using both computing programs and manual comparisons of time series data. The detailed distribution by year and ownership is provided in Appendix A. For deflators, consumer price indexes are obtained from *China Statistical Yearbook 2009*.

The model

Consider a general production function

$$Y_{ijt} = A_{ijt} f(X_{ijt}) \qquad (1)$$

where i, j and t refer to the firm, industry and time indicators respectively. Y is output and X stands for a vector of inputs including physical capital, labor and intermediate inputs. A is an index of technical efficiency or total factor productivity (TFP). TFP in a non-frontier firm i is assumed to be affected by its TC via technology spillovers from the frontier firms in addition to its own R&D and other international technology spillovers in an industry according to ADL(1, 1) cointegrating relationship

$$lnA_{ijt} = \beta_1 lnA_{ijt-1} + \beta_2 lnA^F_{jt} + \beta_3 lnA^F_{jt-1} + Z_{ijt}\gamma + \varepsilon_{ijt} \quad (2)$$

where A^F is the TFP level of foreign-invested firms on the frontier. Z is a vector of variables including a firm's own R&D and technology spillovers from FDI and exports. It also contains a set of dummy variables for industry (2-digit), region and year in order to allow industry differences such as capital and infrastructure, regional differences such as institution environment, geographical distance from material inputs and export markets and geographical clustering effects, and time effects associated with exogenous technological changes and macroeconomic fluctuations. γ is a vector of parameters. ε is an error term. If there is catch-up or convergence, $0 < \beta_1 < 1$.

Assuming long-run homogeneity ($1 - \beta_1 = \beta_2 + \beta_3$), equation (2) can be transformed as

$$\Delta lnA_{ijt} = \beta_2 \Delta lnA^F_{jt} + (1-\beta_1) ln\left(\frac{A^F_j}{A_{ij}}\right)_{t-1} + Z_{ijt}\gamma + \varepsilon_{ijt} \quad (3)$$

The first term on the right hand of equation (3) (ΔlnA^F_{jt}) is TFP growth in the frontier of industry j. Its coefficient β_2 captures the link between TFP growth in non-frontier firms and growth in the frontier. The second term is technology gap between firm j and the frontier. The larger the technology gap, i.e. the larger the value of $ln\left(\frac{A^F_j}{A_{ij}}\right)_{t-1}$, the greater the potential for catching up or convergence. $(1 - \beta_1)$ therefore reflects the speed of catching up and is expected to be positive, with a larger value of $(1 - \beta_1)$ indicating faster speed of catching up and 0 no convergence.

Variable measurements

TFP: There are a number of alternative ways of measuring TFP including an index number, data envelopment analysis, stochastic frontier analysis, instrumental variable estimation technique and semi-parametric estimation technique. Van Biesebroeck (2007) provides a detailed review and shows Olley and Pakes (1996) (OP) method is remarkably robust to different forms of measurement and specification errors based on Monte Carlo simulations. This method is modified by Levinsohn and Petrin (2003). Both methods control for simultaneity bias and selection bias, but their main difference is the proxy used. There are reasons to believe that firms adjust their inputs according to their expectations (Griliches & Mairesse, 1995), so input levels are most likely correlated with idiosyncratic shocks in productivity captured in the error term. The principle of the proxy methods is to use another decision by the firm to provide separate information on the unobserved productivity term. In Olley and Pakes (1996), investment is assumed to be a monotonic function of productivity. However, with this method, firms with zero investment are excluded from the sample. Levinsohn and Petrin (2003) propose to use intermediate inputs as a proxy. They highlight three advantages of using intermediate inputs as compared with using investment. First, there is a stronger link between economic theory and estimation with intermediate inputs as a valid proxy. Second, intermediate inputs respond to the entire productivity term, whereas investments partially respond to the 'news' in the unobserved term. Third, firms usually have positive intermediate inputs though often incur zero investment. In this paper, Levinsohn and Petrin (2003) method is used. A brief description of the Levinsohn-Petrin estimation procedure is provided in Appendix B.

Industrial frontier: An important methodological question is how to define the international technological frontier. We use the average level of the estimated TFP of the top 5% percentile of foreign-invested firms in a given 4-digit industry as the benchmark for the frontier[i]. As noted by Sabirianova, et al. (2005), this measure is superior to the alternatives of using top firms operating in developed countries as the benchmark because the latter are plagued by problems associated with exchange rate fluctuations and country differences in macroeconomic factors and institutions. In addition, in the context of our study – China, the majority of the world's largest MNEs (Fortune 500) have made investments in the country. Therefore, the Chinese national frontier is likely to mimic the world frontier. We then measure technology gap as the firm's distance from the frontier.

