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Document Version:
Author accepted manuscript (postprint)

Citation for published version:

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Heterogeneity and Curvilinearity of FDI-Related Productivity Spillovers in China’s Manufacturing Sector

Sajid Anwar  
School of Business, University of the Sunshine Coast  
Maroochydore DC, QLD 4558, Australia  
Email: SAnwar@usc.edu.au  
Tel: 61-7-5430-1222

&

Sizhong Sun  
School of Business, James Cook University  
Townsville, QLD 4811, Australia  
Email: Sizhong.Sun@jcu.edu.au  
Tel: 61-7-4781-4710

Earlier studies on foreign direct investment (FDI) have mainly focused on its benefits. This paper examines the nature of FDI-related productivity spillovers in China’s manufacturing sector. The empirical analysis based on firm level panel data, over the period 2000-2007, reveals that productivity spillovers arising from FDI from Hong Kong, Macau and Taiwan exhibit not only heterogeneity but also curvilinearity. The size of the spillovers depends on firm age, capital intensity and ownership structure. We find that FDI-related spillovers from the rest of the world are heterogeneous but not curvilinear. We find that the size of productivity spillovers depends on firm size and product quality. The analysis presented in this paper sheds some light on the complex pattern of FDI-related spillovers.

Key Words: FDI; Productivity Spillovers; Heterogeneity; Curvilinearity; China’s manufacturing sector; panel data analysis

JEL Classifications: F21, F23
1. Introduction

The early literature on foreign direct investment (FDI) mainly focused on the impact of FDI and FDI-related spillover effects on firm productivity and export behaviour.\(^1\) Inward FDI was found to be mostly beneficial in the case of developed countries. However, the evidence in the case of developing countries was mixed.\(^2\) The recent studies (such as Yeaple, 2009; Abraham, Konings and Slootmaekers, 2010; and Johnson, 2012) focus on the issue of firm heterogeneity. Specifically, it is argued that firm heterogeneity can account for differences in the benefits from inward FDI to domestic firms. Firm heterogeneity, can also account for differences in the export behaviour and product quality of domestic firms. Firm heterogeneity refers to firm characteristics such as firm size, capital intensity, ownership and whether or not the firm is an exporter.\(^3\) Another strand of the literature, such as the work of Buckley, Clegg, and Wang (2007), shows that FDI-related productivity spillovers can be curvilinear. Their empirical work suggests that FDI initially enhances the productivity of domestic firms. However, once the productivity of domestic firms has reached a certain critical level, further increase in FDI can result in a decline in productivity. Within the context of foreign investment in China, this paper aims to further develop these ideas.\(^4\)

China started receiving foreign investment from the late 1970s. In 1979-1980, China established four special economic zones. In the early period (i.e., 1979-1983), which is also

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\(^1\) For example Okamoto and Sjöholm (2005) reported that foreign direct investment (FDI) has contributed to productivity growth in Indonesia. In a more recent study, Suyanto, Bloch and Salem (2012) examined the presence of FDI-linked productivity spillovers in Indonesia’s garment and electronics manufacturing industries. Anwar and Nguyen (2011) examined the presence of export spillovers in Vietnamese manufacturing sector.

\(^2\) An excellent review of earlier studies that deal with the impact of FDI on economic growth in developing countries can be found in de Mello Jr. (1997). For a review of studies that deal with FDI-related spillover effects, see Havranek and Irsova (2012).

\(^3\) For example, Abraham et al. (2010) argue that FDI affects firms that export and firms that do not export in different ways.

\(^4\) Empirical studies aimed at detecting the spillover effects tend to assume that these effects are linear. However, this is not always the case. The presence of nonlinear spillovers can also account for some studies that have failed to find linear spillovers.
known as the starting phase, the average annual foreign investment in China was approximately US$0.54 billion. During the expansion phase (i.e., 1984-1991), the average annual foreign investment in China increased to US$2.80 billion. In the expansion phase, additional special economic zones were established in ten provinces. The period of 1992 to 2000 is described as the rapid development phase. During this period, average annual foreign investment in China increased to US$35.92 billion. From 2001 to present is described as the adjustment/enhancement phase. The average annual investment in China during this period reached US$55.24. Up until the early 1990s foreign investment in China was concentrated in labour intensive industries. From mid-1990s, China’s capital intensive industries have started attracting significant foreign investment (Meng, 2010).

Most of the foreign investment in China during the starting phase originated from Hong Kong and Macau and it mainly benefitted Guangdong and Fujian provinces. During the expansion phase, Taiwan also started investing in China. The share of accumulated foreign investment in China from Hong Kong over the period of 1979 to 2007 is approximately 39.02%. The corresponding shares of Macau and Taiwan over the same period respectively are 0.97% and 5.79% whereas Japan accounted for 7.81% of foreign investment in China (Meng, 2010).

Using a relatively more recent firm level panel dataset, this paper argues that FDI-related productivity spillovers in China’s manufacturing sector are not only heterogeneous but also curvilinear. Following Buckley et al. (2007) and Du et al. (2012), we distinguish between FDI in China that originates from Hong Kong, Macau and Taiwan and FDI that originates from the rest of the world (mainly Western countries). Due to cultural similarity, FDI from Hong Kong, Macau and Taiwan can have a very different impact on the performance of domestic firms in China. For example, Abraham et al. (2010) have shown that FDI from Hong Kong, Macau and Taiwan can have an adverse impact on domestic firms.
in China.\textsuperscript{5} We find that in addition to the curvilinear effect of FDI on the productivity of domestic firms, the magnitude of productivity spillovers also depends on firm characteristics, such as firm size, age, and capital intensity. This suggests that FDI-related productivity spillovers are heterogeneous. Our analysis yields some new insights into the pattern and causes of FDI-related productivity spillovers in China’s manufacturing sector.

The rest of the paper is organized as follows. Section 2 presents a review of literature on FDI-related productivity spillovers. Section 3 contains a discussion of the heterogeneity of FDI-related productivity spillovers. An empirical model is presented in section. Section 5 includes a brief description of the dataset, variable construction and estimation strategy. Empirical results are presented in section 6. Section 7 contains some concluding remarks.

2. Review of Related Literature

The empirical testing of FDI-related productivity spillovers was pioneered by Caves (1974). Since then a large number of studies on several countries have been conducted. For example, Caves (1974), Chuang and Lin (1999), Sinani and Meyer (2004), Branstetter (2006), and Kohpaiboon (2006), respectively, find the spillover effects to be positive in the case of Australia, Taiwan, Estonia, the United States, and Thailand. However, Aitken and Harrison (1999) and Sadik and Bolbol (2001), respectively, find the FDI-related spillover effects to be negative in the case of Venezuela and five Arab countries. It is interesting to note that most existing studies on China find the FDI-related productivity spillover effects to be positive. As this paper focuses on China, in the literature review presented in this paper, we confine our attention to empirical studies on China.\textsuperscript{6}

\textsuperscript{5} Other important studies that focus on the impact of FDI from Taiwan to China include Lin (2010) and Chen and Yeh (2012). However, these studies do not consider the issue of heterogeneity of FDI-related spillovers to Chinese firms.

