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Manufacturing dynamics and spillovers: The case of Guangdong Province and Hong Kong, Macau, and Taiwan (HKMT)

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ABSTRACT

In this paper we characterize the extent of economic integration between Guangdong, Hong Kong, Macau, and Taiwan (HKMT). We do not find, for the period of 1999–2003, consistent evidence that economic activity on the part of HKMT-funded companies contributed to productivity growth in Guangdong domestic manufacturing firms. Furthermore, HKMT-funded companies were less active than Guangdong domestic companies in pursuing research and development (R&D) and innovation activities. Given that HKMT-funded companies in Guangdong are dominated by companies from Hong Kong, we end by linking our results to a discussion of recent innovation policy actions, both in Hong Kong SAR and Guangdong province.

1. Introduction

Among developing countries, the People's Republic of China (hereinafter "China") has attracted the most foreign direct investment (FDI) over the last two decades. Around one-third of FDI to China over the period 1985–2003 went to Guangdong province (Fig. 1) in southern China. Guangdong province was able to attract 30 percent of China's total FDI in large part because of its geographical and cultural proximity to Hong Kong, Macau, and Taiwan (hereafter referred to as HKMT), all three of which have invested heavily in China over the past three decades. Among the three component entities of HKMT, Hong Kong accounted for the greatest amount, US$ 99.6 billion, during the period of 1979–2004, representing 66.2 percent of total cumulative FDI inflows to Guangdong. This figure was followed by US$ 8.8 billion from Taiwan, representing 5.9 percent of total cumulative FDI, and US$ 6.8 billion from Macau, representing 4.5 percent of total cumulative FDI (Guangdong Statistical Yearbook, 2005). In 2004, 73.2 percent of all FDI in Guangdong was devoted to manufacturing sectors, securing Guangdong's position as a manufacturing center in Southern China.

From Hong Kong's perspective, Guangdong province is the most important investment destination in China. Since the mid 1990s, Hong Kong-based entrepreneurs have allocated almost half of their investments in China to Guangdong province (Fig. 1). Since the opening of China in 1979, Hong Kong has transformed itself from an industrializing city into a center of manufacturing-related service activities. The contribution made by manufacturing to Hong Kong's GDP has dropped accordingly, from 23.6 percent in 1980 to just 4.6 percent in 2002; concurrently, the contribution made by services to Hong Kong's GDP rose from 67.3 percent to 87.4 percent over the same period. A significant proportion of Hong Kong's income has been generated by China-related trade and investment (Chan, 2002; Tao and Wong, 2002). Sun and Wong (2000) estimate that the ratio of Hong Kong's China-related trade and investment to its GDP was 24.4 percent in 1996. Furthermore, since China assumed sovereignty over Hong Kong in 1997, Hong Kong's innovation and technology policymakers have been actively trying to 'leverage the Mainland'—particularly Guangdong—in terms of their innovation and technology policy development strategies in the territory.

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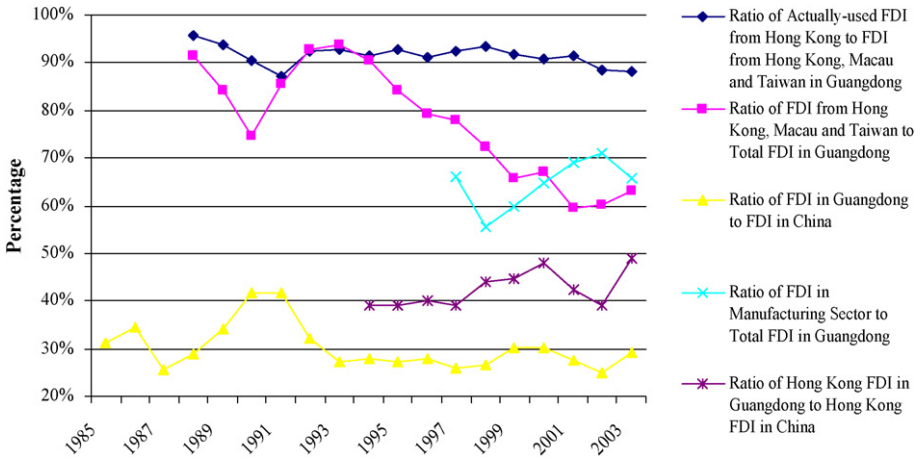

Fig. 1. Foreign Direct Investment in Guangdong, 1985–2003.
Source: Various issues of Guangdong Statistical Yearbook (2000–2004) and China Statistical Yearbook (2005).
Note: 1. When calculating the "Ratio of Hong Kong FDI in Guangdong to Hong Kong FDI in China" for the period of 1994–1997, the authors adopt the FDI data, which include data reflecting foreign loans and foreign non-direct investment.

As noted, companies based in Hong Kong have represented the largest source of FDI in Guangdong. In 1989, 87.4 percent of FDI in Guangdong was invested by Hong Kong entrepreneurs (compared with only 0.4 percent by Taiwanese entrepreneurs and 3.6 percent by entrepreneurs from Macau). As recently as 2003, approximately 55.5 percent of total FDI in Guangdong came from Hong Kong (Fig. 1), approximately 4.0 percent from Taiwan, and 3.5 percent from Macau. The value of exports from Guangdong to Hong Kong rose from US$ 29.2 billion in 1997 to US$ 53.9 billion in 2003. By comparison, the value of exports from Guangdong to Taiwan and Macau in 2003 was only US$ 2.5 billion and US$ 1.1 billion, respectively.

The expansion of HKMT-funded firms in Guangdong was recorded in China's industrial statistical data in the category of output growth of foreign firms (which includes both HKMT- and non-HKMT foreign firms). Table 1 shows the breakdown of the industrial gross output value of Guangdong manufacturing firms, based on the three domestic ownership groups—state-owned companies, collective enterprises, and shareholding enterprises—and one foreign ownership group—foreign enterprises (HKMT- and non-HKMT foreign firms).[1] Shares above 60 percent of gross output value in specific sectors are marked in bold text in the table. From 1997 to 2003, the share in gross industrial output taken by foreign companies increased in 23 of the total of 27 manufacturing sectors. In 2003, foreign firms produced more than 60 percent of the total industrial output in 14 sectors, further securing their predominant sectoral positions in Guangdong's economy.

Even though foreign firms surpassed their domestic counterparts in Guangdong in terms of output growth, domestic enterprises gained in terms of labor productivity (calculated as value-added divided by labor input). As demonstrated in Table 2, in 1997 foreign enterprises featured higher labor productivity than domestic firms in 20 out of 27 sectors. In many of those sectors, foreign firms' labor productivity in 1997 was two or three times that of local enterprises. Significantly, however, domestic companies had, within seven years (i.e. by 2003), gained the lead in 16 out of 27 sectors (marked in bold text in Table 2). From 1997 to 2003, pressured by fierce competition from FDI-funded companies, domestic companies shrank in size while simultaneously achieving higher labor productivity growth rates (as compared with those of foreign firms) and regaining the advantage in over half of Guangdong's manufacturing sectors.

To understand the extent of economic integration between China and HKMT, Wang and Schuh (2002) investigated the effects of such integration between China on the one hand and Taiwan and Hong Kong on the other, using a general equilibrium model for world production and trade. Other scholars, recognizing that HK is the most important entity from among the HKMT group in terms of economic ties to Guangdong, have thus far either dedicated themselves to analyzing Hong Kong's economic transition in the context of manufacturing cross-production in Guangdong (see, for example, Eng, 1997; Hollows, 1999; Kwong et al., 2000) or focused on the two regions' economic integration exclusively from the perspective of Hong Kong (Tuan and Ng, 1995, 2004). Few studies have examined the development of Guangdong's domestic manufacturing firms and their interaction with foreign counterparts, given the context in which foreign businesses—principally Hong Kong-run companies—have flourished in Guangdong. Yeung's articles (2001, 2002) are exceptions in linking Guangdong's industrial development to Hong Kong, but these studies consist almost entirely of qualitative analyses. Yet fewer studies have linked the development of research and development (R&D) in manufacturing firms in Guangdong—both domestic and HKMT-funded—with the implications those R&D activities have for innovation and technology policymaking in the region.

In this paper, we center our analysis on the productivity performance of Guangdong's locally funded manufacturing sectors over the period 1999–2003. By utilizing an industry-level database, we explore in Section 2 the potential impact of economic activity undertaken by foreign firms—both HKMT-funded and non-HKMT foreign-funded—on the productivity growth of Guangdong's domestic manufacturing firms, grounding our work on the FDI spillover literature (Section 2.1). We find no consistent evidence of a significant positive impact (Sections 2.2 and 2.3). In fact, our econometric analyses demonstrate that productivity gains in Guangdong domestic firms result largely from their *own* commitment to R&D investment and innovation efforts (Section 2.4). Finally, in light of our findings and recent policy initiatives on both sides of the Hong Kong/Guangdong border, in Section 3 we connect our results to current and future innovation policies in both Guangdong and Hong Kong. We conclude with final reflections in Section 4.