Figure 1 shows the domestic frontier, foreign frontier and the average technology gap between domestic firms and foreign frontier. From the figure on the left, the overall trend of labor productivity was upward, although its growth rate in 2007 reduced to the level of 1998. There is not a clear growth pattern for TFP[ii]. As indicated in the figure on the right, the domestic frontier is persistently smaller than the foreign one, showing that the average TFP of the top 5% local firms is persistently lower than that of their MNE counterpart in Chinese manufacturing. However, the technology gap seems to be narrowing over the sample period, providing evidence of local Chinese firms' catch-up with MNEs. As a result, this has addressed the first research question: Is there any catch-up of local firms with MNEs in an emerging economy like China?

Insert Figure 1 here

Technological capability (TC): There is no consensus on how to define and measure TC. In Lall (1995), TC is firm-specific, and made up of the combined technical, organizational and institutional skills and experience of its members. Kogut and Chang (1991) suggest that R&D expenditure and innovation are important indicators of TC. Anand and Kogut (1997) emphasize the importance of intangible assets in TC which embodies the firm's competitive advantage over rivals. More recently, Renko, et al. (2009) suggest that patents and a firm's extensive investments in R&D are indicators of a superior TC. Just as TC has numerous dimensions, their sources or determinants are diverse (James & Romijn, 1997). Ju, et al. (2013) employ the data envelopment analysis (DEA) approach to uncover the input/output conversion ability which is then used to measure TC. However, in the catch-up literature, R&D or knowledge stock is often emphasized. Albaladejo and Romijn (2000) suggest that TC is the knowledge and skills required for firms to choose, install, operate, maintain, adapt, improve and develop technologies. Pakes and Griliches (1984), Cockburn and Griliches (1988) and DeCarolis and Deeds (1999) use R&D expenditures, patents or a combination of the two to measure a firm's TC. Anand and Kogut (1997) and Coombs and Bierly (2006) emphasize the importance of intangible assets in a firm's TC as they are usually difficult for competitors to imitate. Cohen and Levinthal (1990) pay special attention to absorptive capacity. As discussed earlier, both NGT and RBV emphasize TC for economic growth or firm competitiveness.

As there are numerous dimensions of TC (Coombs & Bierly, 2006), no single indicator can claim to be the comprehensive measure of all of them. In our dataset, the information on R&D expenditure (as an input indicator of TC) is available only for five years from 2003 onwards, and that on intangible assets (as an output indicator of TC) is available for the whole sample period. As a result, we mainly use the output indicator of TC. We also use the input indicator of TC[iii] for a sub-sample with the latest five-year data for comparison.

The importance of external sources of knowledge for TC is also emphasized in both NGT and RBV. Since international trade and FDI are the widely recognized channels for knowledge diffusion, we use these two variables to capture the sources of advanced technology for local firms to develop their TC and catch-up. Particularly, we focus on the spillover effects of FDI in Chinese manufacturing and local firms' exports. We were unable to include imports into our model as the information is unavailable from our dataset. Various measures of foreign presence to capture FDI spillovers have been proposed in the literature (Wei & Liu, 2006). Recent examples include the employment/capital/fixed assets/sales share of foreign-invested firms in a 3-digit industry, depending on data availability. Different measures may capture different aspects of foreign presence (Wei & Liu, 2006). Our rich dataset allows us to use all of these measures to check the robustness of the results. Export spillovers are measured by the share of local firms' exports excluding the focal firm in sales of the 3-digit industry.

Cultural proximity: Cultural proximity (or distance) is most frequently measured by Hofstede's (1980) cultural values, and particularly by Kogut and Singh's (1988) composite index of Hofstede's (1980) individual indices of culture, although Schwartz's (1994, 1999) framework is also applied in some studies (e.g. Drogendijk & Slangen, 2006). Kogut and Singh's index has been criticized due to its illusions of symmetry, stability, linearity, causality and discordance (Shenkar, 2001; Shenkar, 2012). However, as it provides easily calculated measure of difference between any two countries, this index enjoys continued popularity (Zaheer, et al., 2012). Recent applications include Håkanson and Ambos (2010) where the cultural distance between two countries is calculated as the average of the differences of Hofstede's (1980) country scores adjusted by the variance of the corresponding dimension, and Schmitt and Van Biesebroeck (2013) where the Mahalanobis distance over Hofstede's (1980) cultural dimensions is calculated.

As indicated in hypothesis 2, the main aim of our study is to assess the role of cultural proximity in local Chinese firms' catch-up with two types of foreign investors respectively: HMT and Other-MNEs. Based on the above-mentioned cultural proximity measures, HMT-MNEs are much culturally closer to local Chinese firms than Other-MNEs. Accordingly, instead of creating a cultural proximity variable for each MNE, we simply divide MNEs into these two groups. We then estimate model 3 and compare the significance level and magnitude of the coefficient on the speed of catch-up by local Chinese firms with Other-MNEs (i.e. $1 - \beta_1$) and those of local Chinese firms with HMT-MNEs (results to be reported in table 4). Greater magnitude, controlling for other important factors, would indicate that cultural proximity does help knowledge diffusion and catch-up. In other words, for the purposes of this study, there is no need to directly measure cultural proximity (or distance) between local Chinese firms and MNEs on an individual basis, as we focus on a direct comparison of the speed of catch-up by local Chinese firms with two broad types MNEs: one with very similar cultures and the other with relatively distant cultures. We believe that this is a novel way to test a cultural proximity related hypothesis: we measure the importance of cultural proximity in the model by comparing its impact on local firms' speeds of catch-up, controlling for other important variables.

