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Innovation and Productivity: Evidence from China

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Abstract

This paper investigates a lesser-known effect of innovation on the productivity of manufacturing firms in China using data that cover more than 330,000 firms across 40 sectors from 1998 to 2008. Innovation plays a key role in the productivity of firms and it matters for all types of firms, new as well as established. The ratio of new product output to the firm's total outputs is used to measure innovation ability in this paper. A higher ratio is expected to have a positive impact on a firm's productivity since new products are likely to be more differentiated than old products from other firms' goods, which allows for a higher mark-up and thus greater profits. Comparisons are conducted for different types of firms, domestic firms, foreign firms and Hong Kong, Macau, Taiwan-affiliated firms. I also implement different measures of productivity, such as total factor productivity and labor productivity. After controlling for a number of factors, I find a significantly positive relationship between innovation and productivity across all types of firms in China.

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1. Introduction

Foreign Direct Investment (FDI) flows to developing countries are constantly reaching new heights during recent years. As the world's largest economy, China recorded its largest ever FDI inflows in 2013, at around 124 billion dollars (UNCTAD, 2014). FDI is defined as investments in which the firm acquires a substantial controlling interest in a foreign firm or sets up a subsidiary in a foreign country (Markusen, 2004). There has been an increasing interest for countries, especially in the developing world, to attract FDI. As suggested by most literature, FDI is considered to bring various benefits to host countries, including capital, employment creation, technology spillover and economic growth.

In the view of most policy makers, both foreign investments and innovation are key drivers of economic growth. For instance, at Summer Davos 2013, Chinese Premier Keqiang Li reaffirmed that China welcomed foreign investments and foreign firms would be treated fairly, on an equal footing with domestic firms (Xinhua Net, September 11, 2014). In addition, he emphasized the catalyzing role innovation plays in ensuring China's future success.

Innovation can be measured by its inputs or by its outputs. Research and Development (R&D) expenditure and patent counts are two major proxies for innovation inputs. However, they both have strengths and weaknesses in terms of measuring innovation. Obviously R&D is crucial since it is an important factor that affects the development and introduction of product or process innovations. However, it is only an input and does not have the ability to capture the effectiveness of effort. Although patents also have the ability to reflect innovation ability, they only capture part of the investments. In addition, patent counts are highly sensitive to the intellectual property laws and framework within a country.

On the output side, Geroski, Machin and Reenen (1993) first propose the conceptual idea of innovative output. They investigate the relationship between corporate profitability and

innovation in the United Kingdom using the number of innovations produced as a proxy to measure innovative output and find innovation does not increase profitability. They argue that the approach they use to measure innovative output leads to their unique result. The Oslo Manual (2005) further distinguishes four types of innovation outputs, including: product, process, organizational and marketing innovation.

This paper studies a lesser-studied effect of new products on firms' productivity: how does a firm's introduction of a new product affect its productivity? Raw materials, labor and capital are the major determinants of productivity. However, innovation also plays a key role in the productivity of firms and it matters for all types of firms, new as well as established. As Schumpeter (1942) claims, innovation is a powerful vehicle for new firms to successfully enter the market and undermine established firms. Mohnen and Hall (2013) discuss the relationship between product innovation and productivity in details. They indicate that putting a new product on the market creates new sources of demand and thus can give rise to economies of scale in its production or to improved productivity. The authors also highlight that among the new products launched, some may be more successful than others, because they satisfy an immediate need for customers, or they nicely complement other products or services in the market. As a result of all these, the introduction of a new product is expected to influence productivity.

The ratio of outputs from new products to the firm's total outputs is a measure of revealed innovation ability (RIA). RIA aims to represent the firm's innovation ability and is used to measure innovation in this paper. A higher RIA is expected to have a positive impact on a firm's productivity since new products are likely to be more differentiated than old products from other firms' goods, which allows for a higher mark-up and thus greater profits.

This paper contributes to the existing literature in a number of ways. First, I use a new approach to reveal a firm's innovative ability, which is the ratio of new product outputs over

the firm's total outputs. Products appeared on the market within the year are counted as new products. Moreover, I separate firms into the following three subgroups according to their registration type: domestic firms, foreign-affiliated firms and Hong Kong, Macau and Taiwan (HMT)-affiliated firms. Huang, Jin and Qian (2013) question whether investments from Hong Kong, Macau and Taiwan should be classified in the same category as other foreign investments. They argue that Hong Kong is a known conduit for Western investments in China and most investments from Macau and Taiwan come from overseas Chinese. Moreover, it is widely believed that Taiwan, rather than Western countries, is the largest investor in China through Hong Kong. The reason behind this is associated with early political sensitivity with respect to direct investments from Taiwan. After separating firms according to their ownership type, Huang et. al notice that HMT-affiliated enterprises in China actually underperform non-HMT firms.

The manufacturing firm-level data I am using for this paper covers more than 330,000 firms with sales above 5 million RMB across 40 industries from 1998 to 2008. This dataset has been publicly available recently and is uniquely suited to this investigation since it not only contains detailed balance sheet information but also records values for new products output every year. To the best of my knowledge, to date it has not been used for this specific purpose, as I will document below in the discussion of the related literature.

The paper proceeds as follows. The next section reviews the related literature, including other work using different datasets for China. Then I present the empirical methodology, which is based on a simple theoretical model and includes a thorough description of TFP and labor productivity measurements. Following that, I present the underlying dataset and describe key variables used. Section 5 presents the results and Section 6 concludes.

2. Review of the Literature

This section is organized as follows. First, I summarize literature analyzing the relationship between FDI and productivity. Following that, section 2.2 provides background information on innovation and productivity. Then section 2.3 reviews studies on FDI and Chinese firms' innovation ability at the provincial level. Section 2.4 discusses studies that investigate innovation and productivity in China at firm level.

2.1 FDI and productivity

There are prominent country-specific analyses for developing countries. For example, Jordaan (2008) studies the effect of FDI in Mexico and concludes that the presence of FDI crates negative intra-industry externalities and positive inter-industry externalities. His findings suggest that FDI-externalities are stimulated by the technology gap between foreign firms and Mexican firms.

For Venezuela, Aitken and Harrison (1999) find that foreign equity participation has a positive impact on small domestic enterprises' productivity. Besides, they show that foreign investment has a negative effect on the productivity of domestically owned plants. Joint ventures appear to be the major beneficiary of foreign investment.

Waldkirch and Ofosu (2010) study the relationship between foreign presence and productivity in Ghana. They find that the presence of foreign firms in a sector negatively affects domestic-owned firms, but positively influences most foreign-owned firms.

