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Quantifying Foreign Direct Investment Productivity Spillovers: A Computable General Equilibrium Framework for China

By

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Abstract

We construct a static computable general equilibrium (CGE) model to quantify the endogenous productivity spillovers from foreign-invested firms to domestic firms, taking the Chinese economy as a case study. The coefficients of four spillover channels are estimated from econometric analysis. The simulations are conducted under two alternative market structures, namely perfect competition and monopolistic competition. Simulation results indicate that the spillover premia are positive in terms of national total output, GDP and welfare. The spillover effect is more prominent when the market structure is relatively monopolistic. FDI spillovers can also result in more product varieties produced by domestic enterprises, and can also help domestic enterprises increase their production scale.

JEL Classifications: O33, F21, C68

Keywords: productivity spillovers, foreign direct investment, computable general equilibrium models

Outline

Non-technical Summary

From the host country perspective, productivity spillovers to domestic firms are arguably one of the most important benefits from foreign direct investment (FDI), and many developing countries have adopted preferential FDI policies, characterized as “swapping domestic market access for advanced foreign technology and productivity”, in pursuit of such spillovers. But productivity spillovers can take place through several channels, and, most significantly, need not be confined to the industry or sector in which the FDI itself occurs. Measuring the effects of FDI productivity spillovers as economy-wide and cross-industry (as opposed to sector-specific) phenomena, requires a general equilibrium framework, for which computable general equilibrium (CGE) modelling is an obvious candidate. To date there have been only a handful of papers modelling FDI productivity spillovers using CGE, and their parameters were drawn from the general literature and not specifically related to the economies in question. This research aims overcome this weakness by combining CGE and econometric techniques to quantify FDI productivity spillovers and to simulate their effects.

China is an obvious economy for such a study. Since 1993, China has been the largest FDI host among the developing countries. FDI has been sought for the potential spillovers it can provide, and FDI inflows have been large enough to have had a measurable impact. As an economy in transition, firms in China fall into three ownership types – state-owned enterprises (SOEs), domestic privately-owned private enterprises (Private) and foreign-invested enterprises (FIEs). This naturally raises the question of whether FDI-induced productivity spillovers benefit both domestic ownership types, and if so, whether they benefit both types equally. In our benchmark, competitive model it is the spillovers that ensure an increase in the output of domestic firms following an FDI shock. SOEs have the larger output increase overall, but Private enterprises have the larger output increase from the spillovers themselves.

In addition to the standard competitive analysis, we also explore FDI spillovers under the alternative market structure of monopolistic competition. This recognizes that in the modern theory of the multinational enterprise, FDI occurs when firms exploit ownership-specific advantages in imperfectly competitive markets. It also introduces a further margin of adjustment as productivity spillovers can result in either larger domestic firms, or more domestic firms, and hence an increase in the range of products available to consumers, or a combination of both. Our simulations show that the lower the degree of competition assumed in the benchmark equilibrium, the larger the competitive benefits from the FDI spillovers. The representative state-owned and private enterprises are larger, but they are fewer in number as a consequence of the FDI shock, both with and without the spillovers. But the spillovers themselves tend to increase both equilibrium firm size and numbers, particularly the numbers of Private enterprises. Whatever the market structure assumed, the spillovers are clearly important for FDI to yield benefits to domestic firms of both ownership types.

1. Introduction

Foreign direct investment (FDI) plays an increasingly significant role in the global economic system, especially for the emerging economies. From the host country perspective, productivity spillovers to domestic firms are arguably one of the most important benefits from FDI, and many developing countries have adopted preferential FDI policies, characterized as "swapping domestic market access for advanced foreign technology and productivity" (Long, 2005), in pursuit of such spillovers. Since the 1990s, there has been a rich emerging literature, both theoretical and empirical, exploring FDI productivity spillovers and their effects.

But productivity spillovers can take place through several channels, and, most significantly, need not be confined to the industry or sector in which the FDI itself occurs.[1] Measuring the effects of FDI productivity spillovers as economy-wide and cross-industry (as opposed to sector-specific) phenomena, requires a general equilibrium framework, for which computable general equilibrium (CGE) modelling is an obvious candidate. To date there have been only a handful of papers modelling FDI productivity spillovers using CGE. Gillespie et al. (2002) take FDI spillovers as an *exogenous* externality, while Lejour et al. (2008) allow the magnitude of the spillover to vary with the size of FDI. But both studies make analysis with parameters drawn from the literature and the parameters are not specifically related to the economies in question. This research aims overcome this weakness by combining CGE and econometric techniques to quantify FDI productivity spillovers and to simulate their effects.

We chose the Chinese economy, for two main reasons. First, China has become an attractive FDI destination during the past three decades of "reform and opening-up (Deng et al., 2007). Since 1993, China has been the largest FDI host among the developing countries. FDI has been sought for the potential spillovers it can provide, and FDI inflows have been large enough to have had a measurable impact. Second, as an economy in transition, firms in China fall into three ownership types – state-owned enterprises (SOEs), domestic privately-owned private enterprises (Private) and foreign-invested enterprises (FIEs)[2]. This

[1] The channels are discussed in more detail in the next section. The main channel that we are unable to include is spillovers through labour movements between multinational affiliates and domestic firms. Some evidence on this channel is given in Blake et al. (2009).