Estimation strategy

Given that the focus of the paper is on local Chinese firms' catch-up, following Wei and Liu (2006), our econometric estimations are confined to this group of firms only. Pooling domestic and foreign firms together imposes a condition of the same slope for domestic and foreign firms. There are considerable differences between the two groups of firms in China. Based on our dataset, foreign-invested firms on average perform better than domestic firms according to various measures, including labor productivity (measure by the ratio of value added to employment), sales and profits.

In order to control for the region-, industry- and year-effects and correct for the correlation between error terms for local firms in the same industry-year pairs, the region-, industry- and year dummies are included in the estimation and the standard errors are clustered by industry-year.

MAIN RESULTS AND DISCUSSION

Table 1 provides summary statistics and correlation matrix of the variables. As the values of the correlation coefficients are very low, there is little concern over multicollinearity for models without interaction terms.

Insert Tables 1-3 here

Tables 2 and 3 present the main findings based on the estimation of variants of equation (3). Table 2 reports the results when firms' TC is measured by intangible assets. Table 3 shows the results when TC is measured by R&D expenditure. The results from different measures of foreign presence are included for comparison. For each measure, there are two main sets of results. The first set is a group of general spillover regressions in first differences, regressing TFP growth on changes in R&D and spillovers in addition to changes in the frontier and lagged technology gap variables. As the process of catching up with the frontier can be enhanced by a firm's TC, in the second group we include the interaction term of this variable with the technology gap as an additional explanatory variable.

Starting from our key variable of interest, technology gap in column (2.1), it is positive and statistically significant, indicating a strong catch-up effect in China, given technology spillovers from FDI and trade and local firms' R&D efforts. As the coefficient is around 0.44, the estimated β_1 (the speed of catch up) is around 0.56. This confirms part of H1, i.e. the greater the technology gap between local firms and MNEs, the more likely the local firms is to catch up with MNEs.

Turning to the FDI spillover variable measured by the employment share, its coefficient is positive and significant, confirming a positive impact of foreign presence in Chinese manufacturing. Export_Spillover is also positive and highly significant, showing that firms' productivity growth benefits from knowledge absorption via exports. Firms' intangible asset intensity is positive and highly significant, confirming the importance of own R&D efforts for the growth in TFP. Since the coefficients on all the three variables – TC, trade and FDI – are positive and statistically significant, part of H1 is supported, i.e. the higher the international trade and inward FDI, and the stronger the local firms' own R&D efforts, the more likely the local firms is to catch up with MNEs.

The coefficient on the foreign frontier is positive and highly significant, showing that a local firm's productivity is directly linked to the change in the world frontier. The outward shifting of the frontier has a positive impact on the outward shifting of a Chinese firm's technology level. This may also have captured the productivity spillover effects of the top 5% MNEs in Chinese manufacturing. They may have produced the demonstration effects from which local firms have benefited.

Compared with column (2.1), the results in column (2.2) have an additional variable – the interaction term of intangible assets and technology gap. This interaction term is positive and highly significant, further confirming the positive relationship between technology gap and a firm's R&D efforts for catch-up.

The discussion of the results from columns (2.1) to (2.2) can be readily extended to the remaining columns of table 2. While there are variations in the impact of foreign presence when it is measured by capital, fixed assets and sales, the coefficients on all other variables in these equations are consistently positive and highly significant, lending support to H1.

Table 3 uses R&D expenditure to measure R&D efforts. The overall results are qualitatively the same as those in table 2 except that the coefficient on the R&D intensity variable is consistently insignificant when the interaction term of this variable and technology gap is introduced (columns 3.2, 3.4, 3.6, and 3.8). This is caused by the high correlation between R&D intensity and its interaction term with technology gap.

Overall, the results from tables 2 & 3 provide the answer to the second part of question 2, i.e., what explain the catch-up of local firms with MNEs in Chinese manufacturing? In the case of China, technology gap, local firms' own R&D efforts, and technology spillovers from exports and to some extent the very presence of MNEs are the determinants of the catch-up.

Although there have been some cross-country or cross-region catch-up studies, little research is reported in the existing literature on possible catch-up of local firms with MNEs. It must be noted that the term 'catch-up' is often used in the international technology spillover literature, but it in most cases is meant to say that technology gap is a precondition for local firms to learn and benefit from their trading partners or MNEs, rather than that the income or productivity gap is reduced between the trading countries or between local firms and MNEs. Examples include Kokko (1994, 1996), Sjoholm (1999), Peri and Urban (2006) and Liu et al. (2009). Although FDI and international trade can greatly facilitate knowledge diffusion to local firms in a developing or an emerging economy, this does not necessarily mean the existence of any catch-up. Catch-up is a dynamic process. While followers try to come abreast with leaders, the leaders attempt to stay ahead (Halmenschlager, 2006). Our examination of the catch-up of local firms with MNEs is based on the combination of both NGT and RBV, and conducted in such a dynamic context. Our study should contribute to both theoretical and empirical literature on TGH.