[1] The ownership status of a firm that operates in China is determined, according to Chinese legislative regulations, when the firm registers with agencies of the Administration for Industry & Commerce. In general, a firm is classified as a foreign-funded firm only if the foreign equity stake is at or above 25 percent (the classification standard can be found at: http://www.stats.gov.cn/tjbz/t20061018_402369831.htm accessed on 25 June, 2006). More detailed discussion of the classification of foreign-funded firms in China can be found in Huang, 2003, p. 4, 35.

Table 1
Percentage breakdown of industrial gross output value in Guangdong Province, 1997 and 2003.[a]

Sectors	1997				2003			
	Domestic Enterprises			Foreign Enterprises	Domestic Enterprises			Foreign Enterprises
	State-owned Enterprises	Collective Enterprises	Shareholding Enterprises		State-owned Enterprises	Collective Enterprises	Shareholding Enterprises	
Agri-food Processing	36.4	14.5	9.2	39.9	13.3	3.6	37.6	45.6
Food	18.9	11.6	8.9	**60.6**	8.6	3.5	19.3	**68.6**
Beverage	20.5	15.4	1.9	**62.3**	21.5	1.1	17.9	59.5
Textile	15.6	13.4	9.5	**61.4**	8.4	5.2	13.5	**72.8**
Garments	2.3	34.5	0.0	**63.2**	1.0	10.0	17.9	**71.0**
Leather	3.4	17.5	0.4	**78.7**	1.6	6.5	8.4	**83.5**
Wood processing	15.8	44.0	0.0	40.1	3.3	16.0	40.3	40.4
Furniture	5.4	43.4	0.0	51.2	1.1	4.8	16.2	**77.9**
Paper	12.2	26.9	4.6	56.3	13.1	9.6	20.1	57.2
Printing	19.0	25.0	0.3	55.7	8.7	4.8	23.6	**62.9**
Educational and sports products	5.3	32.7	0.7	**61.2**	2.6	9.0	9.6	**78.8**
Petroleum products	**86.7**	0.8	1.5	10.9	45.3	0.6	47.2	6.9
Chemical products	19.7	15.0	6.4	58.9	17.7	3.1	19.0	**60.1**
Pharmaceutical products	38.6	11.1	4.4	45.9	28.9	4.2	30.5	36.4
Chemical fiber	6.6	13.9	46.1	33.3	19.8	1.8	15.8	**62.6**
Rubber	13.6	12.8	0.0	**73.5**	18.6	5.3	16.7	59.4
Plastics	5.4	33.2	6.2	55.2	4.4	5.6	16.1	**73.9**
Nonmetal mineral products	21.3	38.1	6.8	33.8	7.9	15.5	37.3	39.2
Ferrous metals smelting	41.9	19.2	26.2	12.7	33.0	3.3	29.5	34.2
Nonferrous metals smelting	42.7	25.2	1.5	30.6	14.4	11.3	40.9	33.4
Metal products	6.7	30.4	2.0	**60.9**	3.1	7.1	20.0	**69.8**
General mechanical products	34.2	24.1	2.8	38.9	19.7	5.9	23.3	51.1
Special mechanical products	29.1	30.2	5.0	35.7	8.6	4.9	25.8	**60.8**
Transportation equipment	20.6	17.4	10.4	51.5	32.7	1.4	8.5	57.3
Electrical equipment	10.1	21.2	21.3	47.4	5.3	3.9	36.8	54.1
Telecommunication and computer	5.5	7.8	2.3	**84.4**	15.2	0.3	16.0	**68.4**
Instruments and office machinery	6.0	8.1	0.6	**85.3**	1.3	2.1	3.4	**93.2**

Data Source: Various issues of the Guangdong Statistical Yearbook (2000–2004).

[a] *Note*: Sum of the value of state-owned, collective, shareholding and foreign enterprises is taken as one. Share values over 60 percent are marked in bold text.

Table 2
Labor productivity of state-owned, collective, shareholding, and foreign enterprises in Guangdong Province (10^4 RMB/Person), 1997 and 2003.

Sectors	1997				2003			
	Domestic Enterprise			Foreign Enterprises	Domestic Enterprise			Foreign Enterprises
	State-owned Enterprises	Collective Enterprises	Shareholding Enterprises		State-owned Enterprises	Collective Enterprises	Shareholding Enterprises	
Enterprises Agri-food Processing	2.23	4.66	4.85	14.32	7.30	10.07	9.57	14.63
Food	2.16	1.84	4.39	7.45	5.18	4.80	6.28	12.98
Beverage	**3.88**	**3.74**	**4.06**	**13.03**	**27.77**	**5.14**	**17.36**	**23.40**
Textile	1.21	1.70	5.70	3.18	4.17	3.61	4.25	5.30
Garments	**1.50**	**1.32**	**N.A.**	**1.84**	**1.88**	**3.01**	**3.92**	**2.40**
Leather	**0.92**	**1.45**	**0.35**	**0.45**	**2.54**	**2.59**	**3.13**	**1.84**
Wood Processing	**3.29**	**2.79**	**N.A.**	**4.41**	**5.16**	**8.20**	**7.61**	**4.45**
Furniture	**1.39**	**1.78**	**N.A.**	**2.04**	**2.73**	**3.05**	**4.68**	**3.47**
Paper	**2.19**	**2.57**	**3.20**	**5.85**	**11.41**	**6.78**	**6.42**	**10.21**
Printing	**2.18**	**2.46**	**1.41**	**3.40**	**5.78**	**5.46**	**7.42**	**4.90**
Educational and Sports Products	**2.46**	**1.32**	**1.48**	**1.32**	**9.49**	**1.43**	**4.36**	**2.02**
Petroleum Products	8.62	6.57	22.23	36.78	55.84	4.58	60.77	77.62
Chemical Products	1.72	2.84	4.05	12.72	11.23	7.41	10.47	31.74
Pharmaceutical Products	**4.58**	**3.49**	**2.98**	**13.85**	**12.90**	**7.88**	**11.78**	**12.59**
Chemical Fiber	**1.15**	**2.74**	**6.06**	**2.35**	**8.73**	**11.97**	**4.42**	**11.09**
Rubber	**1.39**	**2.10**	**N.A.**	**2.56**	**6.52**	**3.36**	**11.47**	**3.80**
Plastics	**3.64**	**2.39**	**10.01**	**3.24**	**5.93**	**5.56**	**6.56**	**5.11**
Nonmetal Mineral Products	1.35	1.62	2.35	3.62	5.08	4.09	5.81	7.36
Ferrous Metals Smelting	1.91	4.09	5.33	7.50	18.92	9.38	12.87	31.80
Nonferrous Metals Smelting	2.32	3.64	1.10	7.10	9.51	10.67	11.05	20.47
Metal Products	2.09	2.17	3.36	4.50	4.60	4.66	4.84	6.32
General Mechanical Products	1.65	1.97	1.71	5.67	8.04	5.87	5.29	10.64
Special Mechanical Products	**1.46**	**2.30**	**5.30**	**4.94**	**4.47**	**5.57**	**6.69**	**6.06**
Transportation Equipment	**2.11**	**2.13**	**7.67**	**9.27**	**25.40**	**3.76**	**7.48**	**22.83**
Electrical Equipment	**2.79**	**2.99**	**30.27**	**2.88**	**8.62**	**3.41**	**12.27**	**5.78**
Telecommunication and Computer	**2.98**	**2.49**	**1.96**	**6.58**	**37.30**	**0.95**	**35.60**	**11.82**
Instruments and Office Machinery	2.39	1.45	0.34	3.85	6.50	1.22	6.67	10.26

Note: 1. The sectors in which Guangdong domestic firms had gained the lead in terms of labor productivity over our observation period are marked in bold text.

2. Identifying the source of manufacturing sector productivity growth in Guangdong: exploring spillovers from HKMT firms

As shown in Section 1, domestic firms in Guangdong gained in labor productivity during a time when foreign firms increased their output share in Guangdong's manufacturing sectors. The expansion of FDI, particularly the capital flush from HKMT (a group dominated by Hong Kong firms), occurred during a period of catching-up in labor productivity on the part of domestic firms. Yet an increase in labor productivity can result from an increase in the capital-to-labor ratio without changes in underlying technology. We are thus interested in examining domestic manufacturing productivity growth by using as an econometric framework a production function that controls for capital and labor input. Simultaneously we test a hypothesis that this progress in productivity was bolstered by economic activity generated from foreign capital inflows, the bulk of which were attributable to HKMT entrepreneurs (within which HK-funded firms predominated). Alternatively, the sources of the productivity gain of domestic firms might be their own efforts to invest in sophisticated infrastructure, advanced equipment, and R&D activity, which all contribute to effective technological learning. The literature on spillover of FDI (discussed below) provides examples for conducting such an analysis.