For Lithuania, Javorcik (2004) produces evidence that positive spillover effects from FDI occur between foreign affiliates and their upstream local suppliers. The result indicates that spillovers exist for shared domestic and foreign ownership instead of fully foreign owned investments.

There is a fair amount of literature on this topic devoted to China. For instance, Hale and Long (2007) conduct a firm-level analysis using World Bank survey data for China and find

that FDI spillovers on the productivity of Chinese domestic firms are mixed. They fail to find evidence that supports positive productivity spillovers from FDI in China. Moreover, Liu (2008) distinguishes between productivity levels and productivity growth and concludes that there is a negative productivity level effect in the short run, and a positive growth effect in the long run. Furthermore, Xu and Sheng (2012) analyze the spillover effect of FDI on domestic Chinese firms using manufacturing firm data between 2000 and 2003. They conclude that positive spillovers from FDI arise from forward linkages where domestic firms purchase high-quality goods from upstream foreign firms. Their result also suggests that large and medium-sized, non-stated-owned and exporting firms are more likely to benefit from the presence of foreign firms in China.

There are a number of cross-country analyses. For instance, Görg and Strobl (2001) conducted a meta-analysis on multinational companies and productivity spillovers by collecting information from a sample of papers. Their findings indicate that definitions of the presence of multinationals may have an effect on the results. In addition, they find that it is more likely for cross-sectional studies to overstate the productivity spillover effect and panel data would allow researcher to control for time-invariant factors.

Wooster and Diebel's (2010) meta-analysis reviews 32 developing country studies and finds that the FDI spillover effect is more likely to be significant and positive for Asian countries. It also suggests that studies that use firm-level data tend to find insignificant or negative spillover effects from foreign-owned firms.

Cipollina et al. (2012) analyze a panel of 14 industries for 18 developed and developing countries and reveal a significant effect of FDI on growth. The authors argue that the growth enhancing effect is stronger in more technologically advanced sectors and primarily comes from an increase in total factor productivity.

2.2 Innovation and productivity

The effect of innovation on firm-level productivity has been investigated in many countries. The majority of previous studies uses innovative inputs (R&D expenditures and patents) to measure innovation and the results are generally positive across the globe.

Griffith et. al (2006) examine the role innovation plays in productivity for four European countries: France, Germany, Spain and the UK using manufacturing firm data from Community Innovation Surveys (CIS3). They find that the relationship between R&D expenditure and labor productivity is mixed across countries. Product innovation is associated with higher productivity in France, Spain and the UK, but not in Germany. Besides, only France has a positive relationship between process innovation and productivity.

Parisi et. al (2006) investigate the impact of innovation on productivity using a large sample of Italian firms. The authors also examine the role R&D and fixed capital investment play in increasing the probability of introducing a new product. They conclude that R&D expenditures have a positive impact on the likelihood of new product innovation and fixed capital spending stimulates the innovation process.

Peters (2008) uses data from the 2001 German Community Innovation Survey to form a quantitative measure of process innovation, which is the share of cost reduction due to innovation. The author finds a positive effect for product innovation but weak evidence for a positive impact of process innovation. Peters concludes that innovation input is the major determinant for the success of product and process innovations.

For Latin America, Goedhuys (2007) investigates the effect of innovation activities on firms' total factor productivity (TFP) and their subsequent effect on firm growth, measured by sales. Activities including organizational change, cooperation with clients, human capital development, ICT usage, product innovation and learning by exporting are found to have positive impacts on productivity levels. Although the intensity with which firms participate in

innovation actives is sector dependent, innovation is an important variable in explaining sales growth across all sectors.

An example of a firm-level study in Asia is found in the work of Aw, Roberts and Winston (2007) who investigate the relationship between investments in R&D and future productivity using a Taiwanese electronics industry panel data set. They find a positive relationship between firms' export market participation and their productivity and the effect is larger if the firms also have made investments in R&D.

Hall (2011) reviews the ways in which economists have analyzed the relationship between productivity and innovation, focusing on survey data and other data on innovative output such as patents. The author summarizes 25 studies that have attempted to estimate a quantitative relationship between firm-level productivity and innovation measures. He finds a significant positive relationship between product innovation and productivity, both the level and its growth. However, process innovation has an ambiguous impact on productivity mainly due to the inability to measure the real quantity effect of process innovation. Moreover, the existence of inefficient firms and the entry of new innovating firms is presented as one of the main consequences of innovation. The author suggests that policy makers should pay more attention to how entry and exit regulations influence the rationalization of industry structure in response to innovative activity. Furthermore, the author claims that future research should use new product sales to measure innovation. It is a better indicator since it removes the problem associated with using the innovation dummy variable across a large scale of firms. Following Hall's suggestion, this paper uses the ratio of new products output over total outputs to measure innovation.

2.3 *The relationship between FDI and Chinese firms' innovation ability*

Although some studies investigate how FDI affects Chinese firms' innovation ability, most of the previous research is at the aggregate provincial level rather than firm level. Cheung and

Lin (2003) find positive effects of FDI on the number of domestic patent applications in China using a dataset that covers 26 provinces and 4 administrative cities from 1995-2000. The authors use the number of patent applications to measure R&D output. The effect of FDI is the strongest on minor innovations (particularly external design patents). In addition, the impact on innovation is found to be stronger in Western regions where FDI is spatially more concentrated.

Fu (2008) examines the impact of FDI on the development of the regional innovation capabilities using a similar provincial level panel data set for 31 provinces in China over 1998-2004. The data are collected from China Statistical Yearbook and the Ministry Of Science and Technology of China (MOST) online database. The author asserts that FDI contributes significantly to the overall regional innovation capacity. The magnitude of the positive effect depends on the availability of the absorptive capacity, measure of R&D intensity, labor force skills, and the presence of innovation-complementary assets in the host region.

Girma et. al (2009) investigate whether FDI, either at the firm or industry level, has any impact on product innovation by Chinese state-owned enterprises (SOEs). By using a comprehensive firm-level data set of 20,000 SOEs during 1999-2005, the authors find that foreign capital participation leads to higher innovation activity at the firm level. However, inward FDI at the sector level is found to have a negative impact on SOEs' innovation activities.

2.4 Innovation and productivity in China

There is a small amount of literature focused on the relationship between innovation and productivity using Chinese firm-level data. Jefferson et. al (2002) analyze the relationship among R&D expenditures and innovation, productivity and profitability using China's large and medium-size manufacturing enterprise data from 1995 to 1999 collected by the National

Bureau of Statistics (NBS). They find that new product innovation accounts for approximately 12 percent of total returns to R&D. In addition, returns to industrial R&D in China appear to be at least three to four times the returns to fixed production assets.