So far we have examined the economics or business determinants of catch-up: technology gap, local firms' TC, international trade and FDI. We understand that technology gap of local firms with Other-MNEs is greater than that with HMT-MNEs. Based on the test results for H1, one tends to conclude that the speed of catch-up of local firms with Other-MNEs would be greater than that with HMT-MNEs. However, in H2, we argue that cultural proximity leads to the efficiency of knowledge diffusion and absorption, and therefore, helps catch-up. If this is the case, then the prediction of H1 may need to be altered. To test H2, we separate the frontier of HMT-MNEs and technology gap between local firms and HMT-MNEs from the frontier of Other-MNEs and technology gap between local firms and Other-MNEs, and test whether there is a significant difference in the speed of catch-up of local firms with these two types of MNEs.

The results for H2 test are reported in table 4. In columns (4.1)-(4.4), the intangible assets are used as a proxy of a local firm's R&D efforts, while in columns (4.5)-(4.8), R&D is used. The coefficient on Exports_spillovers is positive and highly significant, and that on intangible assets and R&D is positive and significant at the 5% level, indicating the importance of technology spillover from trade and a firm's own R&D efforts in TFP growth in all columns. The impacts of the presence of HMT-MNEs and Other-MNEs are inconclusive as different results emerge when the different measures (labor, capital, fixed assets and sales in columns 4.1 & 4.5, 4.2 & 4.6, 4.3 & 4.7 and 4.4 & 4.8 respectively). As explained earlier, this may be explained by the fact that some FDI spillover effects are captured by the foreign frontier variables. The overall results about the TC variables in table 4 are quite consistent with those reported in table 2.

Insert Table 4 here

Also from table 4, the coefficients on the HMT frontier and other foreign frontier are both positive and highly significant in all columns, indicating that a local firm's productivity is directly linked to the change in the foreign frontiers. The outward shifting of both HMT and other foreign frontier has a positive impact on TFP growth of local firms.

Finally, the coefficients on the respective technology gaps of local firms with HMT-MNEs and Other-MNEs are also positive and highly significant, indicating that the greater the technology gap of local firms with either HMT-MNEs or Other-MNEs, the more quickly the local firms catch up.

To test H2, we examine whether the coefficient on technology gap of local firms with HMT-MNEs is significantly different from that with Other-MNEs. As indicated in the bottom part of each column in table 4, the coefficients are statistically insignificant. This means that these coefficients are not statistically different from each other, indicating that the speed of catch-up of local firms with Other MNE is not significantly higher than that with HMT-MNEs. Therefore, H2 is supported.

Although the role of cultural values in knowledge diffusion is examined in several studies such as Kedia and Bhagat (1988), Keller and Chinta (1990), Boschma (1999), Palich and Gomez-Mejia (1999) and Hussler (2004), the current research provides a theoretical foundation and discuss this effect in a dynamic context of local firms' knowledge learning and absorption and catch-up with MNEs. Our findings suggest that the traditional TGH may not always hold when cultural proximity is present. Although there can be a positive relationship between technology gap and catch-up, cultural proximity helps culturally close firms to communicate and diffuse knowledge efficiently and enables latecomer firms to catch up relatively quickly. Our study combines and applies NGT and RBV at the firm level, incorporates the role of culture into TGH, and should contribute to the development and refinement of catch-up research.

CONCLUSIONS

This paper has integrated and extended NGT and RBV in order to provide a theoretical foundation for the technology gap hypothesis. Particularly we have extended the exiting literature by assessing the role of cultural proximity in productivity catch-up. Our results indicate that catch-up is positively related to technology gap and local firms' TC which measured by own R&D efforts and technology spillovers from international trade and FDI. Given the larger technology gap of local firms with Other-

MNEs than that with HMT-MNEs, local Chinese firms are expected to catch up with Other-MNEs at a higher rate than with HMT-MNEs, as suggested by the traditional TGH. However, in the presence of cultural proximity, the speed of local Chinese firms' catch-up with HMT-MNEs is not significantly lower than that with Other-MNEs. This suggests that cultural proximity moderates the predication of the traditional TGH.