\textsuperscript{6} A good review of some studies on China can be found in Table 1 of Hale and Long (2011). For a review of the broader literature, see for example, Blomström and Kokko (1998), Saggi (2002), Görg and Greenaway (2004), Smeets (2008), Meyer and Sinani (2009) and Bodeman and Le (2013).
In most theoretical studies, FDI-related productivity spillover effects are linked to technology diffusion. The existing literature highlights two approaches to technology diffusion. The first approach is based on the size of the technology gap between the domestic and foreign firms. It is argued that the larger the technology gap, the quicker the domestic firms will be able to catch up with foreign firms. In other words, technological convergence would occur relatively quickly when the technology gap is large. This idea is based on the observation that during the process of economic growth, as compared to the developed countries, developing countries grow at a faster rate (Barro and Sala-i-Martin, 2003) The second approach views technology diffusion more like the spread of a contagious disease (that is, with a contagion effect). This approach highlights the importance of personal contacts in the process of technology diffusion. Technology is most effectively transferred when there are inter-personal contacts between the actual and the potential users of technology. Findlay (1978) captures both ideas in a single model where the growth rate of domestic technology in a backward region is (i) an increasing function of the technology gap between an advanced and a backward region and (ii) an increasing function of foreign presence. Foreign presence is measured by the ratio of capital stock of FDI-invested firms to that of domestic firms in the backward region. Findlay shows that both the technology gap and foreign presence converge to their steady state values. FDI-related spillovers occur in Findlay’s model because an increase in foreign presence leads to a reduction in the technology gap.

Assuming a cost-reducing technology and costless spillovers, Das (1987) examined the FDI-related spillovers in an oligopolistic market where an FDI-invested firm is the leader and the domestic firms constitute the fringe. Productivity spillover effects reduce the cost of production of domestic firms, which reduces the profitability of the FDI-invested firm. Das shows that, despite a decrease in its profitability, it makes sense for the foreign-invested firm
to import better technology because the positive effect of cost saving from better technology outweighs the negative effect of the reduced profitability arising from the spillovers to domestic firms. In contrast to Das’ model, Wang and Blomström (1992) utilise a model where both the process of technology transfer and the learning activities of domestic firms are costly. They show that FDI-related productivity spillovers are positively related to investment in learning that is undertaken by domestic firms in host economies. We incorporate this idea in our empirical model.

As far as the empirical studies on China are concerned, using the third industrial census data from 1995, Li, Liu, and Parker (2001) examine the FDI-related productivity spillovers in China’s manufacturing sector. They find positive productivity spillovers that vary across types of firm ownership and types of FDI. For example, they find that, in an attempt to compete with FDI-invested firms, state-owned firms improve their technology. Li et al.’s work is extended by Buckley, Clegg, and Wang (2002). Using the same dataset, they find that, as compared to the state-owned firms, collectively-owned firms are relatively more capable of absorbing FDI-related productivity spillovers. Using the same dataset, Chuang and Hsu (2004) re-confirmed the presence of positive FDI-related productivity spillovers. Buckley et al. (2007) also used the same dataset to explore the possibility of curvilinear FDI-related productivity spillovers. They found that the productivity of the Chinese firms increases with spillovers. However, after reaching a certain threshold, any further increase in spillovers leads to a decline in productivity. Using a World Bank stratified survey of Chinese firms in five cities and ten industries conducted in 2001, Hale and Long (2011) find the evidence concerning the link between FDI-related spillovers and productivity is mixed. They argue that some previous studies suffer from aggregation bias or failure to control for

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7 Using meta-analysis involving more than three dozen existing studies, Meyer and Sinani (2009) found the productivity spillovers to be curvilinear.
endogeneity of FDI. However, Hale and Long’s work is based on cross-sectional data, which
is subject to its own limitations.

A number of studies have also considered different regions of China. For example,
using industry level panel data over the period 1993-1998, Liu (2002) tested the presence of
intra-industry and inter-industry productivity spillovers in Shenzhen’s manufacturing sector.
Liu found FDI in the manufacturing sector and the growth rate of productivity in component
industries to be positive and significant, which is interpreted as the evidence of positive FDI-
related spillovers. In a more recent study, using firm level data from the Chinese
manufacturing sector, Liu (2008) distinguishes between change in the level of productivity
and the growth rate of productivity. Liu’s empirical analysis suggests that the relationship
between FDI and the level of productivity of domestic firms is negative in the short-term but
the relationship between FDI and the growth rate of productivity is positive in the long-term.
Anwar and Sun (2012) found that FDI can also affect the market entry/exit of domestic firms
in China’s manufacturing sector.

In a very interesting study, which is based on firm level panel data from China over
the period of 1995-1999, Liu (2008) argues that an increase in FDI at the four-digit industry
level reduces the short-term productivity of domestic firms but its impact on long-term rate of
productivity growth in the same industry is positive. Furthermore backward linkages are
found to be relatively more important channel through which FDI-related spillovers occur.
While most existing studies have focused on the benefits of FDI, by focusing on the nature of
FDI-related spillovers (specifically on the issue of heterogeneity of spillovers, an area which
has received relatively less attention so far), we aim to extend the existing literature on FDI in
emerging economies of Asia. We utilise firm level data from China over the period of 2000 to 2007.8

3. Heterogeneity of FDI-Related Productivity Spillovers

FDI-invested firms, as compared to their domestic counterparts, usually possess some strategic advantages (Buckley and Casson 1976; Dunning, Kogut et al. 1990) that offset the disadvantage of being a foreign firm. Superior technology and know-how are typical strategic advantages that FDI-invested firms possess, particularly in the case of FDI from developed to developing countries. However, these advantages tend to shift to domestic firms thereby enhancing their productivity. Existing studies have identified three main channels through which FDI-related spillovers can occur. These channels include (i) backward and forward linkages that are formed between FDI-invested and domestic firms, (ii) labour mobility and (iii) demonstration and competition effects (Blomström and Kokko 1998).