Wei and Liu (2006) explore the effect of ownership variations on R&D efficiency of 8341 Chinese firms derived from the 1995 General National Survey and find that ownership type significantly affects both R&D and productive efficiencies. They find that the state sector has lower R&D and efficiency than the non-state sector. Also, within the non-state sector, foreign-invested firms and HMT-affiliated companies have higher R&D and productive efficiencies than do domestic collective-owned enterprises and joint stock companies.

Liu and Buck (2007) use data from 1997 to 2002 from the China Statistics Yearbook on High-Technology Industry collected by the Chinese State Statistical Bureau (SSB) to analyze the impact of international technology spillovers on the innovation performance of Chinese high-tech industries. They find that technology spillover and indigenous efforts jointly determine the innovation performance of Chinese high-tech sectors.

In summary, while several studies have analyzed the relationship between innovation and productivity in China, none of these take the effect that new products have on productivity into consideration. Thus, this paper provides a novel analysis of innovation and firm productivity in China.

3. Empirical Strategy

Total factor productivity (TFP), labor productivity and wage productivity are the three major measures of productivity. This paper uses both simple labor productivity as well as total factor productivity.

TFP is estimated using the method developed by Levinsohn and Petrin (2003). Their methodology uses intermediate inputs. The Levinsohn and Petrin (2003) method improves on

Olley and Pakes (1996)'s methodology that requires investment data and must drop any observations that show zero investment. These can be almost half of all observations. Using intermediate inputs which have very few zero observations (only about 0.1 percent in the Chinese data set) solves this problem.

TFP is a function of innovation, foreign presence at the firm and sector levels and other factors that will be explained below.

$$tfp_{it} = \beta_0 + \beta_1\, INNOV_{firm_{it}} + \beta_2\, FDI_{firm_{it}} + \beta_3 FDI_{sectror\, jt} + \beta_4\, (INNOV_{firm} * FDI_{sector})_{ijt} + \beta_5 (FDI_{firm} * FDI_{sector})_{ijt} + \mu_{i/j} + \lambda_t + \theta_l + \varphi_{it} \quad (1)$$

Where tfp is ln(TFP) calculated using the Levinsohn and Petrin (2003) methodology with labor (measured as total number of employees), the total value of paid-up capital and the real value of all materials as inputs and sales as output. $INNOV_{firm_{it}}$ is the new product share in firm *i* at year *t*. $FDI_{firm_{it}}$is the foreign capital share in firm *i* at year *t*. $FDI_{sectror}$ captures the foreign presence in sector j, $\mu_{\frac{i}{j}}$ a sector (μ_i) or firm (μ_j) fixed effect, λ_t is a time fixed effect, θ_l is a location(provinces) fixed effect and φ_{it} is an iid error term. FDI_{sector} is measured as foreign capital shares averaged over all firms in a sector, weighted by each firm's output share.

$$FDI_{sector\, jt} = \frac{\sum_i (FDI_{firm_{ijt}} * Output_{ijt})}{\sum_i Output_{ijt}} \quad (2)$$

Since TFP is estimated from a production function containing labor, capital and inputs, none of these are included in (1).

Following Aitken and Harrison (1999) who use industry fixed effects to control for time-invariant variables at the industry level, I include several fixed-effects specifications in my econometric model. I have forty manufacturing sectors by aggregating the 600 sub-industries from the data following the guidelines of the compositions of each sector in Chinese. Liu (2008) followed the same guidelines to regroup different industries and our manufacturing

sectors are very similar, despite the fact that Liu used a random sample from 1995-1999. Table A1 in the Appendix provides summary statistics for the number of observations in each sector. In addition, I also include location fixed effects to control for unobserved heterogeneity across regions since Jefferson et. al (2008) indicate that firm productivity in coastal regions of China is generally superior to Western, Northeastern and Central regions. Moreover, I include time fixed-effects to take unobserved year heterogeneity into account.

We hypothesize that innovation ability and foreign presence affects total factor productivity and thus a regression of TFP on INNOV, FDI and HMT is an appropriate method. We can also estimate the effect of innovation ability and foreign presence on labor productivity. This approach is also useful for comparing the results of this study to earlier ones that use only labor productivity, not TFP.

Consider a standard Cobb-Douglas function

$$Y_{it} = A_{it}K_{it}^{\alpha 1}L_{it}^{\alpha 2}e_{it} \quad (3)$$

where Y_{it} is value added, A_{it}, $K_{it}$and L_{it} denote total factor productivity (TFP), capital and labor in firm i at time t, respectively, and e is a random disturbance term. Dividing it by L and taking natural logs yields

$$lp_{it} = tfp_{it} + \beta_6\, kl_{it} + \beta_7\, k_{it} + \eta_{it} \quad (4)$$

Where $lp = \ln(Y/L)$ is the log value added per worker (labor productivity), $kl = \ln(K/L)$, $k = \ln(K)$, β_6=(1-α_2), $\beta_7 = (\alpha_1 + \alpha_2 - 1)$ and η_{it} is an error term. Substituting (1) into (4) yields

$$lp_{it} = \beta_0 + \beta_1\, INNOV_{firm_{it}} + \beta_2\, FDI_{firm_{it}} + \beta_3 FDI_{sectror\, jt} + \beta_4\,(INNOV_{firm} * FDI_{sector})_{ijt} + \beta_5 (FDI_{firm} * FDI_{sector})_{ijt} + \beta_6\, kl_{it} + \beta_7\, k_{it} + \mu_{i/j} + \lambda_t + \theta_l + x_{it} \quad (5)$$

Where $x_{it} = \eta_{it} + \varphi_{it}$

Because HMT-affiliated and foreign-affiliated firms may differ in fundamental ways, as discussed above, I treat these two categories separately by running different regressions.