The current research is believed to have enhanced our knowledge in catch-up analysis both theoretically and empirically. In the former case, we have combined the main ideas of NGT which is an aggregate theory of growth with RBV which focuses on firm level competitiveness to explain catch-up of local firms with MNEs as both theories are complementary with each other. We have emphasized the role of R&D, international trade and FDI in knowledge diffusion and catch-up. More importantly, our integrated theoretical framework is further extended to incorporate cultural proximity. This addition is important as it can modify the traditional TGH's prediction that there is a positive relationship between technology gap and catch-up. Specifically, culturally close firms can enjoy efficient communication and knowledge diffusion. As a result, other things being equal, the speed of catch-up with culturally close MNEs will be higher than that with culturally distant MNEs. Empirically, we are among the first to study productivity catch-up of local firms with MNEs in an emerging economy. The results are based on a very large firm-level panel dataset with a dynamic approach, and have supported our hypothesis about the importance of cultural proximity in catch-up.

This study offers some important managerial and policy implications. Firstly, managers need to know that knowledge diffusion and catch-up are not culture-free. For managers of MNEs, in order to effectively transfer knowledge from MNE parent firms to their subsidiaries, R&D and management expatriates need to familiarize themselves with host country cultures. Host country nationals can also be engaged in the management of knowledge transfer and creation. This facilitates inter-cultural communications, and helps subsidiaries to build up their knowledge stock and improve their competitiveness in host economies. On the other hand, while emerging-economy local firms can continue to take advantage of cultural proximity to learn effectively from emerging-economy MNEs with similar cultural backgrounds, they need to realize that too much cultural proximity may be unfavorable for new ideas and innovation as this may lead to inward-looking networks which provide little opportunities for newcomers, and hinder knowledge diffusion and creation. In other words, they need to be open and flexible (Boschma, 1999). Particularly, they need to understand developed-economy cultures so that they can improve their efficiency of learning, imitation and then innovation and catch-up. Developed-economy MNEs possess more advanced technologies than emerging-economy counterparts, and local firms can learn more from the former than from the latter.

In addition, since R&D efforts are important for competitiveness and catch-up, emerging-economy local firms need to put efforts to technology improvement and innovation. While this a straightforward managerial implication from this and many other studies, emerging-economy local firms often do not have strong incentives to do so due to problems of intellectual property right protection. As a result, emerging economy governments need to establish and improve formal institutions to promote more interactive learning and innovation. Emerging economy governments also need to support R&D so that their firms and industries can become competitive internationally. Several emerging economies like China, India and Brazil have already put their R&D and innovation higher on their policy agenda, but they have still been unable to break into the top positions in global innovation (OECD, 2012). Therefore, further and greater efforts are needed by emerging economies to encourage and support their innovative activities. On the other hand, in order to stay ahead, MNEs need to continue their R&D efforts to maintain their global competitive position. Finally, emerging-economy local firms need to realize the importance of international trade and FDI as the sources of knowledge. Engaging in trade and absorbing knowledge which spills from FDI helps emerging economy firms to improve their knowledge stock and conduct innovation.

One of the limitations of this study is related to the dataset. While R&D expenditure is an important measure of a firm's TC, the data available for this variable are for five years only. As a result, we are unable to estimate the full sample using this as a measure. Secondly, the data on imports are unavailable. As a result, we are unable to assess the role of this important channel for knowledge diffusion and catch-up. A second limitation is related to the assessment of the role of cultural proximity. While we are able to distinguish between the Chinese and non-Chinese culture, we cannot further identify the country of origin of Other-MNEs due to lack of information.

A third important limitation is the measure of cultural proximity. Literature on technological learning suggests that knowledge exchange and diffusion between firms is influenced not only by their cultural proximity (Gertler, 2004), but also by their geographical, social, cognitive, and organizational proximity, and other parts than cultural elements of institutional proximity (Boschma, 2005; Torre & Rallet, 2005). It is important to control for the other dimensions of proximity in order to single out cultural proximity as the critical explanatory variables for catch-up.[iv] However, different dimensions of proximity are often closely linked, for instance, shared informal institutions (such as culture) are often much more geographically localized (e.g., at the level of the community). Therefore, good analytical conceptualization is needed before one can really isolate and identify individual impact of each dimension (Boschma, 2005). Some attempts have recently been made on measures and one example is Broekel and Boschma (2012) who have tried quantitative measures of cognitive, social, organizational and geographical proximity. However, as discussed in the conclusion section of their paper, their measures may not exclude overlaps of different dimensions of proximity. In our secondary dataset, we do not have detailed information on proximity. However, our cultural proximity may capture social proximity as HMT-MNEs have much more social connections (such as family links) with local Chinese firms than Other-MNEs. Therefore, our results on the role of cultural proximity in catch-up need to be interpreted with caution.

Notes:

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[i] In robustness check, we also used other benchmarks, e.g. top 1% and top 10% percentile of foreign firms and top 1%, top 5% and top 10% percentile of all firms. The results are broadly similar and are available upon request.

[ii] It is noted that the TPF growth was negative in 2002. A possible explanation is as follows. There were excessive investments in fixed capital due to the Chinese government's proactive fiscal policy, the issue of 150 billion yuan worth government bonds, and deregulation of investment approval in 2002 (Zhang, 2002). Some of such vast investment may not immediately form productive facilities, and therefore cause the calculated TFP growth to be smaller than the previous year. This might in turn increase the technology gap in 2004, as indicated in the right part of the diagram.