2.1. FDI spillover literature

As Blomstrom and Kokko (1998, 2001) suggest, developing countries seek to attract FDI primarily to acquire technology, knowledge, and managerial skills through transfer from advanced investors. As a result of FDI—which inevitably brings competition, labor mobility, the demonstration effect of foreign firm activity, forward or backward linkages between foreign and domestic sellers and buyers, etc.—laggard domestic players can acquire know-how in areas of production, management, and marketing (Saggi, 2002). Technological spillovers from FDI can arise when workers trained in foreign firms are later hired by local firms (Fosfuri et al., 2001). Keen competition brought about by the entry of foreign firms forces domestic firms in developing countries to improve and innovate. This improvement and innovation boosts productivity growth in domestic firms. Additionally, multinational corporations conduct cost-reducing or demand-creating R&D in host developing countries, pressuring domestic firms also to invest in R&D (Griffith et al., 2004). In general, if domestic firms succeed in mastering such advanced production technologies and managerial knowledge, they achieve swifter productivity growth, which is considered a spillover from FDI.

In marked contrast to the clarity of the theory itself, empirical evidence of FDI spillover is full of ambiguity. Early studies by Caves (1974) and Blomstrom (1986), which are based on industry-level data, claim to have discovered positive spillovers from foreign-funded firms to domestic firms. Their conclusions are however questioned by Aitken and Harrison (1999), who argue that foreign investors may flock into sectors where highly productive firms operate. In other words, industry-level data can prove that high productivity levels on the part of domestic firms is correlated with the presence of FDI, but such data fails to confirm causality. By using firm-level data on Venezuelan manufacturing companies, Aitken and Harrison (1999) find that foreign investment negatively affects the productivity of domestically owned plants. The reason, they argue, is that foreign-invested firms gain market share at the expense of domestic firms and force domestic firms to produce smaller outputs at higher average costs. In a study of Moroccan firms, for example, Haddad and Harrison (1993) similarly reject the hypothesis that the presence of foreign firms accelerated productivity growth in domestic firms.

Espousing a different line of thinking, Javorcik (2004) argues that studies based on firm-level data fail to find positive spillovers from FDI because they focus merely on intra-industry, or horizontal, spillovers. Multinational firms naturally have an incentive to prevent technology leakage and spillovers to domestic competitors that operate in the same sectors, but they are not motivated to prevent technology diffusion to upstream sectors because quality improvements in the upstream products that result from spillover could benefit the multinational firms. In addition to horizontal (intra-industry) spillover, Javorcik measures vertical (inter-industry) spillover in the study of Lithuanian manufacturing firms and finds positive productivity spillovers through contact between foreign affiliates and their local suppliers in upstream sectors.

In the context of Chinese manufacturing firms, Liu (2002) analyzes manufacturing firms in Shenzhen with two-digit sector-level data and finds that FDI has large and significant horizontal (intra-industry) spillover effects. Based on firm-level data from Chinese manufacturing firms, Liu (2008) extends his 2002 study to argue that vertical (inter-industry) spillovers—through backward and forward linkages between industries at the two-digit level—have a similar effect on the productivity of domestic firms.

2.2. Data, variables, and results of the Baseline Model

Consistent with the analytical framework that is characteristic of the empirical FDI spillover literature that we have surveyed, we form a two-digit sector-level panel on the Guangdong domestic manufacturing companies of three ownership groups (state-owned, collective, and shareholding) over the period 1999–2003. The data are taken from various issues of the Guangdong Statistical Yearbook and the Guangdong Industrial Statistical Yearbook.[2] With reference to Jefferson et al.'s (1992, 1996) variable deflation methodology, which is designed particularly for Chinese industrial statistics data, we utilize the price deflators for gross industrial output reported in the Chinese Statistical Yearbook to obtain the deflated variable of value-added.[3] The variable of capital input is deflated by the price indices of fixed-asset investment. The details pertaining to our variable deflation are elaborated in Table 8 in Appendix A.

We use as our dependent variable the logarithm of industrial value-added of the three ownership groups in the 27 manufacturing sectors (as shown in Table 9 in Appendix A). As independent variables, the logarithm of capital and labor input are included in the function. In this sense, the econometric framework of this analysis is that of a production function in nature. Nevertheless, the analysis explains part of the total factor productivity growth realized in domestic firms (the residual in the production function) by reference to a spillover effect (by including spillover variables in the function to measure the foreign presence). We use data on HKMT FDI in Guangdong's manufacturing sectors over the period 1999–2003. Within this category of HKMT FDI, however, FDI from Hong Kong predominates: According to various issues of the Guangdong Statistical Yearbook, FDI from Hong Kong accounted for about 90 percent of HKMT capital in the 1988–2003 period. This

[2] The data from the Guangdong Statistical Yearbook is utilized in studies by other scholars such as Tuan and Ng (1995), while data from the Guangdong Statistical Bureau are employed by Tuan and Ng (2001, 2003), Liu (2002) and Ng and Tuan (2003) in their research. In accordance with these studies, we assume that these two data sources provide us with credible data.

[3] According to the China Statistical Yearbook (2004, p.572), Value-added of Industry = Gross Industrial Output Value – Intermediate Input + Value-added Tax. Since there is no specific value-added deflator published in the China Statistical Yearbook, we adopt the Ex-factory Price Indices of Industrial Products as our value-added deflator. Differing from us in their methodology, Jefferson et al. (1992 and 1996) estimate the production function as Gross Industrial Output Value = Capital Input + Labour Input + Intermediate Input. Value-added does not enter their production function.

percentage varied only minimally during our observation period, i.e., between 1999 and 2003 (Fig. 1).[4]

As revealed in the FDI spillover literature (discussed in Section 2.1), spillover takes place through the competition effect, labor mobility, the demonstration effect, forward or backward linkages between foreign and domestic firms, know-how brought to joint ventures by foreign partners, and so on. Because there are no indicators available from the statistical authorities in Guangdong (and China) to measure all of these effects, the crux of our analysis is thus to measure economic activity—usually represented by the foreign capital participation ratio, or the output and employment share of foreign firms—undertaken by foreign investors in Guangdong's manufacturing sectors. Investment from Hong Kong or other foreign sources may impact Guangdong domestic manufacturing firms through any one of the three channels discussed below. Accordingly, we include corresponding variables in our baseline model to estimate the spillover taking place through each channel.

The first such channel consists of investors from HKMT or non-HKMT foreign countries/regions taking part ownership of Guangdong domestic firms through capital participation. As owners of Guangdong domestic firms, HKMT or non-HKMT foreign investors might bring in advanced technology, management, and marketing and sales skills, thereby accelerating productivity growth. We construct a variable, named "HKMT Capital Intra-firm Spillover", to measure this type of spillover. It is defined as:

$$\text{HKMT Capital Intra-firm Spillover} = \frac{\text{Registered capital of state-owned (or collective or shareholding) firms from HKMT investors}}{\text{Total registered capital of state-owned (or collective or shareholding) firms}} \quad (1)$$

Similarly, the registered capital of Guangdong domestic firms that is contributed by non-HKMT foreign investors divided by total registered capital, known as "Foreign Capital Intra-firm Spillover", also enters the regression as an independent variable.