Below are the strategies for HMT-affiliated firms.

$$tfp_{it} = \beta_0 + \beta_1\, INNOV_{firm_{it}} + \beta_2\, HMT_{firm_{it}} + \beta_3 HMT_{sector\,jt} + \beta_4\, (INNOV_{firm} * HMT_{sector})_{ijt} + \beta_5 (HMT_{firm} * HMT_{sector})_{ijt} + \mu_{i/j} + \lambda_t + \theta_l + \varphi_{it} \quad (6)$$

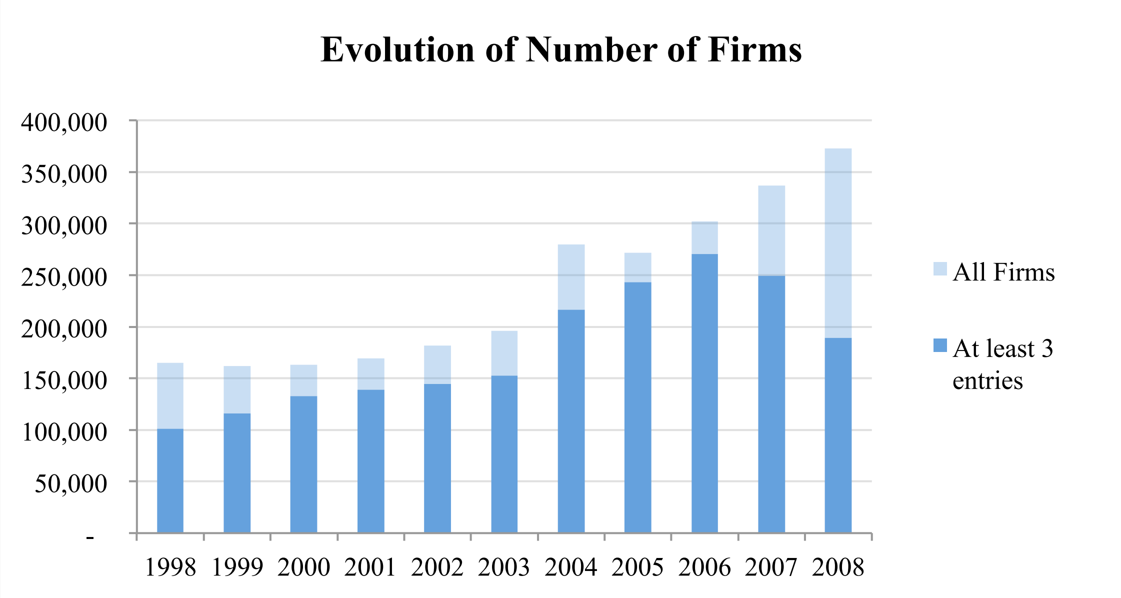
$$lp_{it} = \beta_0 + \beta_1\, INNOV_{firm_{it}} + \beta_2\, HMT_{firm_{it}} + \beta_3 HMT_{sectror\,jt} + \beta_4\, (INNOV_{firm} * HMT_{sector})_{ijt} + \beta_5 (HMT_{firm} * HMT_{sector})_{ijt} + \beta_6\, kl_{it} + \beta_7\, k_{it} + \mu_{i/j} + \lambda_t + \theta_l + x_{it} \quad (7)$$

4. Data

The data employed for the empirical analysis are obtained from China's National Bureau of Statistics (NBS) surveys over the period 1998-2008.[1] This dataset covers all state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs) with sales above 5 million RMB across 31 provinces. The sample is an unbalanced panel dataset for which the total number of firms varies from 160,000 in 1998 to more than 370,000 in 2008. Most previous studies that use the same dataset attribute the change in the amount of enterprises to firms' entry and exit. Unfortunately, we do not know if entry or exit means firms are actually entering or existing the market or simply crossing the 5 million RMB thresholds. One way to check this is by their ages. If a firm enters, but is more than 1 year old, it probably just grew above the threshold. After checking the raw data, I find that 90 percent of the new entries are due to crossing the 5 million RMB thresholds. One thing I can do is to limit the analysis to firms that appear a minimum number of times in the data and discard those that only appear once or twice. Empirical analysis shown in section (5) is conducted on the sample with at least three observations per firm over the 1998-2008 period to get rid of the heterogeneity from frequent entry and exit. Figure 1 illustrates the evolution of the amount of firms from 1998-2008 for all firms and firms with at least 3 entries.

1 Thanks to Survey Research Center, Institute for Advanced Research, Shanghai University of Finance and Economics, for providing the online database.

Figure 1. Evolution of the Number of Firms from 1998 – 2008



This data set contains detailed balance-sheet information, such as age, ownership, output, value added, industry code, exports, employment and value of fixed asset. Observations with missing values for key variables as well as those that failed some basic error checks are excluded from the data analysis. This data exclusion arises either because the information was not originally reported, or because of negative values for variables such as sales, value added, exports and main business revenue. In addition, observations with smaller than one natural log values of TFP generated by each sector are removed. Following Jefferson, Rawski and Zhang (2008), I also drop all firms with less than eight employees as they fall under a different legal regime. After cleaning the dataset in this manner, the number of observations is slightly over 390,100.

Table 1 presents some summary statistics for the variables that are used in the regressions to measure productivity, separately for all firms, foreign-affiliated firms and HKM-affiliated firms. As the table below indicates, there are 36,124 foreign-affiliated observations and 41,489 HKM-affiliated observations.

Table 1. *Summary statistics for various subsamples (Measured in RMB)*

Variables	Mean	Median	S.D.	Min	Max
All Firms (390,121 Observations)					
Age	10.2	7	10.9	0	406
Size (Employees)	289.5	120	1,255	8	171,649
Share of Sales Exported (%)	18.5	0	34.9	0	100
Value Added Per Worker	112.1	53.8	1,084	0	535,252
Wages Per Worker	14.98	12.06	1.80	0	11,589
Total Inputs	75,053	18,398	662,418	1	1.02e+08
New Product Output Share	0.03	0	0.14	0	1
New Product Dummy	0.1	0	0.3	0	1
Foreign-Affiliated Firms (36,124 Observations)					
Age	6.79	6	4.74	0	73
Size (Employees)	339.0	170	867.8	8	82,067
Share of Sales Exported (%)	45.8	38.9	43.3	0	100
Value Added Per Worker	145.8	59.9	783.7	0	83,231
Wages Per Worker	20.4	15.7	18.5	0	580.2
Total Inputs	111,494	28,532	644,492	1	6.26e+07
New Product Output Share	0.04	0	0.16	0	1
New Product Dummy	0.1	0	0.3	0	1
HMT-Affiliated firms (41,489 Observations)					
Age	7.7	7	5.1	0	101
Size (Employees)	340	180	686	8	52,100
Share of Sales Exported (%)	45.3	33.8	44.4	0	100
Value Added Per Worker	112.7	45.9	2,640	0	535,252
Wages Per Worker	17.4	14.2	19.0	0	1,872.5
Total Inputs	76,216	24,923	300,248	1	1.48e+07
New Product Output Share	0.03	0	0.14	0	1
New Product Dummy	0.1	0	0.26	0	1

Notes: Value Added, Wage Per Worker in '000s of RMB per worker.

Employment is the number of persons employed in a firm. Age is calculated by subtracting the firm's opening year from the survey year. I calculate share of sales exported, value added

per worker, and share of output form new product by using the original data: sales, exports, value added, employment, wage, output and new product output.