[iii] Although R&D expenditure is widely used as a measure of TC, one problem is that small or medium companies may not register and report their innovation-oriented efforts as "R&D". We thank one referee for this comment.

[iv] We thank one referee for this comment.

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Appendix A: Distribution of Firms in China, 1998-2007

The detailed distribution of firms in Chinese manufacturing by year and by ownership is provided in table A1. A firm is defined to be domestically-owned, if its foreign equity participation is below 25%.

Table A1: Full Sample Distribution

year	Total	No. of Domestically-owned Firms	No. of Foreign-invested Firms	Of which No. of Firms with HMT FDI	No. of Firms with Other FDI
1998	164,934	138,492	26,442	15,722	10,720
1999	161,850	135,025	26,825	15,775	11,050
2000	162,723	134,285	28,438	16,487	11,951
2001	171,099	139,681	31,418	18,254	13,164
2002	181,415	146,954	34,461	19,543	14,918
2003	196,185	157,608	38,577	21,149	17,428
2004	270,380	215,178	55,202	27,481	27,721
2005	265,729	210,728	55,001	26,863	28,138
2006	301,931	241,062	60,869	29,180	31,689
2007	336,743	269,288	67,455	31,948	35,507

Table A2: Final Sample Distribution

year	Total	No. of Domestically-owned Firms	No. of Foreign-invested Firms	Of which No. of Firms with HMT FDI	No. of Firms with Other FDI
1999	111,402	91,010	20,392	11,870	8,522
2000	109,594	88,196	21,398	12,440	8,958
2001	104,526	82,108	22,418	13,067	9,351
2002	123,379	97,388	25,991	14,995	10,996
2003	127,570	99,225	28,345	15,765	12,580
2004	123,921	92,692	31,229	15,802	15,427
2005	141,193	106,750	34,443	16,854	17,589
2006	219,318	169,563	49,755	24,412	25,343
2007	251,498	195,681	55,817	26,696	29,121

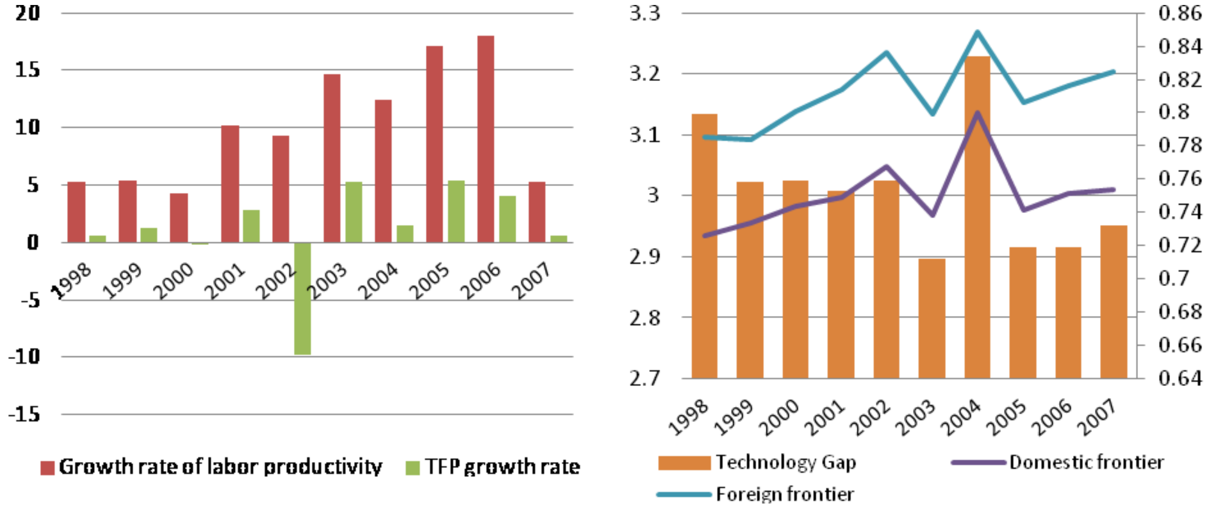
Appendix B: Levinsohn-Petrin Estimation Procedure

A full description of Levinsohn-Petrin estimation is beyond the scope of this paper (interested readers are referred to Levinsohn and Petrin (2003)). To aid the discussion of this paper, below provides a brief sketch of the procedure. The estimation method starts with the following function:

$$y_t = c_0 + c_1 l_t + c_2 k_t + c_3 m_t + \omega_t + \eta_t \qquad (1)$$

where y_t, l_t, k_t and m_t are the logarithm of value added, labor, capital and intermediate inputs, respectively, η_t is the i.i.d. component of the disturbance term, and ω_t is the state dependent unobserved productivity. The assumptions on labor and capital are that the former is a variable input and the latter a state variable. Demand for the intermediate inputs is assumed to be a function of capital and the state dependent productivity term: $m_t = m_t(k_t;\ \omega_t)$. When this demand function is monotonically increasing in ω_t, one can express ω_t by inverting the intermediate inputs demand function. In this case, the unobservable productivity is expressed in terms of observable variables. A final assumption required for the identification of the parameters of the production function is that ω_t follows a first order Markov process: $\omega_t = E(\omega_t|\omega_{t-1}) + \xi_t$,, where ξ_t is an innovation to productivity that is uncorrelated with k_t (Levinsohn and Petrin, 2003). With this model in hand, one can consistently estimate the parameters of the function (1).