Domestic firms can be either local suppliers (backward linkage) or customers (forward linkage) to FDI-invested firms. These contacts can help domestic firms to enhance their productivity. For example, FDI-invested firms can, among other things, help local suppliers (domestic firms) to set up production facilities, provide technical assistance and information, help purchasing raw material and intermediate inputs. FDI-invested firms can also provide training in management and organization (Lall, 1980). The role of backward and forward linkages has also been explored by theoretical studies, such as Rodriguez-Clare (1996), Markusen and Venables (1999), and Lin and Saggi (2007). The mobility of labour (specifically the movement of employees trained by FDI-invested firms to domestic firms) is the second channel through which spillovers can occur. The local employees of FDI-invested firms that are well trained can move to domestic firms or start their own businesses thus

8 It is perhaps worth mentioning that industry level studies are subject to aggregation bias and hence firm level studies are likely to produce relatively more reliable results (see Hale and Long, 2011).
carrying the skills that they acquired from FDI-invested firms to domestic firms. A number of empirical as well as theoretical studies have examined this channel.⁹

The third channel that facilitates spillover effects is through demonstration and competition effects. Domestic firms can observe the business activities of FDI-invested firms, imitate their behaviour, and thus improve their productivity. This channel has been examined both theoretically (for example, see Das 1987 and Wang and Blomström 1992) and empirically (for example, see Görg and Strobl 2001 and Görg and Greenaway 2004). In addition, increased competition arising from FDI in host economies also forces domestic firms to take steps that decrease cost and increase productivity. As observed by Jenkins (1990), domestic firms tend to adopt similar production techniques to those of FDI-invested firms if they are in competition with each other. However, the competition effect in the short run can be very different from the long-run effect. In the short run, the FDI-related competition effect can force some domestic firms out of the market and thus have a negative impact on domestic firms (Harrison 1994 and Aitken and Harrison 1999). However, in the long run, the FDI-related competition effect can have a positive impact on domestic firms. The positive effect in the long run arises from the fact that (i) domestic firms that cannot adapt to the competition are forced out of the market and (ii) the firms that do not exit the industry are forced to adopt advanced technology that improves their productivity (see Barrios, et al., 2005).

The three channels discussed above do not always automatically function. In fact, in order to benefit from FDI, domestic firms have to develop certain capabilities. For example, in order to become local suppliers to FDI-invested firms, domestic firms must be able to produce products that meet the requirements of FDI-invested firms. In order to attract skilled workers and managerial talents from FDI-invested firms, domestic firms must be able to pay

higher wages and also provide favourable working conditions. In order to imitate, domestic firms may have to improve their existing capacity. The competition arising from FDI is likely to have a strong negative effect on relatively less capable firms, forcing them to exit the industry (Harrison, 1994 and Aitken and Harrison, 1999). Wang and Blomström (1992) show that investment in learning undertaken by the domestic firms is positively related to FDI-related productivity spillovers. Empirically, the idea that benefits from FDI-related spillovers depend on the absorptive capacity of domestic firms (Cohen and Levinthal 1989; Cohen and Levinthal 1990) has been examined by a number of studies. For example, Girma (2005) finds that productivity spillovers from FDI depend on absorptive capacity of domestic firms in the UK manufacturing sector. Anwar (2008) has highlighted the role of human capital. In an earlier study, Furthermore Kokko (1994) has argued that the size of positive spillovers arising from FDI to domestic firms also depends on the educational levels of the labour force, the level of competition and the entry requirements on foreign entrants. Bjorvatn and Eckel (2006) and Markusen and Nesse (2007), among others, argue that FDI, though factors such as managerial skill acquisition and development of infrastructure, can improve the productivity of domestic firms, which can also reduce domestic unemployment.

Some existing studies, for example Giroud and Scott-Kennel (2009), have considered the qualitative aspects of a wide range of linkages between foreign and domestic firms. These linkages include competitive pressures induced by the foreign firms on domestic competitors, which could force domestic firms to improve the quality of their products and, in some cases, might force them to exit the industry. Jindra, Giroud and Scott-Kennel suggest that knowledge spillovers arising from vertical supply chain linkages between foreign subsidiaries and domestic firms can contribute to the economic development of host countries.

Depending on their absorptive capacity, benefits from FDI-related spillovers vary across domestic firms in host economies. In other words, differences in absorptive capacity
account for the heterogeneous nature of FDI-related spillovers to domestic firms. By examining the impact of the interaction of FDI with firm characteristics, in this paper, we attempt to capture this heterogeneity. The approach used in this paper is based on Crespo and Fontoura (2007) and Sun (2009). The response of each domestic firm to FDI varies depending on its characteristics. Hence, in this paper, following Buckley et al. (2007), we also allow the FDI-related productivity spillovers to be curvilinear. In other words, while allowing the spillover effects to be curvilinear, this paper also takes firm heterogeneity into account. The hypothesis that we aim to test in this paper is as follows:

**Hypothesis:** Depending on the characteristics of domestic firms in China’s manufacturing sector, FDI from Hong Kong, Macau and Taiwan and FDI from the rest of the world affect the productivity of domestic firms in China’s manufacturing sector in different ways and this effect is not only heterogeneous but also curvilinear.

4. Empirical Model

In order to test whether or not FDI-related productivity spillovers in China’s manufacturing sector are heterogeneous and curvilinear, we combine the methodologies that are used by previous studies, such as Buckley et al. (2002), Buckley et al. (2007), Smeets (2008) and Sun (2009), using the following econometric model:

\[
\ln(lp) = \alpha_0 + \alpha_1 X + \alpha_2 I + \alpha_3 H_{FDI} + \alpha_4 H_{FDI}^2 + \alpha_5 H_{FDI} \times X + \\
\alpha_6 W_{FDI} + \alpha_7 W_{FDI}^2 + \alpha_8 W_{FDI} \times X + \alpha_{15} \text{dyear} + \varepsilon
\]  

(1)

where lp is the firm labour productivity (i.e., the value added divided by number of employees); X is a vector of firm characteristics, which includes the firm size, capital intensity, average wage, age, and ownership structure; I is a vector of industry characteristics, which includes the Herfindahl index, overall industry concentration, and a set of two-digit industry dummies; H_{FDI} is a measure of FDI from Hong Kong, Macau, and Taiwan;
whereas $W_{FDI}$ is a measure of FDI from the rest of the world; and dyear is a set of year dummies.

The squared values of $H_{FDI}$ and $W_{FDI}$ are included in equation (1) to accommodate for the possible curvilinearity of FDI-related productivity spillovers. In addition, following Sun (2009), we also include the interactions of $H_{FDI}$ and $W_{FDI}$ with firm characteristics $X$ as additional explanatory variables, which allows the productivity spillovers to vary across firms and thus captures the heterogeneity of the spillovers. As far as the impact of FDI is concerned, firm characteristics play an important role. For example, bigger firms are generally more capable of absorbing the FDI-related spillovers. Using equation (1), the impact of FDI (i.e., foreign presence) on firm productivity can be calculated as follows:\(^{10}\)

\[
\frac{\partial \ln(p)}{\partial H_{FDI}} = \alpha_3 + 2\alpha_4 H_{FDI} + \alpha_5 X \\
\frac{\partial \ln(p)}{\partial W_{FDI}} = \alpha_6 + 2\alpha_7 W_{FDI} + \alpha_8 X
\] (2) (3)

Once equation (1) has been estimated, using the relevant estimated parameters, the values of firm characteristics, and FDI in equations (2) and (3), one can evaluate the impact of $H_{FDI}$ and $W_{FDI}$ on firm productivity in China’s manufacturing sector. A positive evaluated impact suggests the presence of positive productivity spillovers to domestic firms. On the other hand, a negative evaluated impact suggests the presence of negative productivity spillover effect on domestic firms and hence the presence of FDI-invested firms is harmful to domestic firms in China’s manufacturing sector. In addition, to establishing the presence of positive (or negative) spillovers to domestic firms, equation (1) can also be used to measure