There are two ways to measure the firm's ownership types. One method is to use the direct variable 'registration type' recorded in the original data. Chinese companies established with more than 25% foreign investment comprise a distinct category called foreign invested enterprises (FIEs). FIE usually comprises two sub-categories, wholly foreign owned enterprises (WFOEs) and joint ventures (JVs). There are two types of joint ventures, which are: equity joint venture and contractual joint venture. For this paper, I focus exclusively on FIEs as a whole. Table 2 below shows the ownership types and their corresponding registration number.

Table 2.*Ownership Types and Registration Number*

Ownership Types		Registration Number
HMT-affiliated firms	HMT equity joint venture	210
	HMT contractual joint venture	220
	Wholly HMT owned enterprise	230
	HMT joint venture stock limited company	240
Foreign-affiliated firms	Foreign equity joint venture	310
	Foreign contractual joint venture	320
	Wholly foreign owned enterprise	330
	Foreign joint venture stock limited company	340

The other way of defining foreign ownership is to use the share of foreign (or HMT) owned capital and designate a firm "foreign owned" if that share exceeds a certain threshold, such as 25 percent. I generated the share of capital accounted for by different capital types, such as: state capital, collective capital, corporate capital, personal capital, foreign capital and capital from HMT. Table 3 below presents statistics for different types of capital shares.

Table 3. *Summary statistics different types of capital shares*

Variables	Obs	Mean	Median	Std. Dev.	Min	Max
State Capital Share	390,121	0.08	0	0.26	0	1
Collective Capital Share	390,121	0.08	0	0.24	0	1
Corporate Capital Share	390,121	0.23	0	0.40	0	1
Personal Capital Share	390,121	0.47	0.29	0.48	0	1
HMT Capital Share	390,121	0.08	0	0.25	0	1
Foreign Capital Share	390,121	0.06	0	0.22	0	1

Notes: Denominator of capital ratios is paid-up capital.

The fundamental difference of these two methods leads to different definitions of foreign, HMT or domestic firms. The analysis in this paper is based on the 'registration type' instead of the capital shares since 'registration type' was originally recorded in the data set. After implementing the strategy, the summary statistics displayed in Table 1 above for age, size and wage are consistent with Huang, Jin and Qian (2013) who use data that covers firms from 1998 to 2005.

Table 4 below shows the first-stage regression results of estimating TFP using the Levinsohn and Petrin (2003) methodology for selectt sectors that fail to reject constant returns. Although a fair number of sectors reject constant returns to scale, this is not an issue. This result is consistent with Waldkirch and Ofosu's (2010) paper, which suggests that the rejection occurs often for the LP methodology.

Table 4. *TFP estimation results for selective sectors*

	Special purpose equipment	**Instruments**	**Combined**
	Levinsohn-Petrin		
Labor	0.02*** (0.004)	0.04*** (0.009)	0.02*** (0.004)
Capital	0.035 (0.04)	0.015 (0.01)	0.031 (0.04)
Material	0.63** (0.30)	0.81*** (0.08)	0.68*** (0.23)
Constant Returns?	Yes	Yes	Yes

Notes: Results from first-stage regressions using the Levinsohn and Petrin (2003) methodology. Robust stand errors in parentheses.
Constant returns = Yes if a Wald test for constant returns cannot reject H0 (constant returns) at least at 5% level.
Significance at 10%*
Significance at 5%**
Significance at 1%***

5. Results

Table 5 and 6 below present the main results from using firm level total factor productivity as the dependent variable. Table 5 presents results with industry fixed effects for all firms and domestic firms. Running the model on domestic firms only serves as robustness check. Table 6 includes firm fixed effects. For robustness checks, Tables 7 and 8 use firm-level TFP with industry fixed effects and firm fixed effects correspondingly. Moreover, Tables 9 and 10

present results using labor productivity as the dependent variable to check the robustness of our primary findings.

Table 5. *FDI, HMT, innovation and firm-level TFP by sector with Industry FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV	0.39*** (0.01)	0.53*** (0.01)	0.47*** (0.01)	0.47*** (0.01)	0.52*** (0.01)	0.49*** (0.01)
FDI_firm	0.14*** (0.007)		0.14*** (0.007)			
FDI_sector	0.57*** (0.06)		0.43*** (0.06)	0.64*** (0.07)		0.54*** (0.07)
INNOV * FDI_sector	-0.24*** (0.08)		-0.05*** (0.09)	-0.27** (0.09)		-0.10*** (0.07)
FDI_firm * FDI_sector	0.28*** (0.05)		0.33*** (0.05)			
HMT_firm		0.08*** (0.007)	0.08*** (0.006)			
HMT_sector		0.45*** (0.07)	0.39*** (0.07)		0.22*** (0.08)	0.20*** (0.08)
INNOV * HMT_sector		-1.75*** (0.10)	-2.57** (0.13)		-1.73*** (0.12)	-2.57*** (0.15)
HMT_firm* HMT_sector		-0.22*** (0.05)	-0.26*** (0.05)			
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	389,839	389,839	389,839	312,289	312,289	312,289
R^2	0.83	0.83	0.83	0.84	0.84	0.84
F(.)	27,545	27,523	25,952	23,782	23,878	23,064
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of firm-level TFP by sector. Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%**

Table 5 indicates that innovation ability, measured as the ratio of new product output to total output, has a positive effect on total factor productivity, where a one percentage point increase in innovation ability is associated with up to a 0.53 percent increase in total factor productivity. The effect of foreign ownership of a firm is positive when including industry fixed effects. In addition, the presence of foreign firms in a sector has a significant positive effect on total factor productivity for all firms. The significant and positive coefficient for

FDI_sector for the domestic firm sample indicates that there exists a spillover effect from foreign firms to domestic firms. In addition, the interaction term INNOV*FDI_sector reflects the effect of foreign firms on firms' innovation ability in the same sector, where a negative coefficient on INNOV*FDI_sector indicates a negative competition effect. The results are robust and significant. The interaction terms illustrates that the existence of foreign firms in the sector will bring some competitive pressure that reduces the positive productivity effect of innovation. According to equation (1) above, the effect of innovation is:

$$\frac{\vartheta tfp}{\vartheta INNOV} = \beta_1 + \beta_4 \, FDI_{sector} \qquad (8)$$

Taking the median value of FDI_{sector} and using the coefficients in column (1), the effect of innovation can be calculated, which is, 0.39-0.24*0.106 = 0.37. In order to confirm that the effect of innovation never becomes zero, we take the maximum value of FDI_{sector} and the effect of innovation becomes 0.29, still bigger than zero. To formally reject the possibility of a zero innovation effect, we test the significance of the above equation (8) and confirm that the effect of innovation is significant and positive.