Figure 1: Productivity growth, technology gap and frontiers, 1998-2007



Notes:

1. Frontier data use the 5% benchmark.
2. Technology gap = Distance of domestic firms' TFP to the foreign frontier
3. In the figure on the right, domestic frontier and foreign frontier follow the left-hand axis and technology gap follows the right hand axis.

Table 1: Summary Statistics and Correlation Matrix

Variable	*Mean*	*Std. Dev.*	*2.*	*3.*	*4.*	*5.*	*6.*
1. Δlog(TFP)	0.0177	0.6377					
2. ΔFDI_spillovers	0.0097	0.0589					
3. ΔExports_spillovers	-0.0025	0.0307	0.0153				
4. ΔIntangible_assets	-0.0385	14.4457	0.0028	-0.0001			
5. ΔR&D	0.0033	1.0698	0.0008	0.0006			
6. ΔFrontier	0.0136	0.6541	0.1308	0.0164	0.0001	0.0001	
7. Gap_{-1}	0.7391	0.6104	-0.0128	0.0233	0.0059	0.0059	-0.1963

Notes:

1. Δ is the first difference operator.
2. log(TFP) = the logarithm of TFP obtained by using Levinsohn-Petrin Estimation Procedure.
3. FDI_Spillovers = the share of foreign invested firms' employment in total employment in a four-digit industry.
   Exports_spillover = the ratio of exports by all other domestic firms (the firm's own exports are excluded) to sales in a four-digit industry.
   Intangible assets = the ratio of intangible assets to sales.
   ΔR&D = lagged R&D expenditure to sales.
   Frontier = the average level of the estimated TFP of the top 5%%ile of foreign firms in a four-digit industry.
   Gap_{-1} = lagged difference between firm's own TFP and Frontier.

Table 2: Estimation results, TC = Intangible assets

FDI spillover measurement	(2.1) Employment	(2.2) Employment	(2.3) Capital	(2.4) Capital	(2.5) Fixed assets	(2.6) Fixed assets	(2.7) Sales	(2.8) Sales
ΔFDI_spillovers	0.132*	0.132*	0.066	0.066	0.065	0.065	-0.104*	-0.104*
	[0.066]	[0.066]	[0.046]	[0.046]	[0.045]	[0.045]	[0.046]	[0.046]
ΔExports_spillover	0.347**	0.347**	0.347**	0.347**	0.356**	0.356**	0.323**	0.323**
	[0.077]	[0.077]	[0.077]	[0.077]	[0.079]	[0.079]	[0.078]	[0.078]
ΔFrontier	0.722**	0.722**	0.723**	0.723**	0.722**	0.722**	0.725**	0.725**
	[0.036]	[0.036]	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]
Gap_{-1}	0.436**	0.436**	0.437**	0.437**	0.437**	0.437**	0.437**	0.437**
	[0.023]	[0.023]	[0.023]	[0.023]	[0.023]	[0.023]	[0.023]	[0.023]
ΔIntangible_assets (x10^{-3})	0.065**	0.122**	0.066**	0.123**	0.065**	0.123**	0.066**	0.124**
	[0.024]	[0.038]	[0.025]	[0.038]	[0.025]	[0.038]	[0.025]	[0.038]
ΔIntangible_assets x Gap_{-1} (x10^{-3})		0.157**		0.157**		0.158**		0.158**
		[0.054]		[0.054]		[0.054]		[0.054]
adj. R^2	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530

Notes: For variable definitions, please see table 1. FDI_Spillovers = the share of foreign-invested firms' employment/capital/fixed assets/sales in total employment/capital/fixed assets/sales in a 4-digit industry. Sample size = 1,017,876. Standard errors clustered by industry-year in brackets. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$. All regressions include region-, industry- and year-fixed effects.