The second channel through which investment from HKMT or non-HKMT foreign sources might impact Guangdong domestic manufacturing firms consists of foreign investors from HKMT or non-HKMT foreign countries/regions establishing HKMT-funded or non-HKMT foreign-funded firms in Guangdong. Productivity growth in Guangdong domestic firms may benefit from the entry of these foreign firms in the same sectors through the competition effect, labor mobility, the demonstration effect, forward or backward linkages between foreign and domestic firms, know-how brought to joint ventures by foreign partners, and so on. In the empirical FDI literature, these effects, which arise between domestic and foreign firms that are operating in the same sectors, are seen as "intra-industry (horizontal)" spillovers. Accordingly, we construct a variable, "HKMT Capital Horizontal Spillover", to estimate intra-industry spillover from HKMT companies. It is defined as:

$$\text{HKMT Capital Horizontal Spillover} = \frac{\text{Registered capital of all firms (including HKMT and non-HKMT foreign firms) from HKMT investors}}{\text{Total registered capital of all firms (including HKMT and non-HKMT foreign firms)}} \quad (2)$$

As implied in Eq. (2), the influence of HKMT firms on each type of domestic firm is invariable. That is, regardless of the size of the domestic sector, each type of domestic sector receives the same magnitude of spillovers from foreign firms. It is not however very likely that state-owned, collective, or shareholding companies would receive equal spillovers from foreign firms operating in the same sectors, given their varied production scales. Therefore, "intra-industry (horizontal)" spillover can be defined alternatively as in Eq. (3) below, which is also adopted by Aitken and Harrison (1999), Liu (2002), and Javorcik (2004).

$$\text{HKMT Capital Horizontal Spillover} = \frac{\text{Registered capital of all firms from HKMT investors}}{\text{Total registered capital of all firms}} \times \text{Weight} \quad (3)$$

The different weights for state-owned, collective, and shareholding companies are calculated by the ratio of registered capital or the ratio of employment:

$$\text{Weight of State-owned (or collective or shareholding) Enterprises by Registered Capital} = \frac{\text{Registered capital of state-owned (or collective or shareholding) firms}}{\text{Total registered capital of all firms}} \quad (4)$$

$$\text{Weight of State-owned (or collective or shareholding) Enterprises by Employment} = \frac{\text{Number of employees of state-owned (or collective or shareholding) firms}}{\text{Number of employees of all firms}} \quad (5)$$

In this study, we report the results based on both weights. We build a variable, "Foreign Capital Horizontal Share", which is similar to "HKMT Capital Horizontal Share", to measure the intra-industry spillover from non-HKMT foreign-funded firms to domestic firms.

The third channel through which investment from HKMT or non-HKMT foreign sources might impact Guangdong domestic manufacturing firms involves positively influencing the productivity growth of domestic suppliers or buyers, which in the empirical literature is considered an "inter-industry (vertical)" spillover (Javorcik, 2004; Liu, 2008). Based on the 2002 input-output matrix of the Guangdong economy, we design two variables, "HKMT Capital Upstream Spillover" and "HKMT Capital Downstream Spillover", to measure the spillovers from HKMT-funded firms to domestic upstream sellers and downstream buyers, respectively.

[4] There are no data exactly specifying the percentage of HKMT FDI invested in manufacturing that is specifically from Hong Kong. Through Fig. 1, however, we know that about 90 percent of HKMT FDI invested in all sectors is from Hong Kong, with 70 percent of FDI invested in Guangdong going to the manufacturing sectors.

Their definitions with and without weights are as follows:

$$\text{HKMT Capital Upstream Spillover}_{(\text{Sector } j)} = \sum_k \alpha_{jk} \times \frac{\text{Registered capital of all firms from HKMT Investors}}{\text{Total registered capital of all firms}_{(\text{Sector } k)}} \tag{6}$$

$$\text{HKMT Capital Upstream Spillover}_{(\text{Sector } j)} = \left(\sum_k \alpha_{jk} \times \frac{\text{Registered capital of all firms from HKMT Investors}}{\text{Total registered capital of all firms}_{(\text{Sector } k)}} \right) \times \text{Weight}_{(\text{Sector } j)} \tag{7}$$

where α_{jk} represents the proportion of sector j output supplied to sector k, based on the 2002 Guangdong input-output matrix,[5] and:

$$\text{HKMT Capital Downstream Spillover}_{(\text{Sector } j)} = \sum_k \beta_{kj} \times \frac{\text{Registered capital of all firms from HKMT Investors}}{\text{Total registered capital of all firms}_{(\text{Sector } k)}} \tag{8}$$

$$\text{HKMT Capital Downstream Spillover}_{(\text{Sector } j)} = \left(\sum_k \beta_{kj} \times \frac{\text{Registered capital of all firms from HKMT Investors}}{\text{Total registered capital of all firms}_{(\text{Sector } k)}} \right) \times \text{Weight}_{(\text{Sector } j)} \tag{9}$$

where β_{kj} is the share of inputs purchased by industry j from industry k in total inputs sourced by sector j. Two types of weights are obtained, as in Eqs. (4) and (5), for each domestic ownership group; the results for registered capital weight and employment weight are reported accordingly. Similarly, "Foreign Capital Upstream Spillover" and "Foreign Capital Downstream Spillover" are constructed and estimated in the function.

In addition to the 10 independent variables specified above, we include time dummy variables to control the unobservable effects that are correlated with time. We use the panel data model (function 10 below) as our baseline model to estimate the regression function, since it controls the unobservable sector or ownership-specific effect associated with our industrial sector-level data better than Ordinary Least Square (OLS) regression. The Hausman Test is performed and the chi-square statistic of the test is reported. The result of random effect is reported unless its assumption is rejected at the 10 percent level. All the reported standard deviations are obtained after controlling for heteroskedasticity. The model:

$$\begin{aligned}&[\text{Value-added of domestic firm}]_{it}\\ &= f\{[\text{Capital input of domestic firms}]_{it},\\ &[\text{Labor input of domestic firms}]_{it}, [\text{Intra-firm Spillover}]_{it},\\ &[\text{Intra-industry (horizontal) Spillover}]_{it},\\ &[\text{Inter-industry (upstream and downstream) Spillover}]_{it},\\ &[\text{Time dummy}]_{it}\}\end{aligned} \tag{10}$$

Shown in Table 3, the coefficients of HKMT capital and non-HKMT foreign capital intra-firm spillover variables are either insignificant or negatively significant in various models, demonstrating that foreign capital participation (including that of HKMT) does not result in productivity improvement in Guangdong domestic manufacturing firms. The coefficients of HKMT and non-HKMT foreign horizontal spillover are positive in all fixed-effect and random-effect baseline models, but they are statistically significant in only a few of them, particularly in the models where horizontal spillover is weighted by registered capital. This provides some evidence for the view that intra-industry spillover exists in Guangdong's manufacturing sectors.[6] None of the coefficients of the HKMT and foreign capital upstream and downstream spillover variables is significant in the baseline models.[7]

2.3. Robustness of the result

It may take some time for spillover to generate a discernable effect. A time lag might thus exist in the causal relationship between the spillover variables and dependent variables. To provide a more robust estimation, we therefore run the regression on all the spillover variables with a one-year time lag at the expense of losing some observations. Seen in Table 3, all the coefficients of the HKMT capital and non-HKMT foreign capital intra-firm spillover variables in the one-year lag model are insignificant. None of the coefficients of the HKMT capital horizontal spillover variables is significant in any of the various one-year lag models. The coefficients of the non-HKMT foreign capital horizontal spillover variables are positive and significant only in a few one-year lag models. Almost all the coefficients of the HKMT and non-HKMT foreign capital upstream and downstream spillover variables are insignificant.

Controlling for sector-specific unobservable factors, we also test whether serial correlation biases the estimation result. We take the baseline model weighted by registered capital, which has a good fit with the data, as a test example. The locally best invariant test statistic is 2.03. Following Baltagi and Wu (1999), we conclude that there is no serial correlation affecting our result.

In the results presented in Table 3, the foreign capital presence is measured by registered capital, which does not reflect the actual capital stock of enterprises. To check the robustness of the

[5] Chinese statistical agencies have published an input-output matrix every five years since 1987. The latest input-output matrix for the Guangdong economy is given in the 2002 issue. In Guangdong's input-output matrix, the imports and products purchased from provinces other than Guangdong are not disaggregated from products from each sector. Since the share of products calculated by excluding imports and products from other provinces is preferable, our result should be interpreted with caution.

[6] The negative foreign capital intra-firm spillover is also found in the previous literature. Liu (2002) analyzed the data of 29 manufacturing industries in Shenzhen City, Guangdong province of the period of 1993–1998 and found the negative and statistically significant coefficients of foreign equity participation variable. Drawing evidence from a large firm-level database, Liu (2008) concluded that the productivity of foreign-invested firms in China is not necessarily higher than that of domestic firms, based on the finding of statistically insignificant coefficients for the variable of foreign equity share. The co-existence of the negative intra-firm spillover and positive horizontal spillover occurs because the presence of the foreign firms in the sector, but not the foreign equity participation in individual domestic firms, contributes to the productivity growth of domestic firms. Previous studies such as by Javorcik and Spatareanu (2008) reveal the possibility that foreign investment in upstream, downstream or the same sectors may have different impacts on the productivity growth of domestic firms.

[7] Examination of the correlation of the independent variables and exclusion of highly correlated variables shows that the insignificance of their coefficients is not a result of multicollinearity. The result of the test of multicollinearity is available upon request from the authors.

Table 3
Source of productivity growth of guangdong domestic manufacturing firms: spillover from HKMT Investment (1999–2003).