\(^{10}\) $\frac{\partial \ln(p)}{\partial H_{FDI}}$ and $\frac{\partial \ln(p)}{\partial W_{FDI}}$, respectively are the percentage rates of change in productivity with respect to $H_{FDI}$ and $W_{FDI}$.
the impact of changes in certain firm characteristics on the capacity of domestic firms to absorb FDI-related productivity spillover effects as follows:\textsuperscript{11}

\[
\frac{\partial^2 \ln(lp)}{\partial x_i \partial H_{FDI}} = \alpha_{5,i} \tag{4}
\]

\[
\frac{\partial^2 \ln(lp)}{\partial x_i \partial W_{FDI}} = \alpha_{6,i} \tag{5}
\]

where \( x_i \) is the \( i \)th firm characteristic in the firm characteristic vector \( X \).

Equation (4) shows that a significant and positive estimated value of \( \alpha_{5,i} \) implies that the \( i \)th firm characteristic allows domestic firms to take advantage of the spillover effect that arises from \( H_{FDI} \). On the other hand, if the estimated value of \( \alpha_{5,i} \) is negative and statistically significant then the same characteristic does not allow domestic firms to benefit from \( H_{FDI} \). For example, if the estimated coefficient of the interaction between the foreign presence and firm size is positive and significant then a bigger firm is more capable of benefiting from FDI-related productivity spillovers. In other words, significant estimated values of \( \alpha_{5,i} \) and \( \alpha_{6,i} \) suggest that productivity spillovers are heterogeneous.

While the focus of this paper is on testing whether or not FDI-related productivity spillovers are heterogeneous and curvilinear, in order to reduce the bias that arises from omitted variables, we also control for other factors that may affect firm productivity. The control variables include both firm and industry characteristics. The firm characteristics explicitly considered include firm size, capital intensity, average wage, age, and ownership structure. The firm size is measured by the number of employees; capital intensity is proxied by fixed assets per employee; average wage, which captures the labour quality in a competitive labour market (Wakelin 1998), is the total salary cost divided by the number of employees; firm age reflects a firm’s previous experience, which can potentially affect its

\textsuperscript{11} The cross partial derivatives can be directly derived by making use of equations (2) and (3).
productivity. In addition, we also control for whether a firm is state and collectively owned or privately owned. This distinction can also help one to understand the role of ownership on firm productivity. The ownership effect is taken into account by means of a dummy variable that takes a value of 1 if a firm is privately owned and 0 otherwise. In China, privately owned firms have been found to be more productive than their state and collectively counterparts (Zhang, Zhang et al., 2002 and Zheng, Liu et al., 2003). At the industry level, we control for the impact of both the market structure and concentration of manufacturing activities. The effect of market structure is captured by means of the Herfindahl index, which is the sum of squared firm market share. The concentration of manufacturing activities is measured by the overall industry concentration. Specifically, the ratio of the province-industry (four digit) share of national industry employment to the province share of national manufacturing employment (Aitken, Hanson et al., 1997). A set of two-digit industry dummies is also included to control for other industry-specific factors that may affect firm productivity.

5. The Data

The empirical analysis presented in this paper is based on a firm level balanced panel dataset, which covers 24,056 domestic firms from 2000 to 2007. The dataset was extracted from a comprehensive micro dataset collected annually by the China National Bureau of Statistics, which is used to compile the ‘Industry’ section of the China Statistical Yearbook. This micro dataset accounts for over 85 % of China’s total industrial output. Similar data from the National Bureau of Statistics have been used to study various aspects of Chinese industrial economy. For example, Hu, Jefferson, and Qian (2005) examined R&D and technology transfer in China’s large and medium-size enterprises, Jefferson, Thomas, and Zhang (2008) considered the productivity growth in China’s industrial sector and Sun (2009) tested for the presence of FDI-related export spillovers.

12 The 2001 and 2004 data are not available.
Following the approach of Jefferson et al. (2008), the data set was cleaned before empirical analysis. Specifically, firms that employed fewer than eight workers were excluded since such very small firms may not have reliable accounting systems. Firms that reported negative net values of fixed assets and non-positive outputs, value added, and wages were also excluded along with firms that were located in the upper and the lower tails of the distribution of labour productivity. In other words, we computed Value Added/L, L/ Value Added, Value Added /K, K/ Value Added (where Value Added, L, and K respectively are the firm value added, number of employees and net value of fixed assets) and dropped those firms that lay more than four standard deviations from their means. After cleaning the data, we use the producer price index for manufactured goods obtained from *China Statistical Yearbook 2008* to deflate all monetary variables, such as the value added, to 2000 prices.

The use of a balanced panel dataset allows one to avoid the complication of the impact of firm entry and exit and other non-random panel attrition. Hence, for this study we have a sample of 24,056 domestic firms over six years. Table 1 presents the descriptive statistics of variables used in the empirical estimation. On average the labour productivity of domestic firms, in logarithm form, is 3.85. On average firms employ 420 workers and are 18.37 years old.13 The Herfindahl index that captures the domestic market structure on average is as low as 0.02, which indicates a very high level of competition in the domestic market. FDI from Hong Kong, Macau, and Taiwan (i.e., $H_FDI$) accounts for 14% of the total industry assets with a standard deviation of 0.1, while on average FDI from the rest of the world (i.e., $W_FDI$) accounts for 19% with a standard deviation of 0.12. In our sample, 34% of the firms are privately owned with the rest being state and collectively owned. As our panel regression equation includes interaction terms, in order to reduce multicollinearity that arises when interaction terms are included as independent variables, all continuous variables

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13 Two firms that produce traditional Chinese medicine report a history dating back to the 15th century, making them over 400 years old. Exclusion of a few outliers like these had no effect on the empirical results presented in this paper.
(i.e., $H_{FDI}$, $W_{FDI}$, firm size, age, capital intensity and average wage) are centred, which serves to reduce the bias that arises when interaction terms involve binary variables that take a value of zero or 1 (see Cronbach, 1987).

<insert Table 1 here>

6. Estimation Strategy and Empirical Results

6.1 Estimation strategy

In order to estimate equation (1), we first assume that FDI in China is exogenous and use the fixed effect (FE) estimator. However, the error terms in econometric models are often autocorrelated, which can render the statistical hypothesis testing process to be invalid. Autocorrelation can take many forms but the most common form of autocorrelation involves autoregressive process of order one; i.e., AR(1). In order to test for the presence of AR(1) autocorrelation, we utilise the Wooldridge (2002) test. Drukker (2003) shows that this test has good size and power properties in reasonable sample sizes. In the case of our study, the estimated value of the test statistic is 402.4 with a $p$-value of 0.000. Based on these values, we reject the null hypothesis of no first order autocorrelation at the 5 % significance level.