Table 3: Estimation results, TC = R&D

FDI spillover measurement	(3.1) Employment	(3.2) Employment	(3.3) Capital	(3.4) Capital	(3.5) Fixed assets	(3.6) Fixed assets	(3.7) Sales	(3.8) Sales
ΔFDI_spillovers	0.096	0.096	0.102	0.102	0.034	0.034	-0.164**	-0.164**
	[0.079]	[0.079]	[0.077]	[0.077]	[0.063]	[0.063]	[0.063]	[0.063]
ΔExports_spillover	0.374**	0.374**	0.372**	0.372**	0.376**	0.377**	0.338**	0.338**
	[0.083]	[0.083]	[0.083]	[0.083]	[0.083]	[0.083]	[0.083]	[0.083]
ΔFrontier	0.757**	0.757**	0.758**	0.758**	0.758**	0.758**	0.760**	0.760**
	[0.036]	[0.036]	[0.036]	[0.036]	[0.036]	[0.036]	[0.035]	[0.035]
Gap_{-1}	0.442**	0.442**	0.442**	0.442**	0.442**	0.442**	0.442**	0.442**
	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]
ΔR&D	0.002**	-0.042	0.002**	-0.043	0.002**	-0.042	0.002**	-0.042
	[0.000]	[0.066]	[0.000]	[0.067]	[0.000]	[0.067]	[0.000]	[0.067]
ΔR&D x Gap_{-1}		0.015		0.015		0.015		0.015
		[0.022]		[0.022]		[0.022]		[0.022]
adj. R^2	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578

Notes: For variable definitions, please see table 1. FDI_Spillovers = the share of foreign-invested firms' employment/capital/fixed assets/sales in total employment/capital/fixed assets/sales in a 4-digit industry. Sample size = 561,857. Standard errors clustered by industry-year in brackets. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$. All regressions include region-, industry- and year-fixed effects.

Table 4: Results that separate frontier growth of HMT and other foreign firms

FDI spillover measurement	(4.1) Employment	(4.2) Capital	(4.3) Fixed assets	(4.4) Sales	(4.5) Employment	(4.6) Capital	(4.7) Fixed assets	(4.8) Sales
ΔHMT_spillovers	0.142*	0.063	0.105+	-0.007	0.152	0.113	0.076	-0.050
	[0.072]	[0.058]	[0.061]	[0.074]	[0.111]	[0.078]	[0.095]	[0.116]
ΔOther_spillovers	0.034	0.001	-0.050	-0.189**	-0.029	-0.060	-0.073	-0.216**
	[0.082]	[0.050]	[0.047]	[0.061]	[0.097]	[0.070]	[0.060]	
ΔExports_spillover	0.263**	0.265**	0.262**	0.228**	0.274**	0.276**	0.264**	0.231*
	[0.066]	[0.066]	[0.066]	[0.067]	[0.088]	[0.089]	[0.088]	[0.091]
ΔIntangible_assets (x10^{-3})	0.072*	0.072*	0.072*	0.072*				
	[0.029]	[0.029]	[0.029]	[0.029]				
ΔR&D					0.002**	0.002**	0.002**	0.002**
					[0.000]	[0.000]	[0.000]	[0.000]
ΔHMT_Frontier	0.404**	0.405**	0.404**	0.404**	0.314**	0.314**	0.314**	0.314**
	[0.050]	[0.050]	[0.051]	[0.051]	[0.068]	[0.068]	[0.068]	[0.069]
ΔOther_Frontier	0.334**	0.334**	0.335**	0.336**	0.440**	0.440**	0.441**	0.442**
	[0.052]	[0.052]	[0.052]	[0.052]	[0.066]	[0.066]	[0.066]	[0.066]
HMT_Gap$_{-1}$	0.243**	0.243**	0.243**	0.244**	0.155*	0.154*	0.154*	0.155*
	[0.051]	[0.051]	[0.051]	[0.051]	[0.065]	[0.065]	[0.065]	[0.065]
Other_Gap$_{-1}$	0.191**	0.191**	0.191**	0.191**	0.278**	0.278**	0.278**	0.277**
	[0.051]	[0.051]	[0.051]	[0.051]	[0.062]	[0.062]	[0.062]	[0.062]
Test: HMT_Gap$_{-1}$=Other_Gap$_{-1}$	0.27	0.27	0.27	0.28	0.99	0.99	0.99	0.97
ΔHMT_Frontier=ΔOther_Frontier	0.50	0.51	0.48	0.46	0.95	0.95	0.96	0.96
N	1,004,958	1,004,955	1,004,958	1,004,958	555,823	555,821	555,823	555,823
adj. R^2	0.538	0.538	0.538	0.538	0.574	0.574	0.574	0.574

Notes: For variable definitions, please see table 1. HMT_Spillovers = the share of HMT-invested firms' employment/capital/fixed assets/sales in total employment/capital/fixed assets/sales in a 4-digit industry. Non_HMT_Spillovers = the share of Other-foreign-invested firms' employment/capital/fixed assets/sales in total employment/capital/fixed assets/sales in a 4-digit industry. HMT_Gap$_{-1}$ = lagged difference between firm's own TFP and HMT-invested firm's Frontier. Other_Gap$_{-1}$ = lagged difference between firm's own TFP and Other-foreign invested firms' Frontier. Standard errors clustered by industry-year in brackets; $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$; All regressions include region-, industry- and year-fixed effects.