Independent Variables	Dependent variable: *Industrial Value-added*											
	Without weight			Weighted by Registered Capital				Weighted by Employment				
	Baseline model		One-year Lag	Baseline Model		One-year Lag		Baseline Model		One-year Lag		
	Fixed Effect	Random Effect	Fixed Effect	Fixed Effect	Random Effect	Fixed Effect	Random Effect	Fixed Effect	Random Effect	Fixed Effect	Random Effect	
ln *Capital*	.547 (.063)***	.538 (.055)***	.546 (.064)***	.475 (.070)***	.496 (.060)***	.531 (.063)***	.530 (.053)***	.552 (.062)***	.544 (.050)***	.538 (.060)***	.544 (.047)***	
ln *Labor*	.361 (.090)***	.395 (.076)***	.264 (.095)***	.339 (.091)***	.381 (.072)***	.237 (.093)**	.318 (.078)***	.302 (.119)***	.383 (.078)***	.246 (.097)**	.327 (.079)***	
HKMT Capital Intra-firm Spillover	.103 (.287)	.156 (.314)	.097 (.300)	.121 (.255)	.118 (.291)	.142 (.294)	.126 (.312)	.158 (.271)	.169 (.301)	.201 (.282)	.179 (.316)	
Foreign Capital Intra-firm Spillover	−.661 (.299)**	−.636 (.293)**	−.441 (.393)	−.528 (.262)**	−.549 (.278)**	−.395 (.375)	−.402 (.363)	−.540 (.275)*	−.557 (.291)*	−.340 (.388)	−.373 (.377)	
HKMT Capital Horizontal Spillover	1.25 (.575)**	.382 (.414)	.796 (.691)	5.32 (1.89)***	3.74 (1.78)**	−1.48 (2.13)	−1.98 (1.90)	4.28 (1.59)***	2.15 (1.63)	−.962 (1.98)	−1.97 (1.93)	
Foreign Capital Horizontal Spillover	.887 (.569)	.302 (.376)	1.60 (.679)**	4.37 (1.28)***	4.11 (1.25)***	4.08 (1.75)**	3.70 (1.49)**	3.50 (1.04)***	2.92 (1.40)**	1.36 (1.92)	1.50 (1.90)	
HKMT Capital Upstream Spillover	.295 (.881)	−.040 (.617)	−.734 (1.06)	−1.06 (2.64)	−3.14 (2.41)	1.30 (3.11)	−2.51 (2.23)	−1.60 (2.77)	−2.87 (2.56)	−3.24 (3.13)	−5.16 (3.04)*	
Foreign Capital Upstream Spillover	−2.86 (2.27)	−.452 (1.07)	−2.24 (2.72)	−.797 (4.42)	1.08 (4.21)	−5.88 (5.13)	−.016 (3.76)	.462 (4.14)	1.83 (3.97)	2.91 (4.33)	5.71 (4.82)	
HKMT Capital Downstream Spillover	−1.36 (1.39)	−.836 (.734)	−.554 (1.73)	−3.41 (3.34)	−1.87 (3.07)	7.51 (3.68)**	8.63 (2.92)***	−4.36 (3.61)	−1.87 (3.37)	4.21 (3.36)	6.17 (2.89)**	
Foreign Capital Downstream Spillover	1.49 (1.70)	1.01 (1.01)	−1.93 (2.19)	3.04 (4.19)	2.17 (4.37)	−1.51 (5.17)	−3.95 (3.79)	−1.37 (4.06)	−2.04 (3.96)	−.487 (4.88)	−3.00 (3.73)	
Number of Observations	405	405	324	405	405	324	324	405	405	324	324	
Number of Groups	81	81	81	81	81	81	81	81	81	81	81	
R^2 (Within-groups Transformation) for Fixed Effect Model	0.82	–	0.78	0.83	–	0.792	–	0.82	–	0.78	–	
F-Statistics for Fixed Effect Model/Wald χ^2 Statistics for Random Effect Model	56.52***	33169.2***	37.14***	69.0***	36665.8***	41.70***	28739.7***	58.5***	34062.5***	36.32***	29444.3***	
Hausman Test Chi-square	−13.16[2]		26.97**	2.1		1.78		−62.9[2]		11.8		

Note: 1. Data within parentheses are standard deviations. 2. A negative value is obtained for the Chi-square statistic. The model fitted on these data fails to meet the asymptotic assumptions of the Hausman Test. No conclusion is made over the choice of a fixed-effect or a random-effect model.

* Significance at the 10 level.
** Significance at the 5 percent level.
*** Significance at the 1 percent level.

Table 4
Source of productivity growth of Guangdong domestic manufacturing firms: foreign capital presence measured by average balance of net value of fixed assets (1999–2003).

Independent Variables	Dependent Variable: *Industrial Value-added*			
	Without weight		Weighted by average balance of net value of fixed asset	
	Fixed Effect	Random Effect	Fixed Effect	Random Effect
ln *Capital*	.572 (.068)***	.563 (.054)***	.476 (.073)***	.525 (.063)***
ln *Labor*	.349 (.091)***	.379 (.073)***	.345 (.092)***	.391 (.073)***
Foreign Capital Horizontal Spillover	.985 (.394)**	.541 (.238)**	1.67 (.852)**	.866 (.726)
Foreign Capital Upstream Spillover	−.625 (1.04)	−.301 (.380)	.543 (1.55)	.426 (1.27)
Foreign Capital Downstream Spillover	−1.50 (1.63)	−.215 (.157)	.198 (.587)	−.610 (.437)
Number of Observations	405	405	405	405
Number of Groups	81	81	81	81
R^2 (Within-groups Transformation) for Fixed Effect Model	0.81	–	0.82	–
F-Statistics for Fixed-Effect Model/Wald χ^2 Statistics for Random Effect Model	72.93***	29085.65***	85.39***	28487.46***
Hausman Test Chi-square	2.58		10.88	

Note: 1. Data within parentheses are standard deviations.
** Significance at the 5 percent level.
*** Significance at the 1 percent level.

result, we thus take advantage of the average balance of the net value of fixed assets, which is also provided in the dataset, to obtain the result of an alternative measurement of the foreign capital presence. Because the data on the average balance of the net value of fixed assets do not distinguish HKMT capital from non-HKMT foreign capital, the constructed spillover variables reflect the joint impact of HKMT and non-HKMT foreign firms on Guangdong domestic firms. Shown in Table 4, the coefficients of foreign capital horizontal spillover variables are positively significant, except in the random-effect model regressed on the weighted spillover variables. None of the coefficients of the foreign capital upstream and downstream variables is significant.

To summarize these results, the coefficients of HKMT and non-HKMT foreign capital intra-firm spillover variables are either insignificant or negatively significant in all model specifications, disproving the hypothesis of the existence of intra-firm spillover in Guangdong manufacturing sectors. Weighted by the proportion of registered capital, HKMT- and non-HKMT foreign-funded firms significantly influence the productivity growth of domestic firms operating in the same sectors. Yet no consistent evidence of such a significantly positive influence is found when the variable is obtained without weight or weighted by employment. Inter-industry spillover from foreign firms to domestic buyers and sellers in Guangdong manufacturing sectors is not found in this study. All of the above conclusions obtained through measuring foreign capital presence by registered capital are confirmed by the robust method of quantifying foreign capital by net value of fixed assets. Examination of any time lag that might exist in the causal relationship between the spillover variables and dependent variables leads to the same results as those for the models without lag.

2.4. The effect of R&D investment on Guangdong's domestic firms

The analyses conducted in the previous section rule out the possibility that HKMT and non-HKMT foreign intra-firm spillover and inter-industry spillover exist to any statistically significant extent in Guangdong manufacturing. Neither do they provide consistent evidence of the existence of intra-industry spillovers. In order to explain the improved productivity achieved by Guangdong domestic firms, we offer several alternative candidate explanations. These include the consolidation and restructuring of the state-owned, collective, and shareholding sectors in the period; investment on the part of domestic firms in advanced equipment and technology; the dedication of these firms to R&D activity; and so on.

Among these possible explanations, we are interested in testing (in this section) whether R&D investment on the part of Guangdong domestic manufacturing firms accounts for the stellar productivity growth. Such an explanation is plausible because a causal relationship between R&D and productivity enhancement has been documented by scholars such as Griliches (1980, 1994). Since the R&D expenditure data are available only for 2001–2003, we run the baseline model based on the observations of this period, including the R&D intensity variable, which is defined as R&D expenditure divided by industrial output value. The results of the baseline models shown in Table 5 unambiguously confirm that R&D intensity contributes to productivity growth in Guangdong manufacturing firms.