Moreover, columns (1) and (3) demonstrate that foreign firms significantly benefit from other foreign firms in a sector. In contrast, the presence of other HMT-affiliated firms significantly decreases the productivity of HMT firms in the same sector. This result suggests that other HMT-affiliated firms may not be able to withstand the competitive pressure brought by more HMT firms.

The presence of HMT-affiliated firms has a positive impact on total factor productivity. The significantly positive HMT_sector coefficient indicates the spillover effects to domestic firms. This positive spillover effect is confirmed by the right part of Table 5, where the model is run on domestic firms only. According to equation (4) above, the effect of HMT presence in a sector is:

$$\frac{\vartheta tfp}{\vartheta HMT\_sector} = \beta_3 + \beta_4 \, INNOV_{firm} \quad (9)$$

For domestic firms, the effect is just the $\beta_3 + \beta_4$ $INNOV_{firm}$ since HMT_{firm} is 0. Using the statistics in column (2), the effect of HMT ownership on productivity can be calculated by taking the interaction effect into account, which is 0.45-1.75*0.09=0.29. The coefficients for the domestic firms only sample on the right is consistent with our theoretical prediction.

The interaction term for INNOV*HMT_sector is significantly negative and in line with the negative coefficient for INNOV*FDI_sector. This result indicates that the negative competition effect might partially offset the positive spillover effects from foreign and HMT ownership, as is further investigated in Table 6, where firm fixed effects replace sector fixed effects. These are not chosen as the main specification, because there is too little variation in firm-level foreign ownership to separately identify this firm ownership effect with the inclusion of firm fixed effects.

Table 6. *FDI, HMT, innovation and firm-level TFP by sector with Firm FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)
FDI_sector	0.08** (0.03)		0.07*** (0.03)	-0.01 (0.04)		-0.01 (0.04)
INNOV * FDI_sector	-0.14*** (0.07)		-0.08** (0.07)	-0.13*** (0.08)		-0.05** (0.09)
FDI_firm * FDI_sector	0.08*** (0.03)		0.16*** (0.03)			
HMT_sector		0.23*** (0.04)	0.22*** (0.04)		0.15*** (0.05)	0.15*** (0.05)
INNOV * HMT_sector		-0.26*** (0.07)	-0.25** (0.09)		-0.17** (0.09)	-0.14** (0.11)
HMT_firm * HMT_sector		-0.06*** (0.03)	-0.14*** (0.03)			
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	389,839	389,839	389,839	312,289	312,289	312,289
R^2	0.15	0.15	0.15	0.16	0.16	0.16
F(.)	1,438	1,439	1,323	1,370	1,370	1,287
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of firm-level TFP by sector. Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***

Nonetheless, most of the results from Table 6 confirm the findings with industry fixed effects. Higher innovation ability is associated with higher total factor productivity, for all types of firms in China. Besides, there exists a large spillover effect from HMT-affiliated firms to domestic firms, where a one percentage point higher HMT sector ownership will increase total factor productivity by up to 0.23 percent, depending on specification. This result is consistent with the findings in Table 5.

Moreover, the significant and negative coefficients for both INNOV*FDI_sector and INNOV*HMT_sector confirm my findings above. Domestic firms will face more competitive pressure from more innovative foreign firms and HMT-affiliated firms in the same sector. This could happen if foreign firms and HMT-affiliated firms bring advanced technology with them when entering the market and thus decrease the ability for domestic firms to come up with novel product ideas. The domestic only sample on the right of Table 6 confirms the result, as the size of the HMT_sector spillover effects decreases when running the regression on domestic firms only. Furthermore, foreign firms benefit from other foreign firms in the sector, while HMT-affiliated firms suffer from competition brought by other HMT firms. This could happen if HMT investments are concentrated on certain sectors. As a result of that, the entry of one additional HMT firms will bring more competitions to other HMT firms in the market.

In contrast with industry fixed effect results shown in Table 5, the effect of foreign presence in a sector is ambiguous. Foreign presence in a sector is significantly positive for all firms when including firm fixed effects. However, the coefficient becomes negative and insignificant after running the regression on domestic firms only. This result also indicates the negative competition effect from foreign firms to domestic firms.

Table 7 and Table 8 below use firm-level aggregate TFP with industry fixed effects and firm fixed effects correspondingly. Results from both tables confirm our primary findings: (1)

Innovation ability has a significant and positive effect on productivity. (2) Effects of foreign presence and HMT presence at firm level are significantly positive. (3) Foreign firms benefit from other foreign firms in the same sector, but HMT-affiliated firms don't. In fact, HMT-affiliated firms are worse off with more competition brought by other HMT firms. (4) There exists a large positive spillover effect from HMT-affiliated firms to domestic firms. (5) The negative competition effect partially offsets the positive spillover effect on TFP from HMT ownership. (6) The effect of the foreign presence at sector level is again significantly positive with industry fixed effect but ambiguous with firm fixed effect.

Table 7.*FDI, HMT, innovation and TFP with Industry FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV	0.38*** (0.01)	0.46*** (0.01)	0.42*** (0.01)	0.40*** (0.01)	0.46*** (0.01)	0.44*** (0.01)
FDI_firm	0.14*** (0.006)		0.15*** (0.007)			
FDI_sector	0.18** (0.05)		0.08* (0.05)	0.09*** (0.06)		0.04*** (0.06)
INNOV * FDI_sector	-0.35*** (0.07)		-0.28*** (0.08)	-0.38*** (0.08)		-0.34*** (0.08)
FDI_firm * FDI_sector	0.22*** (0.04)		0.29*** (0.04)			
HMT_firm		0.08** (0.006)	0.08*** (0.006)			
HMT_sector		0.22*** (0.06)	0.17*** (0.06)		0.03* (0.07)	0.02* (0.07)
INNOV * HMT_sector		-1.29*** (0.09)	-1.63*** (0.11)		-1.18*** (0.11)	-1.47*** (0.13)
HMT_firm * HMT_sector		-0.06*** (0.04)	-0.01*** (0.03)			
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	389,839	389,839	389,839	312,289	312,289	312,289
R^2	0.13	0.12	0.13	0.14	0.14	0.14
F(.)	820	782	791	747	746	724
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of TFP. Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***