[2] SOEs include enterprises with their largest share of registered capital invested by state agencies. FIEs include enterprises registered as joint-venture, cooperative, sole (exclusive) investment enterprises or limited liability corporations with funds from outside the China Mainland. Private enterprises include all types of

naturally raises the question of whether FDI-induced productivity spillovers benefit both domestic ownership types, and if so, whether they benefit both types equally. Our simulation results show that both SOEs and Private enterprises can benefit from these spillovers, but that Private enterprises benefit more.

In addition to the standard competitive analysis, we also explore FDI spillovers under the alternative market structure of monopolistic competition. This recognizes that in the modern theory of the multinational enterprise, FDI occurs when firms exploit ownership-specific advantages in imperfectly competitive markets (Markusen, 2002). It also introduces a further margin of adjustment as productivity spillovers can result in either larger domestic firms, or more domestic firms, and hence an increase in the range of products available to consumers, or a combination of both. Monopolistic competition has been applied widely in the CGE analysis of trade liberalization (e.g. Harrison et al., 1994, 1995, 1997, Francois and Roland-Holst, 1997, Blake et al., 1999), but has yet to be applied to the analysis of FDI productivity spillovers. Our results suggest that the type of competition matters and that the lower the degree of competition in the benchmark, the higher the competitive benefits from the FDI spillovers.

The remainder of the paper is organized as follows: the next section discusses the spillover channels that we consider. Section 3 then outlines the CGE framework under both perfect and monopolistic competition, and describes the data that we employ. Section 4 introduces our decomposition of total factor productivity and our model of productivity spillovers. The spillover parameters are then estimated econometrically. Section 5 presents the simulation results of FDI shocks under the two alternative market structures. Section 6 concludes.

2. The channels of productivity spillovers

In this section we briefly review the theoretical and empirical literature on the channels through which productivity may spill over from foreign affiliates to local firms through product markets.

2.1. *Vertical input-output linkages*

MNE's affiliates may provide their domestic suppliers and customers with technical assistance and training in management and organization (Markusen and Venables, 1999, Javorcik, 2004, Girma and Gong, 2008, Girma et al., 2008). *Backward linkages* arise when

enterprises other than SOEs and FIEs.

affiliates in downstream sectors source from upstream domestic firms. Sourcing locally can reduce affiliates' production costs and can trigger competition among upstream domestic firms. Multinationals' high technical requirements for their intermediate inputs often necessitating a transfer of technology to their upstream domestic suppliers (Javorcik, 2004). Domestic firms in downstream sectors can also benefit from the improved intermediate products supplied by domestic suppliers, and this benefit may outweigh the competition effect which multinational firms impose on domestic firms in upstream sectors. Similarly, *forward linkages* promote the transfer of knowledge from multinational affiliates in upstream sectors to downstream indigenous firms. This allows domestic firms to improve their productivity by purchasing high-quality intermediate products from multinational firms[3].

2.2. *Exports of MNE affiliates*

To export involves sunk costs incurred for market research, advertisement, establishing distribution networks etc. Firm level data confirms that entry into exporting is a self-selection process in which only the more productive firms become exporters (Clerides et al., 1998, Melitz, 2003). But even when domestic firms are productive enough to enter export markets, they may be unfamiliar with overseas markets and foreign consumers may be unfamiliar with Chinese products. The presence of large multinationals with well established international trade networks and extensive knowledge of international markets, can reduce the information barriers facing both domestic firms and foreign consumers (Aitken et al., 1997, Greenaway and Kneller, 2008, Lawless, 2009). Even if domestic firms do not currently find exporting profitable, the success of multinational firms in international markets can stimulate domestic firms to improve their productivity and product quality to meet international standards so as to emulate them (Alvarez and López, 2005). FDI from the East Asian economies has transferred labour-intensive, export-oriented assembly to the coastal provinces in China (Deng et al., 2007), and the export of FIEs accounts for more than 50% of China's total export volume in the last ten years.

2.3. *Horizontal effects: demonstration and competition*

Demonstration is probably the "most evident" spillover channel (Crespo and Fontoura, 2007, pp. 411), particularly in economies which are transforming quickly from a centrally-planning economy, dominated by SOEs, into a market economy with a variety of

[3] Similar spillover effects via forward linkages in international trade have been widely acknowledged in the literature (e.g. Falvey et al., 2004, Keller, 2004).

ownerships. FIEs with technological and managerial advantages showcase their superior practices in production, management, and services to their domestic counterparts, who can at least partially imitate them through "reverse engineering" (Das, 1987). The *increased competition* created by the entry of MNEs intensifies the competition for resources in host countries and constrains the market power of domestic firms forcing them to make more efficient use of existing resources.

3. The CGE framework

3.1. *A benchmark CGE model under perfect competition*

Our approach to calculating the productivity spillover effects of FDI involves estimating FDI productivity spillover coefficients and then implementing simulations of FDI shocks in a CGE model. This static, single-country CGE model contains 93 industrial sectors (mining, manufacturing, and utilities, MMU) and 8 non-industrial sectors (agriculture and services). The representative consumer has a nested consumption structure, each level of which is represented by a CES function, as shown in Figure 1.