It is debatable whether rapid industrial output growth motivates the managers of Guangdong's domestic firms to increase R&D investment. It is also possible that the dependent variable and R&D intensity are simultaneously influenced by certain omitted factors such as output value, since both variables encompass industry-level output-value data. The instrumental variable method is thus implemented in order to correct any potential endogeneity associated with the R&D intensity variable. Legitimate instrumental variables need to be highly correlated with the endogenous variable, which in our case is R&D intensity. At the same time, they should not be correlated with the residual of structural functions.

R&D activity leads to the development of new products or services, so R&D intensity is correlated with new products that firms develop to sell on the market. Taking advantage of the new-product output value reported in the database, we construct an instrumental variable, new-product intensity, which is defined as new-product value divided by industrial-output value. If a firm has more slack resources, it would be more likely to invest in R&D or increase R&D investment. With greater financial resources, a firm would have more opportunities to experiment and face less stringent requirements for performance, which could facilitate risky investment in R&D. In general, abundant slack resources lead to increased R&D investments. Following Greve (2003), Daniel et al. (2004), and Tan and Peng (2004), we include the ratio of administrative, financial, and selling expenses to sales value as the other instrumental variable in our regression. To ensure that the residual of the structure function is not correlated with the instrumental variables, we use the two-year lag observations of two instrumental variables to instrument the R&D intensity variables. The instrumental variable estimation results, shown in Table 5, exhibit no material difference from those of the baseline model, further confirming that R&D investment undertaken by Guangdong manufacturing firms is one of the principal factors accounting for their enhanced productivity.

Table 5
Source of productivity growth of Guangdong domestic manufacturing firms: effect of R&D investment (2001–2003).

Independent Variables	Dependent variable: ln *Industrial Value-added*									
	Without Weight			Weighted by Registered Capital			Weighted by Employment			
	Baseline Model	Instrument Variable		Baseline Model	Instrument Variable		Baseline Model		Instrument Variable	
	Fixed Effect	Fixed Effect	Random Effect	Fixed Effect	Fixed Effect	Random Effect	Fixed Effect	Random Effect	Fixed Effect	Random Effect
ln *Capital*	.522(.073)***	.532(.050)***	.567(.039)***	.469(.086)***	.477(.056)***	.548(.046)***	.512(.056)***	.556(.056)***	.529(.049)***	.552(.038)***
ln *Labor*	.172(.107)	.168(.049)***	.277(.045)***	.176(.110)	.173(.049)***	.301(.045)***	.007(.089)	.265(.093)***	−.008(.064)	.266(.051)***
HKMT Capital Intra-firm Spillover	−.517(.368)	−.451(.394)	−.174(.344)	−.485(.390)	−.420(.395)	−.093(.347)	−.231(.343)	−.135(.375)	−.095(.399)	−.068(.345)
Foreign Capital Intra-firm Spillover	−.837(.362)**	−.811(.447)**	−.521(.420)	−.784(.390)**	−.746(.460)	−.493(.426)	−.566(.345)	−.468(.410)	−.459(.468)	−.424(.428)
HKMT Capital Horizontal Spillover	1.06(.485)**	1.11(.582)*	.191(.328)	1.13(1.59)	1.06(1.52)	−1.11(1.32)	3.32(1.05)***	−.228(1.25)	3.48(1.19)***	−.159(1.11)
Foreign Capital Horizontal Spillover	1.25(.485)**	1.44(.632)**	.915(.426)**	1.21(1.08)	1.40(1.15)	2.06(1.12)*	3.07(1.07)***	2.32(1.17)**	3.38(1.08)***	2.50(1.03)**
R&D Intensity	1.52(.597)**	3.42(3.25)	4.76(2.34)**	1.33(.575)**	3.36(3.26)	5.06(2.37)**	1.51(.536)***	1.82(.700)***	5.51(3.31)*	5.38(2.42)**
Number of Observations	243	243	243	243	243	243	243	243	243	243
Number of Groups	81	81	81	81	81	81	81	81	81	81
R^2 (Within-groups Transformation) for Fixed Effect Model	0.68	–	–	0.67	–	–	0.71	–	–	–
F-Statistics for Fixed Effect Model/Wald χ^2 Statistics for Random Effect Model	26.37	–	–	25.8***	–	–	36.1***	21458.2***	–	–
Hausman Test Chi-square	167.88***	–	17.2**	–	−18.9[2]	–				

Note: 1. Data within parentheses are standard deviations. 2. A negative value is obtained for the Chi-square statistic. The model fitted on these data fails to meet the asymptotic assumptions of the Hausman Test. No conclusion is made over the choice of a fixed-effect or a random-effect model.

* Significance at the 10 percent level.
** Significance at the 5 percent level.
*** Significance at the 1 percent level.

Table 6
Average R&D Intensities of state-owned, collective, shareholding, and foreign enterprises in Guangdong province (Percentage), 2001–2003.

Sectors	State-Owned Enterprises	Collective Enterprises	Shareholding Enterprises	Foreign Enterprises
Agri-food Processing	**0.06**	**0.08**	**0.05**	0.03
Food	**0.12**	**0.20**	**0.33**	0.08
Beverage	**0.19**	**0.46**	**0.28**	0.04
Textile	**0.03**	0.02	**0.03**	0.03
Garments	**0.04**	**0.06**	**0.17**	0.02
Leather	0.00	**0.07**	0.02	0.04
Wood Processing	0.01	0.01	**0.66**	0.04
Furniture	0.01	**0.05**	**0.06**	0.04
Paper	**0.11**	0.02	0.04	0.11
Printing	**0.05**	**0.08**	**0.09**	0.04
Educational and Sports Products	**0.20**	**0.08**	**0.09**	0.04
Petroleum Products	**0.07**	**0.04**	**0.05**	0.00
Chemical Products	0.16	0.06	**0.22**	0.17
Pharmaceutical Products	**0.93**	0.14	**1.18**	0.71
Chemical Fiber	**0.05**	0.00	0.00	0.02
Rubber	**0.15**	**0.08**	**0.13**	0.05
Plastics	0.07	0.02	0.07	0.08
Nonmetal Mineral Products	**0.24**	**0.11**	**0.13**	0.09
Ferrous Metals Smelting	0.11	0.02	0.02	0.15
Nonferrous Metals Smelting	**0.34**	0.02	**0.17**	0.05
Metal Products	**0.30**	**0.05**	**0.05**	0.05
General Mechanical Products	**0.46**	**0.23**	**0.34**	0.21
Special Mechanical Products	**1.22**	0.38	**0.90**	0.58
Transportation Equipment	**0.21**	0.11	0.13	0.21
Electrical Equipment	**0.26**	0.15	**0.88**	0.21
Telecommunication and Computer	**1.68**	**0.42**	**5.19**	0.24
Instruments and Office Machinery	**1.54**	0.04	**1.23**	0.23

Source: Various issues of the Guangdong Industrial Statistics Yearbook (2000–2004). Figures in bold text denote intensities that are equal to or greater than those of foreign enterprises.

3. Discussion and recent policy developments in Hong Kong and Guangdong

3.1. Discussion of results

The most striking result that we find in this study in attempting to explain how Guangdong's domestic firms have achieved so much progress towards catching-up in manufacturing productivity is consistent evidence of the efficacy of R&D investment. In sharp contrast, we find no similar evidence pertaining to the efficacy of HKMT or non-HKMT foreign capital participation or of intra-industry and inter-industry technological spillover to Guangdong domestic firms.

The first explanation we posit to account for these results is that manufacturing firms in Guangdong are more firmly committed to using R&D to enhance productivity than are their foreign counterparts (HKMT and non-HKMT foreign firms). Table 6 shows that, in almost all sectors, the average R&D intensities (R&D expenditure divided by output value) in at least one ownership group of domestic firms are higher than or equal to those of foreign firms. In 2000, seven ministries in the Chinese central government jointly launched the first national R&D census. As revealed by the census data shown in Table 7, HKMT and non-HKMT foreign companies placed themselves in an unfavorable position against their domestic Guangdong counterparts in terms of R&D and innovation, despite controlling a considerable portion of manufacturing production in Guangdong province.[8]

The second reason we propose to account for the little spillover from HKMT manufacturing firms in Guangdong—which are dominated by firms from Hong Kong—lies in a critical reflection on the technological and organizational sophistication of HKMT firms in general, the historical transition of firms in Hong Kong's manufacturing industry and the changing nature of cross-border production in Guangdong and Hong Kong. Zhang (2005) contends that the Hong Kong and Taiwan-funded firms in China in general have not been at the world's frontier of technology and organizational sophistication. Compared with the foreign firms funded by American, European and Japanese companies, the Hong Kong and Taiwan firms rely on their capability of delivering timely uniform quality products to overseas markets or adapting mature technologies to production in a labor-intensive economic context.