Table 8.*FDI, HMT, innovation TFP with Firm FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV	0.03*** (0.008)	0.04*** (0.009)	0.04*** (0.009)	0.04*** (0.01)	0.03*** (0.01)	0.04*** (0.01)
FDI_sector	0.06** (0.04)		0.07** (0.04)	-0.17*** (0.04)		-0.16*** (0.04)
INNOV * FDI_sector	-0.12*** (0.06)		-0.04*** (0.07)	-0.11** (0.08)		-0.07** (0.09)
FDI_firm * FDI_sector	0.07*** (0.03)		0.14*** (0.03)			
HMT_sector		0.32*** (0.04)	0.31*** (0.04)		0.24*** (0.05)	0.24*** (0.05)
INNOV * HMT_sector		-0.18** (0.07)	-0.16* (0.09)		-0.09** (0.09)	-0.05** (0.11)
HMT_firm * HMT_sector		-0.05*** (0.03)	-0.03*** (0.03)			
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	389,839	389,839	389,839	312,289	312,289	312,289
R^2	0.14	0.14	0.14	0.15	0.15	0.15
F(.)	1,293	1,296	1,192	1,214	1,215	1,142
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of TFP. Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***

Table 9 and Table 10 below present results from repeating the exercise with value added per worker as our measure of labor productivity. We measure productivity by labor productivity to check the robustness of our primary findings. According to equations (3) and (5), such a model can be derived from the production function with capital labor ratio and capital stock required in the regressions.

Results in Table 9 follow the basic insights from TFP regressions. Innovation ability has a positive impact on labor productivity. In agreement with the TFP results, HMT and foreign presences at firm level have significantly positive impacts on labor productivity. In addition, there exists a positive spillover effect from both foreign and HMT-affiliated firms to

domestic firms when including industry fixed effects. Moreover, the significant and positive coefficients for HMT presence at sector level further confirm the positive spillover effects. Furthermore, the significantly negative interaction terms for INNOV*FDI_sector and INNOV*HMT_sector demonstrate the negative competition effect. The negative coefficient on HMT_firm*HMT_sector is consistent with previous TFP estimation.

In contrast to the TFP results, we notice that foreign firms do not benefit from other foreign firms in the same sector when using labor productivity as the dependent variable.

Table 9. *FDI, HMT, innovation and labor productivity with Industry FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV	0.22*** (0.02)	0.32*** (0.01)	0.27*** (0.02)	0.24*** (0.0001)	0.34*** (0.0001)	0.28*** (0.02)
FDI_firm	0.10*** (0.01)		0.09*** (0.01)			
FDI_sector	0.55*** (0.11)		0.48*** (0.11)	0.44*** (0.12)		0.38*** (0.13)
INNOV * FDI_sector	-0.49*** (0.14)		-0.34*** (0.17)	-0.29* (0.16)		-0.19*** (0.15)
FDI_firm * FDI_sector	-0.18*** (0.09)		-0.37*** (0.09)			
HMT_firm		0.04*** (0.01)	0.03** (0.01)			
HMT_sector		1.58*** (0.13)	1.57*** (0.13)		1.21*** (0.15)	1.20*** (0.15)
INNOV * HMT_sector		-0.55*** (0.17)	-0.49** (0.23)		-0.66*** (0.20)	-0.58*** (0.25)
HMT_firm * HMT_sector		-1.09*** (0.09)	-1.11*** (0.09)			
Capital Per Worker	1.00*** (0.005)	1.00*** (0.005)	1.00*** (0.005)	0.98*** (0.005)	0.98*** (0.005)	0.98*** (0.005)
Capital	0.018*** (0.001)	0.019*** (0.001)	0.018*** (0.001)	0.003** (0.001)	0.003** (0.001)	0.003** (0.001)
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	389,686	389,686	389,686	312,171	312,171	312,171
R^2	0.31	0.31	0.31	0.31	0.31	0.31
F(.)	2,389	2,401	2,264	2,044	2,045	1,983
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of value added per worker. Value added in '000s of RMB per worker. Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***

Table 10. *FDI, HMT, innovation and labor productivity with Firm FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV	0.09*** (0.02)	0.08*** (0.02)	0.09*** (0.02)	0.08*** (0.03)	0.08*** (0.02)	0.09*** (0.03)
FDI_sector	0.06*** (0.07)		0.06*** (0.07)	-0.28** (0.09)		-0.27*** (0.09)
INNOV * FDI_sector	-0.49*** (0.14)		-0.34*** (0.17)	-0.28* (0.18)		-0.12* (0.22)
FDI_firm * FDI_sector	0.07*** (0.06)		0.26*** (0.07)			
HMT_sector		1.04*** (0.09)	1.02*** (0.09)		0.96*** (0.11)	0.95*** (0.11)
INNOV * HMT_sector		-0.47*** (0.17)	-0.23* (0.21)		-0.29** (0.21)	-0.22** (0.25)
HMT_firm * HMT_sector		-0.22*** (0.07)	-0.37*** (0.08)			
Capital Per Worker	1.18*** (0.007)	1.18*** (0.007)	1.18*** (0.007)	1.19*** (0.008)	1.19*** (0.008)	1.19*** (0.008)
Capital	-0.19*** (0.002)	-0.19*** (0.002)	-0.19*** (0.002)	-0.198*** (0.003)	-0.198*** (0.003)	-0.198*** (0.003)
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	389,686	389,686	389,686	312,171	312,171	312,171
R^2	0.22	0.22	0.22	0.24	0.24	0.24
F(.)	2,164	2,170	2,003	2,118	2,121	2,000
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of value added per worker. Value added in '000s of RMB per worker.
Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***

Most of the results from Table 10 confirm the TFP findings in Table 6. All firms are positively affected by their innovation ability, where 1 percentage point increase in innovation ability is associated with up to 0.09 percent increase in labor productivity. Besides, domestic firms are positively affected by the presence of HMT firms in a sector, where one percentage point higher HMT sector ownership share increases labor productivity for up to 1.21 percent, depending on specification. The effect of foreign presence in a sector on labor productivity is ambiguous and in line with previous findings. The significant and negative interaction terms INNOV*FDI_sector and INNOV*HMT_sector confirm the negative

competition effect, suggesting there is an offsetting positive spillover effect on labor productivity from foreign and HMT ownership. The significant and negative coefficient for HMT_firm*HMT_sector is also consistent with previous result, which indicates that HMT-affiliated firms suffer from the competition brought by other firms.

In contrast to previous TFP results, it remains unclear whether foreign firms benefit from other foreign firms in the same sector because the coefficient switches sign from negative to positive when changing from industry fixed effects to firm fixed effects.

In conclusion, most of the results estimated with labor productivity as the dependent variable are consistent with the TFP findings. [2]

6. Conclusions

The impact of innovation ability on firm-level productivity has been examined across the globe. Methods of measuring the impact of innovation on firm productivity can be differentiated by innovative inputs and innovative outputs. The majority of the existing studies use R&D expenditures and patent counts to analyze firms' innovative ability and generally find a positive relationship. While very few investigate the impact using innovative output as proxy and find negative relationship between innovation and productivity. As discussed above, innovative inputs neither have the ability to capture the effectiveness of the expenses nor the capability to reflect the expenses fully. As a result, as Hall (2011) suggests measuring innovation with innovative outputs, such as the share of output from new products could provide a useful solution to the problem.