======*Figure 1 about here*======

The lowest level (level 4) aggregates commodities across firms in the same industry with the same ownership type, *e.g.* the products of SOEs in the textile industry. In the right panel of Figure 1, the eight sectors in agriculture and services do not contain information on ownership, so they are exempted from the level 4 aggregation. At the second lowest level (level 3) commodities are further aggregated across the three ownership types. Level 2 is an Armington aggregation over domestically produced and imported commodities, and the top level, aggregates the products of all sectors.

3.2. *CGE extension under monopolistic competition*

The CGE model constructed above assumes that the Chinese economy has perfectly competitive markets. As noted above, however, it is recognised that FDI is undertaken to exploit firm-specific advantages in an imperfectly competitive environment. Monopolistic competition refers to an industry structure where a relatively large group of firms produce different varieties of a particular product. Each firm has monopoly power over its own variety, and in the long run there are no entry barriers. Since China is a large market and our industries are still aggregates of a large number of products, monopolistic competition seems to be an appropriate imperfectly competitive market structure.

The potential impact of FDI productivity spillovers in a scenario of monopolistic

competition can be illustrated by a variety-scale diagram (Francois and Roland-Holst, 1997, pp. 349). The number of varieties ("*N*") and production scale per variety ("*Q*") of the representative firm are shown on the vertical and horizontal axes, respectively in Figure 2. Locus A_0A_0 depicts the "variety-scale possibility frontier" and represents the pre-spillover trade-off between variety and scale given the resources available to the representative firm. FDI-productivity spillovers then increase the production capacity of this sector (given these resources) from A_0A_0 to A_1A_1, which allows expansion in both the scale and variety dimensions.

======*Figure 2 about here*======

The potential outcomes can be illustrated algebraically using a standard model (Krugman, 1980). Suppose production requires a composite factor input, with the representative firm's input requirements given by $x=f+vQ$, where f and v denote fixed cost and variable cost measured in units of the composite factor input, respectively, and Q is firm output (value added). Then if p and w denote the prices of the output and input, respectively, profit maximisation gives us $MR = p\left(\frac{\varepsilon-1}{\varepsilon}\right) = v \times w = MC$, where $\varepsilon(>1)$ is the price elasticity of demand. Free entry implies zero profits in long-run equilibrium, (*i.e.* price = average cost*)* which gives us $p = w\left[\frac{f}{Q}+v\right]$. Substituting we can derive the equilibrium production scale $Q = \frac{f[\varepsilon-1]}{v}$. Solving for the representative firm's input requirements and then using $X=N*x$ to solve for the equilibrium number of firms given the resources available to the industry (X), we have $x = f\varepsilon$ and $N = \frac{X}{f\varepsilon}$. So the equilibrium solution of scale and variety is $(Q^*, N^*)=\left(\frac{f(\varepsilon-1)}{v}, \frac{X}{f\varepsilon}\right)$.

We now examine how FDI productivity spillovers may affect this solution. The spillovers affect the industry's resource constraint by reducing fixed and variable costs. A reduction in fixed costs increases the number of firms and reduces the output of the representative firm in the same proportion. A reduction in variable costs leaves the number of firms unchanged but increases firm size. If both costs fall in the same proportion, then firm size is unchanged but the number of firms increases. A typical outcome is shown by the shift from the initial production point $E_0(Q, N)$ to a new equilibrium point $E_1(Q', N')$ in Figure 2. Under monopolistic competition, productivity spillovers from foreign-invested

firms can bring consumers welfare improvement through more varieties at lower prices. Only the price benefits may be available if goods are homogeneous and markets are perfectly competitive.

3.3. *Data*

Our CGE model is based on a transformation of the Chinese input-output table for 2002. The transformation involves two main steps. First, we aggregate the original 122 by 122 input-output table into a 39 by 39 table (see Table 1 for the list of aggregated industries), as data on FDI inflows are only available for those 39 aggregate industries. Second, we use data estimated for FIE, SOE, and Private enterprises (see Table 2), to disaggregate 31 of these 39 industries into 31*3=93 ownership-type sectors following a similar strategy to Gillespie *et al* (2001, 2002)[4]. The final product is a 93+8=101 dimension input-output table, which allows us to examine productivity spillovers from FIEs to SOEs and Private enterprises. The data employed are mainly from *China Input-Output Table* (hereafter "*I/O*"), *China Statistical Yearbook* and *China Industry Economy Statistical Yearbook* (hereafter "*CIESY*") for 2002, all of which were published by the National Bureau of Statistics of China (hereafter "NBS", 2003a, , 2003b, , 2006)

======*Tables 1 and 2 about here*======

4. Incorporation of endogenous FDI spillovers

4.1. *Productivity spillovers*

The benchmark CGE model can be extended to incorporate our four productivity spillover channels. We begin by writing value added in industry i at time t ($VA_{i,t}$) as the product of industry total factor productivity at time t ($TFP_{i,t}$) and Cobb-Douglas function of capital ($K_{i,t}$) and labour ($L_{i,t}$) inputs. Thus

$$VA_{i,t}=TFP_{i,t}\times K_{i,t}^{\alpha_K} L_{i,t}^{\alpha_L} \quad (1)$$

Then TFP can in turn be *decomposed* into $TFP = TFP_{indigenous} + TFP_{spillover}$ where $TFP_{indigenous}$ captures the indigenous factors that contribute to TFP (*e.g.* R&D, employee education and skills, and management skills), while $TFP_{spillover}$ measures the FDI