Taiwanese firms do not play as significant a role as Hong Kong firms because, on the one hand, they account for a far smaller proportion of firms from within the HKMT-based group (as we have indicated in our introduction to this paper). On the other hand, while Hong Kong has a long history of economic, social, and cultural closeness with Guangdong based largely on its geographical proximity, Taiwanese firms have neither been as deeply involved in investing in Guangdong (although they have traditionally played a larger role in Fujian province), nor have there been any large-scale movements of the manufacturing industry out of Taiwan to Guangdong (on anything like the scale at which manufacturing shifted from Hong Kong to Guangdong after the opening of China in 1979).

From early on (between the 1950s and 1970s), technological sophistication had little to do with the establishment of Hong Kong manufacturing firms in either Hong Kong or Guangdong. In fact, the roots of Hong Kong manufacturing can be traced to the opportunistic exploitation of a geographic area by Mainland Chinese immigrants, particularly textile barons from Shanghai (fleeing the Communist regime), who transferred start-up capital and managerial expertise to the territory (Wong, 1988; Hollows, 1999).[9]

[8] Similar evidence is found in surveys of other regions and cities in China. For instance, Fan and Hu (2007) studied a dataset obtained from a World Bank firm-level survey from 1998 to 2000 in five Chinese cities, namely Beijing, Shanghai, Tianjin, Guangzhou and Chengdu, and found that the firms which have higher foreign equity participation spend less on R&D.

[9] These Shanghai industrialists concentrated on low-cost manufacturing in the labor-intensive textile and clothing industries and turned to the British trading

Table 7
Several Innovation indicators of state-owned, collective, shareholding, and Hong Kong, Macau, and Taiwan-Invested and non-HKMT foreign enterprises in Guangdong: 2000 Data.

Indicator	Domestic Enterprises			Foreign Enterprises	
	State-owned Enterprises	Collective Enterprises	Shareholding Enterprises	Hong Kong, Macau, and Taiwan-Invested Enterprises	Non-HKMT Foreign Enterprises
Value-added as a Share of Total (Percentage)	17.84	9.36	14.90	40.05	17.86
Labor Productivity (Thousand RMB/Person)	88.64	33.00	81.23	52.82	83.35
R&D Intramural Expenditure/Value-added (Percentage)	2.62	0.78	2.84	1.37	1.34
R&D Personnel Full Time Equivalent/Annual Average Number of Employed Personnel (Percentage)	0.91	0.24	0.35	0.29	0.57
New Product Output/Total Output (Percentage)	9.60	1.89	11.31	7.76	10.60
Patent Application/Value-added (Unit per Million RMB)	70.12	152.58	143.96	88.26	77.52
Invention Patent Application/Value-added (Unit per Million RMB)	37.06	36.15	23.33	19.61	15.99
Technology Upgrading Expenditure/Value-added (Percentage)[a]	4.61	0.93	2.97	1.53	2.60

Source: National Industrial Statistics on the 2000 R&D Census (2001) and the Guangdong Statistical Yearbook, 2001.

[a] Technology upgrading expenditure specified in the National Industrial Statistics on the 2000 R&D Census includes expenditure involved in purchasing technology from domestic and foreign sources, training personnel, tax deductions from various levels of government for in-house R&D activity, and other expenditures related to the technology upgrading.

Over time, however, as Hong Kong manufacturers faced limits on low-cost manufacturing, they found an escape route for their manufacturing industries in the opening-up of China from 1979 onwards (leading to cheaper land and labor resource costs). Unlike those who were driving other newly industrialized East Asian economies, Hong Kong's entrepreneurs, because of their linguistic and cultural familiarity, could easily leverage the abundant labor and land resources in Guangdong to offset the disadvantage of heightened labor costs. Enjoying the cost advantage of cross-border production in Guangdong, Hong Kong's manufacturing firms did not pursue technological sophistication nearly as vigorously as did their counterparts in the other 'Asian tigers'. Among Hong Kong-owned firms, automated processes were limited, and significant R&D activities were rarely undertaken (Eng, 1997).[10] Indeed, in the early 1980s, Hong Kong was not recognized as a major source of advanced technology by firms in China and the technology transferred through Hong Kong's FDI outflows was either low-level or standardized technology (Kamath, 1990).

3.2. The recent policy reaction in Hong Kong and Guangdong

Partly as a result of their acknowledgment that Hong Kong-based firms do not achieve productivity growth through investments in R&D, and partly as a result of Guangdong's intense efforts to move up the value-added ladder, Hong Kong policymakers began to reconsider their engine for future economic growth in light of the marginalized role of manufacturing in the territory, its decreasing importance as a trading hub, and the scarcity of opportunities for further reducing factor input costs. A 'Commission on Innovation and Technology' (CIT) based its vision of Hong Kong's new role explicitly on science, technology, and innovation (HKSAR, 1999). Since the publication of the Commission's two reports (HKSAR, 1998, 1999), Hong Kong has launched several measures to increase competitiveness through methods other than lowering factor input costs. Most notable among these measures was the establishment of the 'Innovation and Technology Fund' (ITF) in 1999 with US$ 640 million,[11] earmarked to provide funding support to projects that contribute to innovation and technology upgrading in industry, as well as to projects essential to the upgrading and development of new industries.[12] The main purpose of the ITF was to respond positively to what scholars such as Kwong et al. (2000) and Tuan and Ng (1995) were advocating: increasing competitiveness through higher value-added goods and services.

Furthermore, in June 2004, the government proposed a new strategic framework for innovation and technology development.

houses in Hong Kong, which had established links with international export markets (Tsui-Auch, 1998, p. 9).

[10] The idea that the growth and profitability of Hong Kong's manufacturing firms was based on lowering their factor input costs is supported by many scholars in the field. For example, Kwong et al. (2000) find that, during the period of 1984–1993, firms in Hong Kong's manufacturing sector demonstrated an overall decrease in TFP, although such a technological decline did not mean lower profitability. It was during this period that Hong Kong firms engaged in a frenzy of manufacturing facility relocation to Guangdong. Because the unfinished products shipped at low prices from the manufacturing base in Guangdong, firms in Hong Kong could enjoy high profitability even as productivity declined. Thus Kwong et al. conclude that Hong Kong has grown mainly by utilizing China's cheaper resources, instead of through technological advancement. They also argue that technology upgrading might have seemed too daunting a task for firms in Hong Kong as compared with moving the production base to Guangdong to maintain a competitive edge in global markets. Tuan and Ng's (1995) findings complement those of Kwong et al. Tuan and Ng find that the principal reasons that Hong Kong firms moved their manufacturing base to Guangdong were Guangdong's cheap labor costs, low rents, and geographical proximity. A higher return on investment, a shorter pay-back period, and factor-cost savings are strongly associated with the cross-border operation of Hong Kong manufacturing firms. Therefore, existing studies already provide historical and empirical evidence that helps explain our findings related to productivity growth in Guangdong manufacturing sectors and the potential impact of Hong Kong-based firms.

[11] The exchange rate for US$:HK$ is 1:7.8 as of April 2006.

[12] Before the ITF was set up, there were two other funds in place providing financial assistance to projects that would enhance the competitiveness of local industry. One was the Industrial Support Fund (ISF) established in 1994 (subsumed by the Innovation and Technology Fund in June 1999), and the second was the Services Support Fund established in 1996 (subsumed by the Innovation and Technology Fund in June 1999).

A main element in this framework is a strategy of 'leveraging the Mainland', that is, utilizing the production base in the Guangdong region as a platform for developing applied R&D and the commercialization of applied R&D deliverables. This proposal reflected the increasing interest of Hong Kong-based firms in conducting R&D in Guangdong. Lastly, in 2004, the ITF also instituted, in parallel with the above-mentioned initiative, a funding scheme for Hong Kong-Guangdong technology cooperation. In this scheme, a total of US$ 44 million is made available to fund 86 chosen projects, thereby enhancing technology cooperation and raising the value-added on goods and services produced in Hong Kong and Guangdong. Each partner contributes US$ 22 million to this scheme.