The dependent variable in equation (1) is the value added per worker, which shows significant variation across industries within China’s manufacturing sector. This suggests that heteroskedasticity might also be a serious problem, which like significant autocorrelation can bias the estimated results. In order to test for the presence of heteroskedasticity, while applying the fixed effect estimator, we utilise a modified Wald test for groupwise heteroskedasticity. The estimated value of the test statistic is very large (approximately $1.3 \times 10^7$) and the corresponding $p$-value is 0.000. Accordingly, at the 5 % level of significance, we reject the null hypothesis of homoskedasticity. In other words, the fixed effect estimation suffers from both autocorrelation and heteroskedasticity problems. Accordingly, we estimate equation (1) using the ordinary least square (OLS) estimator with
the Newey-West standard errors which takes into account the presence of significant heteroskedasticity and AR(1) autocorrelation.

Treating FDI as an exogenous variable may also be a very strong assumption. It is possible that FDI is in fact endogenous, which can render the results of econometric estimation to be inconsistent and biased. The endogeneity problem can occur if there is reverse causality or any of the independent variables depends on other factors. FDI tends to flow into industries where the productivity level is higher and it is increasing at an increasing rate. Additionally, FDI may also be correlated with some unobserved and uncontrolled factors that also affect the productivity of domestic firms. For example, in 1995, the Chinese government produced some guidelines for FDI in China. These guidelines include classification of all industries into four categories: industries where FDI is encouraged, industries where FDI is allowed, industries where FDI is restricted, and industries where FDI is prohibited. Such classification can create serious endogeneity problem in empirical studies. If classifications are based on the productivity (technology) level of industries, for example high-tech industries were FDI is encouraged, then FDI inflow will self-select into industries where the level of productivity is high. As a result of endogeneity, the measures of FDI and their interaction terms are correlated with the error term in equation and hence the estimated results are likely to be biased and inconsistent. In order to overcome this difficulty, we also utilise an instrumental variable (IV) estimation technique. This estimation technique involves identification of an appropriate instrument for FDI, which is the source of the endogeneity problem. The instrument must be relevant (in the sense that it is correlated with FDI) and valid (in the sense that it is uncorrelated with the error term). Most existing studies, where the variables are not subject to persistent autocorrelation, utilise one-period lagged values of the relevant variable as an instrument. Accordingly, in this paper, one-period lag of FDI and the
interaction of one-period lagged firm characteristics and one-period lagged FDI are used as the instruments.

The IV estimation is carried out using the Schaffer (2007) procedure. We first test the relevance of the instruments. Following Baum, Schaffer, and Stillman (2003), the relevance of the instruments can be tested by examining the fit of the first stage regressions. The first stage regressions yield three test statistics - the Bound, Jaeger, and Baker (1995) partial $R^2$-squared, the Shea (1997) partial $R$-squared and the $F$ statistic for joint significance of the lagged variables and the number of firms. Table 2 presents the estimated test statistics. The results presented in Table 2 confirm that all instruments are relevant. This follows from the fact that the estimated $R$-squareds are reasonable and the estimated $F$ statistics are also significant.

<insert Table 2 here>

As we found evidence of significant heteroskedasticity in earlier estimation, where FDI was assumed to be exogenous, it is reasonable to suspect that heteroskedasticity may also be present when FDI is assumed to be endogenous. Accordingly, we used the Pagan and Hall (1983) procedure to test for heteroskedasticity. The estimated value of the test statistic is 1206.75 with a $p$-value of 0.000 which allows one to reject the null hypothesis of homoskedasticity at the 5% level of significance. As a result of the presence of significant heteroskedasticity, equation (1) was also estimated by means feasible efficient two-step generalized method of moments (GMM) which utilises robust standard errors. In the presence of significant heteroskedasticity, this estimation technique is known to be relatively more efficient (Baum, Schaffer et al. 2003).

While equation (1) is estimated by means of four estimation techniques (FE estimation and OLS with Newey-West standard errors, where FDI is assumed to be exogenous, and IV and GMM estimation, where FDI is assumed to be endogenous), we also
attempted to identify the most reliable estimation technique. This task was accomplished by using a statistical test to determine whether or not FDI is endogenous. The endogeneity test is carried out using the \( C \)-test (Eichenbaum, Hansen et al. 1988; Hayashi 2000), which tests the orthogonality of an endogenous variable. This test is based on chi-square distribution. The estimated value of the \( C \) statistic is 27.23 with a \( p \)-value of 0.018, which allows us to reject the null hypothesis of orthogonality of FDI. In other words, the empirical evidence appears to suggest that FDI is an endogenous variable and hence the estimated results based on the IV/GMM estimation technique are more reliable.

6.2 FDI-related productivity spillovers in China’s manufacturing sector

As indicated in section 4, whether or not FDI-related productivity spillovers are present in China’s manufacturing sector can be investigated by means of equations (2) and (3). However, in order to make use of equations (2) and (3), the empirical model presented in equation (1) has to be estimated. The results of this estimation are reported in Table 3, where columns one to four, respectively, contain the results of FE estimation, OLS estimation with Newey-West standard errors, IV estimation and feasible efficient two-step GMM estimation with instruments. The results based on FE and OLS estimation with Newey-West standard errors are presented purely for comparison purposes. A comparison of the results from FE and OLS estimation with the results derived from IV and GMM estimation allows us to make a few interesting observations. For example the estimated coefficient of \( W_{\text{FDI}} \) (i.e., the impact of FDI from the rest of the world) is significant when FE and OLS estimation techniques are used but insignificant when under IV and GMM estimation. As FDI is found to be endogenous, the discussion and interpretation presented in the rest of this paper will be based on IV/GMM estimation results. The IV and GMM estimation appears to lead to robust results in the sense that the signs of all the estimated coefficients under both estimation
techniques are the same and almost all estimated coefficients lie within one standard deviation of each other. Since the GMM estimation is relatively more efficient in the presence of heteroskedasticity (Baum, Schaffer et al. 2003), the subsequent interpretation is based on GMM estimation with instruments.

Column (4) of Table 3 shows that a significant curvilinear relationship exists between FDI from Hong Kong, Macau and Taiwan and the productivity of the domestic firms in China’s manufacturing sector. This result is consistent with the finding of Buckley et al. (2007). However, unlike Buckley et al.’s work that is based on an older cross-sectional dataset, we find that firm level spillovers do not decrease. Buckley et al. have suggested that the short-run competition effect channel dominates all the other channels and hence after FDI has reached a critical level, further increase in FDI increases the competition between domestic and foreign firms to a level where increased competition is harmful to domestic firms. However, an increase in FDI not only strengthens the forward and backward linkages between domestic and foreign firms but also increases the prospects of labour mobility and imitation that could enhance the productivity of domestic firms. Our finding that an increase in FDI increases firm productivity at an increasing rate appears to capture this latter impact. In addition, differences in our results in terms of the nature of the curvilinearity can also be attributed to the use of a relatively new panel dataset. Specifically, Buckley et al. (2007) employ a cross-sectional industry level dataset, while this study uses a firm level panel dataset. Görg and Stobl (2001) suggest that, compared to panel data studies, studies that are based on cross-sectional data often find relatively large FDI-related productivity spillovers. Caballero and Lyons (1989) show that spillovers at a lower level of aggregation may be internalized at a higher level of aggregation. The results presented in column (4) of Table 3 also suggest that W_FDI does not lead to curvilinear productivity spillovers. This follows
from the fact that the estimated coefficients of both $W_{FDI}$ and $W_{FDI}^2$ are statistically insignificant.