[4] Firstly, data from *China Industry Economy Statistical Yearbook*, was used to estimate the ratios of output and value added by ownership to total output and total value added in each sector. Secondly, we multiplied these ratios with the corresponding flows of intermediate output and value added of each sector to disaggregate the latter. Thirdly, we adjusted final demands, intermediate input, and error terms to construct a balanced ownership-disaggregated input-output table. Full details of this aggregation-disaggregation data compilation are available in Deng (2009).

productivity spillover effects. We assume that $TFP_{indigenous}$ is unchanged in our simulations. Estimation then takes place in two stages[5]:

$$\ln(VA_{i,t})=\alpha_0 + \alpha_K \ln K_{i,t} + \alpha_L \ln L_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$TFP_{i,t} = \exp(\alpha_0 + \varepsilon_{i,t}) = \alpha_1 + \boldsymbol{\beta}^{*}\boldsymbol{SPL}_{i,t} + \zeta_{i,t} \quad (3)$$

where vector ***SPL*** includes our four FDI spillover channel variables calculated as follows: (1) the horizontal demonstration effect, $HZDS_{i,t}$, is the share of FIEs in the gross output in sector j at time t; (2) backward linkages $BL_{i,t}$, and forward linkages $FL_{i,t}$, are designed to capture local firm interactions with *FIEs* as purchasers and suppliers, respectively. The specifications follow Javorcik (2004):

$$BL_j = \sum_k \gamma_{j,k} * HZDS_k \quad (4)$$

$$FL_j = \sum_k \eta_{k,j} * HZDS_k \quad (5)$$

where $\gamma_{j,k}$ is the proportion of sector j's output supplied to sector k ($\sum_k \gamma_{j,k} = 1$); and $\eta_{k,j}$ is the proportion of sector k's output supplied to sector j ($\sum_k \eta_{k,j} = 1$)[6]. These are taken from the *Input-Output Table of China* for 2002; (3) the "export concentration". $EXCO_i$ is the ratio of the exports of FIEs in sector i to total exports in that sector.

Equations (2) and (3) are estimated using industry-level panel data. As Görg and Strobl (2001) note, panel data analyses are superior to cross-sectional studies in their capability of capturing time-invariant sector-specific factors which may impact on the relationship between foreign presence and the performance of domestic enterprises. Ignoring such time-invariant factors usually leads to an overestimation of FDI productivity spillovers. We can then calculate the share of TFP attributable to spillovers.

$$NTFP = \frac{TFP_{spillover}}{TFP_{total}} = \frac{\hat{\boldsymbol{\beta}} \times \boldsymbol{SPL}}{\hat{\alpha}_1 + \hat{\boldsymbol{\beta}} \times \boldsymbol{SPL}} \quad (6)$$

where $\hat{\boldsymbol{\beta}} \times \boldsymbol{SPL} \equiv \hat{\beta}_1 BL_{i,t} + \hat{\beta}_2 FL_{i,t} + \hat{\beta}_3 HZDS_{i,t} + \hat{\beta}_4 EXCO_{i,t}$.

In the CGE modelling, the share of FIEs in sectoral output ($HZDS_i$) and the share of FIEs in sectoral exports ($EXCO_i$) are both *endogenously* determined in counterfactual

[5] Data limitations imply that we estimate common capital and labour shares for all industries of the same ownership type. Ideally we would accommodate differences in human capital across industries and ownership types, but data on employee schooling is not available by ownership sector. Similarly we are unable to include industry or year dummies because of limited observations (for Private enterprises in particular).

[6] For example, assume FIEs' output shares in industry 1, 2, 3 are 10%, 20%, and 30%, respectively. Industry 1 provides its products to itself, industry 2 and 3 with proportion of 40%, 35% and 25%. Then coefficient of backward linkage is BL = 40%×10% + 20%×35% + 30%×25% = 0.185.

experiments. Backward linkages (BL_i) and forward linkages (FL_i) are also endogenously determined by (4) and (5), respectively. The share of productivity spillovers is then also *endogenous*, as specified by (6). The changes in these variables in the simulations are discussed in Section 5.2 (Tables 9 and 10). We can transform equation (1) into

$$VA_i = \Theta_i * \overline{TFP0}_i \times K_i^{\alpha_K} L_i^{\alpha_L} \quad (7)$$

where $\Theta_i = \frac{TFP_i}{\overline{TFP0}_i}$, $\overline{TFP0}_i$ denotes the benchmark TFP in sector *i*. In the benchmark scenario, Θ_i=1, so that equation (7) simplifies to $VA_i = \overline{TFP0}_i \times K_i^{\alpha_K} L_i^{\alpha_L}$.

4.2. *Econometric estimation of spillover parameters*

Our data sources for the econometric analysis are summarised in Table 3. The CGE model is built on the I/O Table for 2002, which is also employed to calculate the input-output coefficients ($\gamma_{j,k}$ and $\eta_{k,j}$) for the spillover channels. For compatibility the FDI spillover parameters $\boldsymbol{\beta}$ should be estimated for the years around 2002, and the available *CIESY*s are for 2001-2003 and 2005-2006. This gives us 155 (panel data) observations for SOEs (31 industries and 5 years), but the data for Private enterprises are only available in 2005 and 2006, giving only 62 total observations.