China's central government, recognizing the importance of investments in R&D and hoping to strengthen its support of indigenous R&D and innovation efforts, announced an ambitious strategy (in March 2006) for nurturing 'home-grown' innovation over the next decade.[13] Half a year earlier, in September 2005, the Guangdong provincial government published its own "Decision on Enhancing Indigenous Innovation Capability and Improving Industry Competitiveness" (Guangdong Provincial Government, 2005). The earlier announcement of Guangdong's version of its indigenous innovation strategy demonstrates its ambition to strengthen its role as an engine for economic growth in the Southern China region as well as to maintain the competitive edge of its industries in the increasingly competitive global marketplace. The "Decision" calls for strengthening Guangdong's innovation system, reducing Guangdong's dependence on foreign technology, fostering the central role of enterprises in the innovation system, strengthening the industry-academy relationship, protecting intellectual property rights, and promoting international cooperation.[14]

Guangdong province's innovation initiatives mirror Hong Kong's actions in promoting innovation, creating further opportunities for cooperation between Guangdong and Hong Kong. If Guangdong meets its goals successfully, the province is set to play a more important role in economic integration and regional development in the Pearl River Delta region, which includes Hong Kong and Macau. The expectation is that, because of its low factor-input costs, more foreign firms will want to conduct R&D in Guangdong in addition to merely locating their manufacturing plants there.

4. Conclusions

In this paper we demonstrate that labor productivity grew more rapidly in Guangdong domestic firms as compared with their foreign counterparts in the observation period of 1997–2003. Yet in terms of output value in manufacturing sectors in Guangdong, foreign firms have further secured their dominant position. We have studied the impact of economic activity undertaken by foreign firms, including HKMT-funded firms, on productivity growth in Guangdong's domestic manufacturing firms using an econometric framework based on a production function. We find no consistent evidence for a significant positive impact on Guangdong's domestic manufacturing firms as a result of the economic activity undertaken by foreign firms. Rather, productivity gains from Guangdong's domestic manufacturing firms have resulted from the commitment of Guangdong's domestic firms to R&D and innovation.

From a regional perspective, the rise of Guangdong as an innovation center in the region could pose a serious challenge to Hong Kong's ambition to act as an R&D hub (cf. Baark and Sharif, 2006), as both foreign and Hong Kong-based firms would have a choice of cities in Guangdong province (excluding Hong Kong) as potential alternative sites at which to set up their R&D activities. Since Hong Kong and Guangdong are becoming ever more closely integrated, our findings suggest that mutual economic interdependence calls for the delicate coordination of industrial and innovation policy to ensure that the interests of both regions are promoted hand-in-hand.

[13] The concrete goals set in the blueprint for 2006–2020 include bringing the ratio of gross expenditure on R&D to GDP to 2.5 percent in 2020, seeing technological progress contribute 60 percent of economic growth, growing business expenditures in R&D to twice as much as expenditures on technology transfer (as the degree of dependence on foreign technology is reduced below the level of 30 percent), and increasing the number of invention patents granted to Chinese citizens and the citation of international scientific papers so that both will rank among the top five in the world (State Council, 2006).

[14] Quantitative targets for the implementation of the "Decision" are specified in the document. For instance, granted invention patents per million inhabitants will reach 80 by 2010, the high-tech sector's value-added will account for 35 percent of the total value-added of all industries, and the share of new product sales in total product sales will grow to 20 percent.

Appendix A

Table 8
Formation of variables for TFP calculation.[a].

Variables Entered in the Function (6)	Variables Directly or Calculated from the Statistical Yearbook	Deflator or Calculation Equation	Deflator Data Description	
			1997–2000	2001–2003
Deflated Value-added	Industrial Value-added (100 million RMB at current price)	Deflator of Value-added = Ex-factory Price Indices of Industrial Products (2000 Price as 1)	Data cover only 15 industry sectors. The general indices for all sectors are adopted for industry sectors that lack data.	Data cover 37 two-digit industry sectors.
Deflated Gross Industrial Output Value	Gross Industrial Output Value (100 million RMB at current price) The data for three ownership groups i.e., state-owned collective and foreign enterprises, are collected separately.	Deflator of Gross Industrial Output Value = Ex-factory Price Indices of Industrial Products (2000 Price as 1)	Data only cover 15 industry sectors. The general indices for all sectors are adopted for industry sectors that lack data.	Data cover 37 two-digit industry sectors.
Deflated Capital Input	Average Balance of Net Value of Fixed Assets for Production	Average Balance of Net Value of Fixed Assets for Production = (1) Average Balance of Net Value of Fixed Assets* (2) Ratio of Fixed Assets for Production to Total Fixed Assets		
	(1) Average Balance of Net Value of Fixed Assets (100 million RMB at current price)	Deflator of Average Balance of Net Value of Fixed Assets = Price Indices of Investment of Fixed Assets (2000 Price as 1)	Data are available for the period of 1997–2003.	
	(2) Ratio of Fixed Assets for Production to Total Fixed Assets	Ratio of Fixed Assets for Production to Total Fixed Assets = Fixed Assets for Production[a] (100 million RMB without depreciation)/Total Fixed Assets[a] (100 million RMB without depreciation)	Not Available. The mean of the data for the period of 2001–2003 is adopted for this period.	Panel Data cover three ownership groups, i.e., state-owned, collective, and foreign enterprises and 37 two-digit industry sectors. The capital deflator of state-owned enterprise is also applied to shareholding enterprise.
Labor Input	Annual Average Number of Employed Persons (10 000 persons)			
Deflated Intermediate Input	Intermediate Input = Gross Industrial Output Value–Value-added of Industry + Value-added Tax	Deflator of Intermediate Input = Purchasing Price Indices of Raw Materials Fuels and Power (2000 Price as 1)	Data only cover 9 industry sectors. The general indices for all sectors are adopted for industry sectors that lack data.	Data cover 37 two-digit industry sectors.

[a] All variables and price deflators are taken from various issues of the Guangdong Statistical Yearbook (2001, 2005) except for Fixed Assets for Production and Total Fixed Assets, which are taken from various issues of China Industry Economy Statistical Yearbook (2000–2004).

Table 9
Harmonization of manufacturing sector categorization.

Abbreviation in this Paper	Categorization in Guangdong Statistical Yearbook	Categorization In ISIC Rev 3.1[a]	
		Code	Sector Name
Agri-food Processing	Farm and Sideline Food Processing		
Food	Food Manufacturing	D15	Manufacture of Food Products and Beverages
Beverage	Beverage Manufacturing		
Textile	Textile Industry	D17	Manufacture of textiles
Garments	Textile Garments, Footwear and Headgear Manufacturing	D18	Manufacture of wearing apparel; dressing and dyeing of fur
Leather	Leather, Furs, Down, and Related Products	D19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery harnesses, and footwear
Wood Processing	Timer Processing, Bamboo, Cane, Palm Fiber, and Straw Products	D20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
Furniture	Furniture Manufacturing	D36	Manufacture of furniture; manufacturing n.e.c.
Paper	Papermaking and Paper Products	D21	Manufacture of paper and paper products
Printing	Printing and Record Medium Reproduction	D22	Publishing, printing, and reproduction of recorded media
Educational and Sports Products	Culture, Educational, and Sports Goods	D36	Manufacture of furniture; manufacturing n.e.c.
Petroleum Products	Petroleum Refining, Coking, and Nuclear Fuel Processing	D23	Manufacture of coke, refined petroleum products, and nuclear fuel
Chemical Products	Raw Chemical Materials and Chemical Products		
Pharmaceutical Products	Medical and Pharmaceutical Products	D24	Manufacture of chemicals and chemical products
Chemical Fiber	Chemical Fiber		
Rubber	Rubber Products	D25	Manufacture of rubber and plastics products
Plastics	Plastic Products		
Nonmetal Mineral Products	Nonmetal Mineral Products	D26	Manufacture of other non-metallic mineral products
Ferrous Metals Smelting	Smelting and Pressing of Ferrous Metals	D27	Manufacture of basic metals
Nonferrous Metals Smelting	Smelting and Pressing of Nonferrous Metals		
Metal Products	Metal Products	D28	Manufacture of fabricated metal products, except machinery and equipment
General Mechanical Products	General Purposes Equipment Manufacturing	D29	Manufacture of machinery and equipment n.e.c.
Special Mechanical Products	Special Purposes Equipment Manufacturing		
Transportation Equipment	Transport Equipment Manufacturing	D34	Manufacture of motor vehicles, trailers, and semi-trailers
		D35	Manufacture of other transport equipment
Electrical Equipment	Electric Equipment and Machinery	D31	Manufacture of electrical machinery and apparatus n.e.c.
Telecommunication and Computer	Telecommunications, Computers, and Other Electronic Equipment Manufacturing	D32	Manufacture of radio, television, and communication equipment and apparatus
Instruments and Office Machinery	Instruments, Meters, Cultural, and Office Machinery	D30	Manufacture of office, accounting, and computing machinery
		D33	Manufacture of medical, precision, and optical instruments, watches, and clocks

[a] *International Standard Industrial Classification of All Economic Activities Revision 3.1* is from Statistics Division, United Nations. Available from: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=17 (accessed on 24 August, 2005).

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