In addition to the curvilinearity, the productivity spillovers arising from $H_{FDI}$ also depend on firm age, capital intensity, and ownership structure. By differentiating the estimated version of equation (1) with respect to $H_{FDI}$, equation (6) can be derived as follows:

$$\frac{\partial \ln(lp)}{\partial H_{FDI}} = 1.8244 \times H_{FDI} - 0.007 \times age + 0.0017 \times k - 0.2255 \times ownership$$

(6)

where $age$ is the firm age; $k$ is capital intensity; and $ownership$ is firm ownership structure, which takes a value of 1 if the firm is privately owned.

Equation (6) shows the marginal effect of $H_{FDI}$ on the productivity of domestic firms in China’s manufacturing sector, where the impact of insignificant variables has been excluded. Equation (6) suggests that firms that are older, less capital intensive and privately owned, gain fewer benefits from $H_{FDI}$. In other words, younger, less capital intensive firms that are not privately owned appear to benefit more from $H_{FDI}$, which could be attributed to the fact that such firms are better equipped with financial resources such as credit from state-owned banks.

By using the average values of variables that appear on the right hand side of equation (6), we can also evaluate the overall impact of FDI on an average firm. Using the average values in equation (6), we estimate that a 1% increase in $H_{FDI}$ increases the productivity of an average firm that is not privately owned by 0.12%. In contrast, an average firm in China’s manufacturing sector that is privately owned experiences a decrease in productivity by 0.11%. If we evaluate the marginal effect equation at the values of individual firm characteristics, we can obtain the distribution of the marginal effect (see Figure 1). A close examination of Figure 1 suggests that the distribution is slightly biased towards right, which
suggests that, in overall term, the number of firms that benefit from H_FDI is greater than the number of firms that experience a decline in productivity.

<insert Figure 1 here>

Regarding the impact of FDI from the rest of the world, just like Buckley et al. (2007), we fail to find a curvilinear relationship between FDI and the productivity of domestic firms. However, we find that W_FDI affects firm productivity through its interaction with firm characteristics. The magnitude of FDI-related productivity spillovers depends on firm size and average wage. By differentiating the estimated version of equation (1) with respect to $W_FDI$, we obtain equation (7) as follows:

$$\frac{\partial \ln(lp)}{\partial W_FDI} = -0.1108 \times \text{firmsize} - 0.0083 \times \text{averagewage}$$

(7)

where $\text{firmsize}$ is the firm size; and $\text{averagewage}$ is the average wage.

As the estimated coefficients are significantly negative, it seems that $W_FDI$ negatively affects the productivity of domestic firms. This situation could be attributed to the strong short-run competition effect, which outweighs the positive impact on productivity from other channels. Large domestic firms that, on average, pay higher wages (where average wage is a proxy for labour quality) are more likely to be adversely affected by the competition that arises from $W_FDI$. As indicated earlier, $W_FDI$ comes mainly from Western countries.

Equation (7) can also be used to evaluate the impact of an increase in FDI on productivity using average values of the relevant variables as well as using the individual values of firm characteristics. Our calculations suggest that, for an average domestic firm, a 1 % increase in $W_FDI$ decreases firm productivity by 0.15 %. Figure 2 presents the distribution of the marginal effect of $W_FDI$. Figure 2 suggests that, as $W_FDI$ increases, a great majority of (if not all) domestic firms experience a decline in their productivity.

<insert Figure 2 here>
In summary, as some of the interaction terms included in equation (1) are found to be statistically significant, it can be argued that both types of FDI (i.e., from Hong Kong, Macau and Taiwan and from the rest of the World) lead to heterogeneous productivity spillovers. In other words, depending on firm characteristics, the magnitude of FDI-related productivity spillovers to domestic firms in China’s manufacturing sector varies across firms.

6.3 Impact of other factors on firm productivity

Firm characteristics also affect the productivity of domestic firms. Column (4) of Table 3 shows that both firm size and age have a significant negative impact on firm productivity. In other words, both relatively large and older firms experience a decline in productivity. Younger firms appear to benefit from a late-comer advantage. However, firms that are relatively more capital intensive are more productive and firms that use higher quality labour (as reflected by higher average wage) also experience an improvement in productivity. However, the estimated coefficient of the interaction of average wage and \( W_{FDI} \) is negative and significant. This suggests that in the presence of increased competition that arises from \( W_{FDI} \), paying higher wages reduces the productivity of domestic firms. Generally speaking, Western firms pay higher wages and as \( W_{FDI} \) increases, higher wages paid by some domestic firms are perhaps not that high anymore. The estimated coefficient of average wage is 0.0126, while the estimated coefficient of its interaction term with \( W_{FDI} \) is -0.0083. However, at all levels of FDI from the rest of the world, the marginal impact of average wage on firm productivity is always positive as 0.0126 > -0.0083. Ownership structure significantly affects firm productivity level as well. Compared to state and collectively owned firms, private firms are more productive. However, competition arising from \( H_{FDI} \) reduces the productivity of privately owned firms. The net marginal impact of the ownership structure on productivity of domestic firms in China’s manufacturing sector depends on the level of
H_FDI. In the absence of H_FDI, the privately owned firms are 3.2% more productive. The domestic market structure (Herfindahl index) does not appear to have a significant impact on firm productivity. However, the estimated coefficient of the overall industry concentration is negative and statistically significant. A firm that is located in a concentrated industry is more likely to learn from foreign firms and imitate. However, all firms are affected by competition that arises from FDI. In the short-run the competition arising from FDI may have a negative impact on most domestic firms. It seems that the short-run negative impact from FDI-related competition outweighs the positive impact of learning and imitation.

The empirical results presented in this paper so far suggest that both types of FDI affect the productivity of domestic firms in China’s manufacturing sector but W_FDI affects firm productivity only through its interaction with firm characteristics. So far we have measured FDI in China as the share of the assets of FDI-invested firms within a four-digit industry classification. Previous studies have used three methods to measure FDI in an industry; namely, the output, the employment, or the assets/capital share of the FDI-invested firms in an industry. Are the result presented in this paper sensitive to the choice of FDI measurement? In order to determine whether our main results are sensitive to different measures of FDI, we re-estimated the model using both the employment and the output measures of FDI. The results, that are not reported here to save space, were very similar. In both cases, productivity spillovers from both types of FDI were found to be heterogeneous and, like the results presented in Table 3 of this paper, curvilinearity was found only in the case of H_FDI.