======*Table 3 about here*======

Tables 4 and 5 report the econometric estimation of value added and spillovers, respectively. The value added estimations in Table 4 show significant differences in the factor shares between private and state-owned enterprises, with the former having the higher labour cost share. The estimates in Table 5 show significant positive spillovers through forward linkages and horizontal demonstration effects, with higher coefficients estimated for Private firms. There appear to be no significant backward linkages, and a higher concentration of foreign firms in exports appears to have no effect on SOEs, but a significant negative impact on Private firms. It is difficult to make sense of this as a "negative spillover", and what it may simply be indicating is that Private enterprises tend, for other reasons, to have low TFP in those industries in which FIEs have a larger share of exports.[7] Unfortunately data limitations, particularly for Private enterprises, do not allow us to estimate the industry fixed effects that might settle this issue. For this reason we retain all the spillover channels in the simulation analysis, while recognising that our results are at least partly contaminated by non-spillover effects.

[7] Although it has been suggested that export-oriented FIEs may "cherry pick" skilled workers from their domestic rivals reducing the productivity of the latter (Girma and Gong, 2008).

======*Table 4 and 5 about here*======

5. CGE simulations and results

5.1. *FDI shocks*

The FDI shock that is introduced into the model is an increase of the capital stock in each foreign-invested sector corresponding to the **actual FDI inflow in 2003**. As Table 1 shows, FDI into the manufacturing sectors accounted for almost 70% of total FDI in 2003. The five main manufacturing recipients are highlighted in bold. The aggregate effects of this FDI shock, with and without spillovers, are shown in Table 6. Aggregate output increases by 5.9% without spillovers and 6.8% with. The largest increase in output is by FIEs in each case, and in fact the output of domestic enterprises falls by 1.9% (0.6% SOEs and 2.3% Private) in the absence of spillovers. But the output of both domestic ownership types increases once spillovers are taken into account. Table 7 shows how FDI affects the performance of enterprises of different ownerships in the top 5 FDI recipient sectors. The changes in output, value added, and exports are consistent with Table 6.

======*Table 6 and 7 about here*======

The underlying process at work here, is that a capital inflow into FIEs in each sector, reduces the price of capital in FIEs and encourages a movement of capital into the other ownership types in that sector. Conversely the price of labour in FIEs increases, encouraging an inflow of labour from domestic enterprises into FIEs in each sector. The net result for the domestic enterprises depends on the relative ease of mobility of capital and labour across ownership types. The elasticity of transformation[8] of labour between ownerships is assumed to be lower (τ_L=0.5) than that of capital (τ_K=2) because inter-ownership labour mobility is still very low in China[9]. As Table 7 shows, the prices of capital in all ownership types are pulled down by the FDI influx, while the prices of labour in foreign-invested sectors rise significantly. However, the low transformability of labour between FIEs and domestic enterprises, implies that the contraction of the domestic sectors will lead to a reduced demand for and lower price of labour there.

To test the sensitivity of these results to the transformation parameters, we rerun the

[8] We use "transformation" rather than "substitution" because the supplies of primary inputs (labour and capital) are disaggregated to each ownership-type sector with a constant elasticity of *transformation* (CET) function.

[9] According to a recent survey of 1,500 firms conducted by Asia Market Intelligence, only about 0.2% of the employees had work experience in foreign-invested enterprises in 2000. Knight and Yueh (2004) also argue that the inter-firm labour mobility in urban areas in China is still very low.

experiments allowing the elasticities of capital and labour transformation to take 10 alternative values (0.1, 0.4, 0.7, …, 2.8).[10] Table 8 reports the changes in national output - without spillovers in the upper block, with spillovers in the middle block and the differences between them (the spillover premia) in the lower block - for each of these experiments. The numbers themselves will be discussed below[11]. In each case, the output increase is larger the larger the elasticity of transformation of labour, for any given elasticity of transformation of capital. While the output increase is smaller the larger the elasticity of transformation of capital, for any given elasticity of transformation of labour. In the current context of an FDI inflow, while a higher elasticity of capital transformation leads to a greater capital outflow from FIEs to domestic enterprises, a higher elasticity of labour transformation leads to a greater labour outflow from domestic enterprises to FIEs. The implications for total output reflect the higher TFP in FIEs.

======*Table 8 about here*======

5.2. *FDI shocks with spillovers under perfect competition*

The spillover premia in Table 8 also increase with labour transformability and decline with capital transformability, for a given degree of transformability of the other factor. But the latter effect is greater than the former, implying a net decline as we move down the main diagonal.

======*Figure 3 about here*======

Figure 3 illustrates the corresponding effects (including spillovers) on total output and aggregate outputs for each of the ownership types. Panels (b) and (c) exhibit a similar pattern. If the transformability of labour between foreign firms and domestic firms is relatively high, FDI shocks can attract labour from domestic firms, making the total output of the latter decrease. But if the transformability of capital between foreign firms and domestic firms is relatively high, then domestic enterprises can benefit more from the influx of FDI. Panel (d) shows the corresponding changes for FIEs. Panel (a) implies that the positive impact of FDI shocks on FIEs outweighs any negative impact on the domestic firms[12].

[10] While elasticities of capital transformation as large as 4 are used in the literature (e.g. Lejour et al., 2008, Springer, 1998), we view 2.8 as a reasonable upper limit given the idiosyncratic characteristics of foreign capital, state capital and private capital in the Chinese economy in transition. For symmetry we also set 2.8 as the upper limit for the elasticity of labour transformation, though we expect the actual value to be at the lower end of this range.