In contrast to Geroski et. al (1993) results, I find a significantly positive relationship between innovation and productivity using new products output over total outputs as the proxy of my RIA. After controlling for observed and unobserved heterogeneity along a number of

[2] In order to address the reverse causality concern, we also run the regressions with lagged innovation ability. The result tables shown in Appendix A2 and A3 indicate that our primary findings still hold.

dimensions, the presence of HMT-affiliated firms in a sector has a positive effect on the productivity of domestically owned. However, the effect of foreign presence in a sector is ambiguous. The coefficient sign switch or become insignificant after changing from industry fixed effects to firm fixed effects indicates large firm-level heterogeneity. These results shed some light on the heterogeneity between different ownership types and illustrate the importance of analyzing HMT-affiliates separately. We also find that there exists a negative competition effect that partially offsets the positive spillover effect from foreign and HMT ownership. This might happen due to the difficulty for domestic firms to invent new products after foreign firms and HMT-affiliated firms bringing advanced technology and novel product ideas from abroad. In addition, HMT-affiliated firms are worse off with competition bought by other HMT firms. This might occur since HMT investments are concentrated on certain sectors thus the entry of one additional HMT firms brings more competitions in the market.

In future work, it is also hoped that more recent firm level data for China can be analyzed along the lines of this study in order to ascertain how firms benefit from innovation. In addition, it would be interesting to investigate whether there exists a productivity boost after Chinese government implementing innovation-driven development strategy in 2013 at a faster pace.

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Appendix:

Table A1. *Summary statistics for each sector*

Sector Name	Number of Observations	Number of Firms	Sector Name	Number of Observations	Number of Firms
Coal Mining	44,310	25,918	Medical & pharmaceutical products	336,48	22,088
Oil and gas exploitation	1,027	511	Fiber manufacturing	10,784	5,927
Ferrous Metals Mining	15,218	8,658	Rubber products	23,274	13,251
Nonferrous Metals Mining	11,327	8,037	Plastic products	90,188	50,908
Non-metallic Mining	21,096	11,897	Nonmetal mineral products	172,169	98,019
Other Mining	172	95	Processing of ferrous metals	46,226	26,790
Food processing	123,244	70,551	Processing of non-ferrous metals	31,769	22,198
Food manufacturing	45,906	26,241	Metal products	108,855	60,475
Beverage manufacturing	32,337	18,325	Ordinary machinery	154,761	85,895
Tobacco processing	1,798	974	Special purpose equipment	77,888	44,144
Textile	164,609	99,626	Transportation equipment	75,551	47,545
Garment & other fiber products	92,292	52,066	Electronic equipment & machinery	85,113	50,646
Leather (including furs & related products)	45,458	26,772	Electronic & telecom machinery	68,513	37,029
Timber processing	45,125	25,088	Instruments	30,886	16,164
Furniture	22,928	13,034	Other machinery	34,874	21,038
Paper-related products	58,625	33,381	Living products manufacturing	15,353	6,945
Printing & record medium	36,060	20,518	Thermal Power generation	42,319	23,507
Educational & sports goods	24,429	14,033	Gas supply	3,014	1,570
Petroleum processing	14,033	8,077	Hydropower generation	19,262	11,080
Chemical material & products	146,095	83,100	Logging	1,556	841

Notes: This summary statistics is based on the original dataset. A number of sectors are removed after implementing the strategy discussed in Session 4.

Table A2. *FDI, HMT, lagged innovation and labor productivity with Industry FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV_Last Year	0.24*** (0.01)	0.23*** (0.01)	0.23*** (0.01)	0.24*** (0.01)	0.24*** (0.01)	0.24*** (0.01)
FDI_firm	0.10*** (0.02)		0.08*** (0.02)			
FDI_sector	1.12*** (0.16)		0.90*** (0.16)	1.02*** (0.19)		0.76*** (0.20)
FDI_firm * FDI_sector	-0.18*** (0.11)		-0.36*** (0.10)			
HMT_firm		0.06*** (0.02)	0.05** (0.02)			
HMT_sector		2.14*** (0.20)	1.95*** (0.20)		1.62*** (0.23)	1.44*** (0.24)
HMT_firm * HMT_sector		-1.07*** (0.11)	-1.08*** (0.11)			
Capital Per Worker	0.96*** (0.006)	0.96*** (0.006)	0.96*** (0.006)	0.94*** (0.007)	0.94*** (0.007)	0.94*** (0.007)
Capital	0.02*** (0.001)	0.02*** (0.001)	0.02*** (0.001)	0.01*** (0.002)	0.01*** (0.002)	0.01*** (0.002)
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	268,812	268,812	268,812	215,667	215,667	215,667
R^2	0.30	0.30	0.30	0.30	0.30	0.30
F(.)	1,631	1,642	1,568	1,390	1,392	1,370
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of value added per worker. Value added in '000s of RMB per worker. Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***

Table A3. *FDI, HMT, lagged innovation and labor productivity with Firm FE*

	All firms			Domestic Firms Only		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
INNOV_Last Year	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.05*** (0.02)	0.05*** (0.02)	0.05*** (0.02)
FDI_sector	0.20*** (0.11)		0.20** (0.11)	-0.09* (0.13)		-0.10*** (0.13)
FDI_firm * FDI_sector	0.07*** (0.09)		0.19*** (0.10)			
HMT_sector		1.07*** (0.14)	1.06*** (0.14)		0.82*** (0.16)	0.82*** (0.16)
HMT_firm * HMT_sector		-0.15*** (0.09)	-0.26*** (0.11)			
Capital Per Worker	1.30*** (0.01)	1.31*** (0.01)	1.31*** (0.01)	1.32*** (0.01)	1.32*** (0.01)	1.32*** (0.01)
Capital	-0.22*** (0.003)	-0.23*** (0.003)	-0.23*** (0.003)	-0.23*** (0.003)	-0.23*** (0.003)	-0.23*** (0.003)
Location FE?	Yes	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	268,812	268,812	268,812	215,667	215,667	215,667
R^2	0.20	0.20	0.20	0.21	0.21	0.21
F(.)	1,134	1,136	1,072	1,082	1,083	1,049
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is the natural log of value added per worker. Value added in ‘000s of RMB per worker.
Robust standard errors in parentheses clustered by firm.
Significance at 10%*
Significance at 5%**
Significance at 1%***