7. Concluding Remarks

A number of studies have examined the impact of FDI-related spillovers on productivity in both developed and developing countries. However, most existing studies

14 These results are available from the authors upon request.
assume that this relationship is linear and that productivity spillovers to domestic firms in host countries are homogeneous. This paper aims to extend the existing literature by examining the issue of heterogeneity as well as nonlinearity in the spillovers. Using firm level panel data over the period 2000-2007, this paper examines the impact of FDI-related spillovers on the productivity of domestic firms in China’s manufacturing sector. We distinguish between FDI that originates from Hong Kong, Macau and Taiwan and FDI that originates from the rest of the world. FDI from the rest of the world comes mainly from Western countries.

Using the Generalised Method of Moments (GMM), the empirical analysis presented in this paper suggests that productivity spillovers arising from FDI from Hong Kong, Macau and Taiwan are not only curvilinear but also heterogeneous. Older and privately owned firms appear to experience a decline in productivity but firms that are more capital intensive experience larger productivity spillovers. As far as the impact of FDI from the rest of the world is concerned, we find that productivity spillovers are heterogeneous but not curvilinear. Firms that are larger and firms that pay higher average wage (which is a proxy for product quality) experience a decline in productivity as FDI from the rest of the world increases.

The empirical results presented in this paper suggest that productivity spillovers arising from FDI from Hong Kong, Macau and Taiwan are curvilinear. This result has an important policy implication. The estimated U-shaped relationship with the minimum occurring at a negative value of FDI suggests that an increase in FDI originating from Hong Kong, Macau and Taiwan would result in a positive productivity spillover to China’s manufacturing sector. This implies that the recent policy of the Chinese government, which aims to restrict FDI in some sectors, should only be applied to FDI from the rest of the world.

Recent studied have highlighted the implications of heterogeneity at various levels. For example, using logit regression on firm level data from Japan, Hayakawa and Matsuura (2013) find that a reduction in tariff attracts even less productive vertical foreign direct investment. This study mainly deals with the heterogeneous impact of trade liberalisation on vertical FDI.
In addition, because productivity spillovers are heterogeneous, not all firms benefit from FDI from either source and hence more focused industrial policy that takes into account the distributional characteristics of domestic firms in China’s manufacturing sector is required. Finally, the heterogeneity of spillovers may account for the absence of FDI-related productivity spillovers reported by some studies, especially in the case of developing countries.

The research in their area of heterogeneity of FDI-related productivity spillovers can be further extended by conducting a disaggregated analysis of China’s manufacturing sector. This will allow one to identify specific industries within the manufacturing sector where restrictions on FDI may be necessary.

Acknowledgements

This paper has greatly benefitted from helpful comments and suggestions received from two anonymous reviewers of this journal. We are also thankful to several colleagues, particularly Robert Alexander and John Rice, for helpful comments and suggestions. However, the authors are responsible for all remaining errors and omissions.
**Table 1:** Descriptive Statistics of the Sample