[11] The changes of GDP and national welfare are all positive and their patterns are very similar to that of national total output shown in Table 8.

[12] The changes in GDP and national welfare are all positive and their *patterns* are very similar to those

Tables 9 and 10 illustrate the percentage changes in variables relating to SOEs and Private enterprises, respectively, by sector, including spillovers. As discussed in Section 3.3, the changes in the spillover variables (*i.e. HZDS, BL, FL* and *EXCO*) will determine the changes in productivity of domestic firms. The contribution of FDI productivity spillovers to total productivity (*NTFP*), has increased for both SOEs and private firms in all industries[13]. The change in the level of total productivity (*TFP*), is also positive in all industries. On average, SOEs have 9.6% *NTFP* improvement and 1.8% *TFP* improvement, while Private enterprises have 8.6% *NTFP* improvement and 3.6% *TFP* improvement. The four spillover channel variables (*HZDS*, *BL*, *FL* and *EXCO*) do not necessarily change in the same direction. The top five FDI recipient industries are marked in bold in the Tables, and are *not* necessarily among the top recipients of FDI productivity spillovers. Likewise the top FDI spillover recipients do not necessarily have the largest output increases. The spillover effects on exports and imports can be positive or negative, and product prices (*P*) are generally lower. The effects on output are also mixed, reflecting the fact that the FDI shock can bring both positive spillover effects and negative competition effects by attracting resources away from the domestic enterprises.

======*Table 9 and 10 about here*======

The spillover premia shown in Table 8, are illustrated in Figure 4(a). Panels 4(b) and 4(c) show how the positive premia which SOEs and Private enterprises obtain in aggregate from FDI productivity spillovers are related to the elasticities of transformation of capital and labour between enterprise types. A comparison of panels 4(b) and 4(c) suggests that Private enterprises obtain higher spillover premia than SOEs. The increase in FIEs' output is lower than that without FDI productivity spillovers for any given combination of elasticities of transformation, *i.e.* a negative spillover premium as shown in panel 4(d). But the net outcome of the spillovers is a total output increase as shown in panel 4(a)

======*Figure 4 about here*======

5.3. *FDI shocks with spillovers under monopolistic competition*

Simulating the effects of FDI productivity spillovers under monopolistic competition involves all the channels considered above plus changes in variety (numbers of firms) and the scale of firm production.

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shown in panel (a) of Figure 3.

[13] For both SOEs and Private enterprises, the "production of tap water" gains the most (26.3% and 40.7% respectively) from the FDI spillovers. This is probably because the initial FDI volume in this industry was relatively low, while an FDI shock (accounting for 0.5% of total FDI) to this industry can bring the largest increase in terms of the contribution rate of FDI spillovers in total TFP, as measured by equation (6).

(a) Changes of GDP, output and welfare

The impacts of FDI productivity spillovers on aggregate variables for different initial degrees of monopolistic power are shown in Table 11. *N* denotes the initial number of firms and varieties, chosen for each ownership type in each industry in the benchmark economy. We also include the outcomes for perfect competition for comparison. As we can see, the weaker the level of competition the stronger the effects of an FDI shock (in absolute values), with or without FDI spillovers. The change in total output of domestic firms tends to be relatively stable across ownership types, with a positive spillover premium for both, but larger for Private enterprises (1.2%) than for SOEs (0.5%).

(b) Changes of variety and scale

FIEs expand in size and number with and without the spillovers, though the spillover premium reflects a small increase in scale and a reduction in numbers. Figure 5 is drawn to summarise how the FDI shocks *with* and *without* productivity spillovers affect the domestic sectors in our CGE model. Collectively, they shift from benchmark equilibrium E_0 to either E_1 or E_2. As shown scale increases but the number of varieties falls for both ownership types, with and without the spillovers. But the total number of varieties in each sector increases thanks to more foreign-invested varieties. Panel 5(b) depicts how spillovers can affect these changes. The spillover premia on both variety and scale are positive, pushing A_1A_1 and A_2A_2 upwards, resulting in a new equilibrium at E_1' or E_2'. The effects of the spillovers on scale are very similar for both ownership types, but there is a greater percentage increase in the number of Private enterprises. These spillovers negatively affect the number of varieties produced by foreign enterprises, however, as some of their resources are attracted away when domestic rivals become more productive.

Though FDI spillovers can result in more product varieties produced by domestic enterprises, and can also help domestic enterprises increase their production scale for each product, the net result of the FDI shock will be fewer domestic varieties as the value of elasticity of transformation of capital falls and that of labour rises. The changes in key variables at industry-level under monopolistic competition are similar to those shown in Tables 9 and 10. The contribution of productivity spillovers in total TFP of domestic enterprises (*NTFP*) also increases, resulting in a moderate productivity (*TFP*) improvement.

6. Concluding remarks

To the best of our knowledge, this is the first study in the literature to endogenise FDI productivity spillovers by incorporating spillover channels within a CGE framework. In our

competitive model, we find that both state-owned and private enterprises benefit from FDI productivity spillovers. In our benchmark model it is the spillovers that ensure an increase in the output of domestic firms. SOEs have the larger output increase overall, but Private enterprises have the larger output increase from the spillovers themselves. This is also the first study exploring FDI spillovers under monopolistic competition. This allowed us to comment on the impact on representative domestic firms. The lower the degree of competition assumed in the benchmark equilibrium, the larger the competitive benefits from the FDI spillovers. The representative state-owned and private enterprises are larger, but they are fewer in number as a consequence of the FDI shock, both with and without the spillovers. But the spillovers themselves tend to increase both equilibrium firm size and numbers, particularly the numbers of Private enterprises. Whatever the market structure assumed, the spillovers are clearly important for FDI to yield benefits to domestic firms of both ownership types.

This research can be extended in several dimensions. Its major weakness is that we were forced to rely on industry level data to estimate the parameters of the productivity spillover channels. Our spillover channels are potentially contaminated by industry specific effects which we could not control for. Better estimates will be obtained when firm-level data sets covering a wide range of industries and all three ownership types become available. Given the apparent significance of the degree of competition for the outcomes, extending the analysis to include monopolistic competition with heterogeneous firms (Melitz, 2003) should also be fruitful. This relaxation of the assumption of a representative firm would allow the consideration of intra-industry resource reallocation towards those most productive enterprises. This can lead to potentially even more prominent FDI productivity spillover effects since the surviving foreign firms are more productive and thus more likely to generate spillovers, and because the surviving domestic firms are more capable of absorbing spillovers from FDI (Deng, 2009). This research can also be employed to simulate the effects of changes in the corporate income tax system. Countries have "increasingly" relied on policy incentives (United Nations Conference on Trade and Development, 2000, pp. 3) to attract FDI, partially allured by the potential for productivity spillovers. To check if the tax concessions made to foreign-invested firms, our model can examine whether FDI has generated compensating benefits through productivity spillovers.

Figures

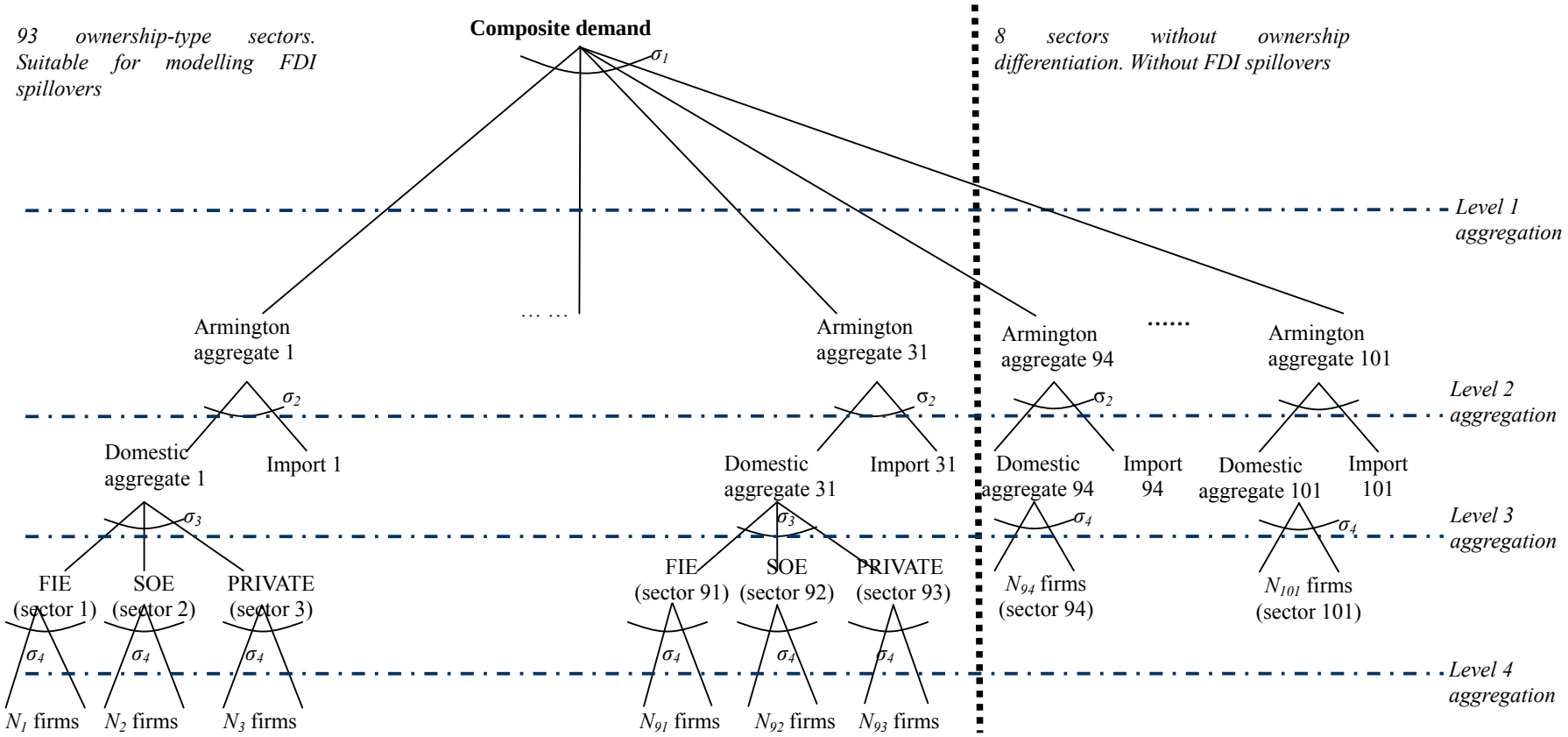


Figure 1. Consumption aggregation.