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(labour productivity)</td>
<td>3.85</td>
<td>1.00</td>
<td>-2.46</td>
<td>8.20</td>
</tr>
<tr>
<td>firm size</td>
<td>0.42</td>
<td>1.73</td>
<td>0.01</td>
<td>161.65</td>
</tr>
<tr>
<td>firm age</td>
<td>18.37</td>
<td>15.04</td>
<td>1</td>
<td>408</td>
</tr>
<tr>
<td>capital intensity</td>
<td>69.13</td>
<td>105.20</td>
<td>0.01</td>
<td>4654.17</td>
</tr>
<tr>
<td>average wage</td>
<td>11.93</td>
<td>9.13</td>
<td>0.01</td>
<td>478.11</td>
</tr>
<tr>
<td>ownership</td>
<td>0.34</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Herfindahl index</td>
<td>0.02</td>
<td>0.03</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>overall industry concentration</td>
<td>31.65</td>
<td>181.06</td>
<td>0.01</td>
<td>25873.59</td>
</tr>
<tr>
<td>(H_{FDI})</td>
<td>0.14</td>
<td>0.10</td>
<td>0</td>
<td>0.82</td>
</tr>
<tr>
<td>(W_{FDI})</td>
<td>0.19</td>
<td>0.12</td>
<td>0</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Note: \(H_{FDI}\) is FDI from Hong Kong, Macau, and Taiwan; and \(W_{FDI}\) is FDI from the rest of the world.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Shea Partial R^2</th>
<th>Bound et al. Partial R^2</th>
<th>$F(14, 47994)$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H_FDI</td>
<td>0.12</td>
<td>0.15</td>
<td>184.41</td>
<td>0</td>
</tr>
<tr>
<td>H_FDI^2</td>
<td>0.08</td>
<td>0.11</td>
<td>52.81</td>
<td>0</td>
</tr>
<tr>
<td>H_FDI × firm size</td>
<td>0.07</td>
<td>0.08</td>
<td>6.93</td>
<td>0</td>
</tr>
<tr>
<td>H_FDI × firm age</td>
<td>0.20</td>
<td>0.22</td>
<td>79.40</td>
<td>0</td>
</tr>
<tr>
<td>H_FDI × capital intensity</td>
<td>0.05</td>
<td>0.05</td>
<td>13.18</td>
<td>0</td>
</tr>
<tr>
<td>H_FDI × average wage</td>
<td>0.02</td>
<td>0.03</td>
<td>19.04</td>
<td>0</td>
</tr>
<tr>
<td>H_FDI × ownership</td>
<td>0.19</td>
<td>0.19</td>
<td>167.92</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI</td>
<td>0.17</td>
<td>0.21</td>
<td>291.79</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI^2</td>
<td>0.07</td>
<td>0.14</td>
<td>37.43</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI × firm size</td>
<td>0.46</td>
<td>0.52</td>
<td>14.03</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI × firm age</td>
<td>0.22</td>
<td>0.26</td>
<td>75.40</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI × capital intensity</td>
<td>0.07</td>
<td>0.09</td>
<td>9.36</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI × average wage</td>
<td>0.01</td>
<td>0.03</td>
<td>19.07</td>
<td>0</td>
</tr>
<tr>
<td>W_FDI × ownership</td>
<td>0.19</td>
<td>0.22</td>
<td>193.61</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: H_FDI is FDI from Hong Kong, Macau, and Taiwan; and W_FDI is FDI from the rest of the world.
Table 3: Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>(1) FE</th>
<th></th>
<th>(2) OLS with Newey-West Standard Errors</th>
<th>(3) IV</th>
<th></th>
<th>(4) GMM with Instruments</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(labor productivity)</td>
<td></td>
<td>Coefficient</td>
<td>Robust Standard Error</td>
<td>t-value</td>
<td>Coefficient</td>
<td>Newey-West Standard Error</td>
<td>t-value</td>
</tr>
<tr>
<td>firm size</td>
<td>-0.1156*</td>
<td>0.0104</td>
<td>-11.08</td>
<td>-0.0121*</td>
<td>0.0031</td>
<td>-3.92</td>
<td>-0.1512*</td>
</tr>
<tr>
<td>firm age</td>
<td>-0.0019*</td>
<td>0.0003</td>
<td>-6.99</td>
<td>-0.0101*</td>
<td>0.0002</td>
<td>-41.02</td>
<td>-0.0014*</td>
</tr>
<tr>
<td>capital intensity</td>
<td>0.0013*</td>
<td>0.0001</td>
<td>18.99</td>
<td>0.0019*</td>
<td>0.0001</td>
<td>25.55</td>
<td>0.0012*</td>
</tr>
<tr>
<td>average wage</td>
<td>0.0153*</td>
<td>0.0006</td>
<td>25.29</td>
<td>0.0256*</td>
<td>0.0007</td>
<td>36.01</td>
<td>0.0125*</td>
</tr>
<tr>
<td>ownership</td>
<td>0.0306*</td>
<td>0.0063</td>
<td>4.84</td>
<td>0.1082*</td>
<td>0.0060</td>
<td>17.91</td>
<td>0.0322*</td>
</tr>
<tr>
<td>Herfindahl index</td>
<td>-0.0993</td>
<td>0.0854</td>
<td>-1.16</td>
<td>0.2645*</td>
<td>0.0885</td>
<td>2.99</td>
<td>-0.2313</td>
</tr>
<tr>
<td>overall industry concentration</td>
<td>0.00001</td>
<td>0.00001</td>
<td>-0.82</td>
<td>-0.0001*</td>
<td>0.00001</td>
<td>-5.2</td>
<td>-0.0001*</td>
</tr>
<tr>
<td>H_FDI</td>
<td>0.1410*</td>
<td>0.0466</td>
<td>3.02</td>
<td>-0.0730</td>
<td>0.0496</td>
<td>-1.47</td>
<td>0.0155</td>
</tr>
<tr>
<td>H_FDI²</td>
<td>0.5855*</td>
<td>0.1923</td>
<td>3.04</td>
<td>-0.2336</td>
<td>0.2125</td>
<td>-1.1</td>
<td>0.9451*</td>
</tr>
<tr>
<td>H_FDI × firm size</td>
<td>-0.1007*</td>
<td>0.0414</td>
<td>-2.43</td>
<td>-0.0025</td>
<td>0.0296</td>
<td>-0.09</td>
<td>-0.0784</td>
</tr>
<tr>
<td>H_FDI × firm age</td>
<td>-0.0126*</td>
<td>0.0021</td>
<td>-6.05</td>
<td>-0.0024</td>
<td>0.0023</td>
<td>-1.05</td>
<td>-0.0073*</td>
</tr>
<tr>
<td>H_FDI × capital intensity</td>
<td>0.0017*</td>
<td>0.0007</td>
<td>2.66</td>
<td>0.0029*</td>
<td>0.0009</td>
<td>3.19</td>
<td>0.0017*</td>
</tr>
<tr>
<td>H_FDI × average wage</td>
<td>-0.0039</td>
<td>0.0043</td>
<td>-0.89</td>
<td>-0.0117*</td>
<td>0.0056</td>
<td>-2.1</td>
<td>-0.0018</td>
</tr>
<tr>
<td>H_FDI × ownership</td>
<td>-0.3286*</td>
<td>0.0488</td>
<td>-6.74</td>
<td>-0.5364*</td>
<td>0.0558</td>
<td>-9.61</td>
<td>-0.2364*</td>
</tr>
<tr>
<td>W_FDI</td>
<td>0.1896*</td>
<td>0.0386</td>
<td>4.91</td>
<td>0.5764*</td>
<td>0.0414</td>
<td>13.91</td>
<td>0.0450</td>
</tr>
<tr>
<td>W_FDI²</td>
<td>-0.4216*</td>
<td>0.1324</td>
<td>-3.18</td>
<td>-1.9729*</td>
<td>0.1485</td>
<td>-13.29</td>
<td>-0.2432</td>
</tr>
<tr>
<td>W_FDI × firm size</td>
<td>-0.1093*</td>
<td>0.0320</td>
<td>-3.41</td>
<td>-0.0545*</td>
<td>0.0197</td>
<td>-2.77</td>
<td>-0.0963*</td>
</tr>
<tr>
<td>W_FDI × firm age</td>
<td>0.0026</td>
<td>0.0016</td>
<td>1.56</td>
<td>-0.0035*</td>
<td>0.0018</td>
<td>-1.96</td>
<td>0.0038</td>
</tr>
<tr>
<td>W_FDI × capital intensity</td>
<td>-0.0009*</td>
<td>0.0004</td>
<td>-2.11</td>
<td>-0.0006</td>
<td>0.0005</td>
<td>-1.01</td>
<td>-0.0005</td>
</tr>
<tr>
<td>W_FDI × average wage</td>
<td>-0.0070*</td>
<td>0.0028</td>
<td>-2.49</td>
<td>-0.0062*</td>
<td>0.0031</td>
<td>-2</td>
<td>-0.0072*</td>
</tr>
<tr>
<td>W_FDI × ownership</td>
<td>-0.1487*</td>
<td>0.0457</td>
<td>-3.25</td>
<td>-0.3458*</td>
<td>0.0531</td>
<td>-6.51</td>
<td>-0.0120</td>
</tr>
<tr>
<td>industry dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>year dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>constant</td>
<td>3.2814</td>
<td>0.0543</td>
<td>60.48</td>
<td>3.6932</td>
<td>0.0173</td>
<td>213.49</td>
<td>n.a.</td>
</tr>
<tr>
<td>R-square</td>
<td>0.1454</td>
<td>n.a.</td>
<td>60.48</td>
<td>3.6932</td>
<td>0.0173</td>
<td>213.49</td>
<td>n.a.</td>
</tr>
<tr>
<td>F statistic</td>
<td>434.26</td>
<td>447.52</td>
<td>115.4</td>
<td>115.5</td>
<td>72100</td>
<td>72100</td>
<td></td>
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</table>
Note: H_FDI is FDI from Hong Kong, Macau, and Taiwan; and W_FDI is FDI from the rest of the world. * denotes significance at the 5% level (two-tailed test).
**Figure 1:** Distribution of the Incremental Effect of FDI from Hong Kong, Macau and Taiwan on Productivity of Domestic Firms

Note: Change in productivity in percentage is measured along the vertical axis; change in FDI in percentage is measured along the horizontal axis.
**Figure 2:** Distribution of the Incremental Effect of FDI from the Rest of the World on Productivity of Domestic Firms

Note: Change in productivity in percentage is measured along the vertical axis; change in FDI in percentage is measured along the horizontal axis.
References


Poole, J. P. (2007) Multinational spillovers through worker turnover. Santa Cruz, Department of Economics, University of California, Santa Cruz.