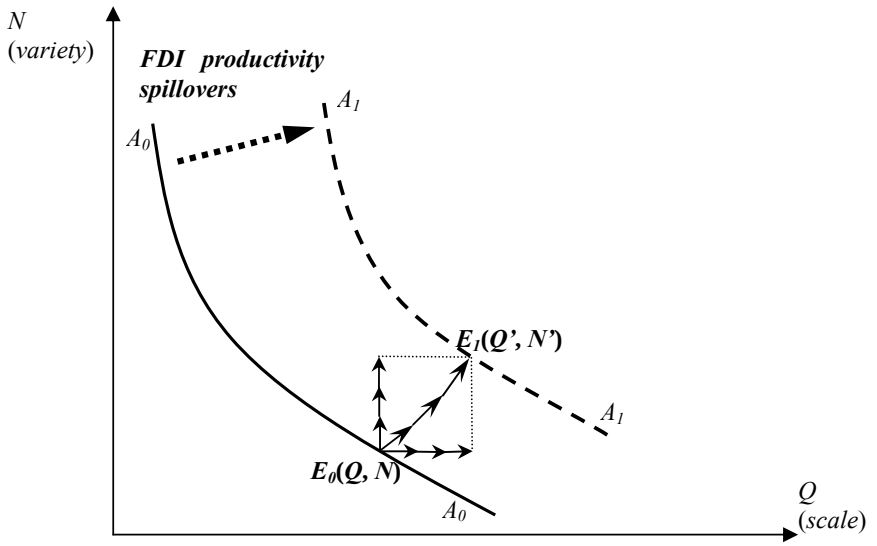
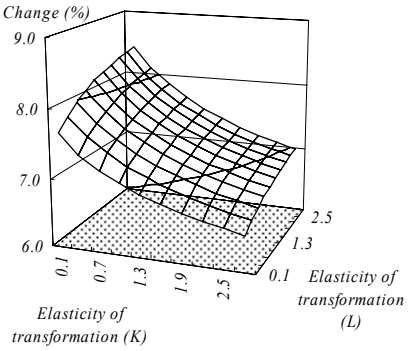
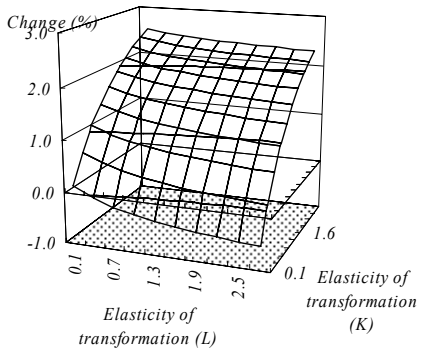


Figure 2. FDI productivity spillovers under monopolistic competition.

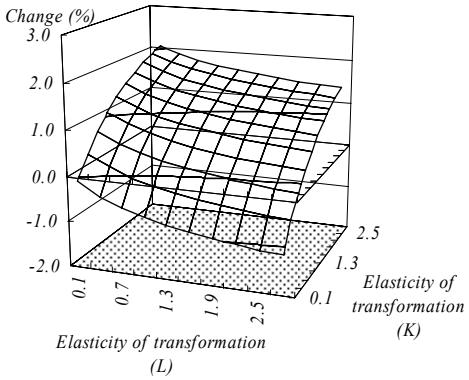
(a) Total output change (%)



(b) Change of SOEs' output (%)



(c) Change of Private enterprises' output (%)



(d) Change of FIEs' output (%)

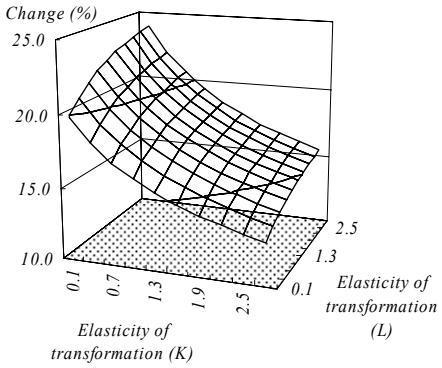
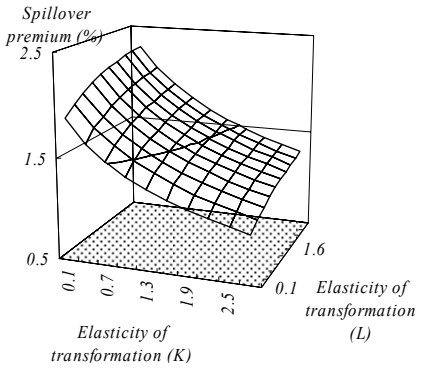
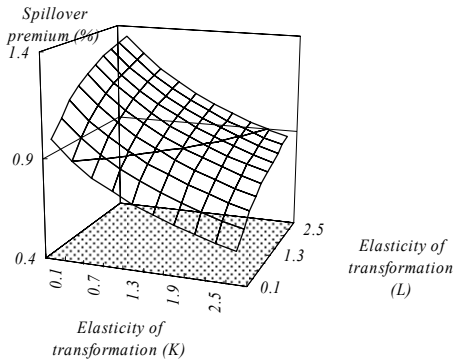


Figure 3. Impact of FDI shock on output with spillovers.

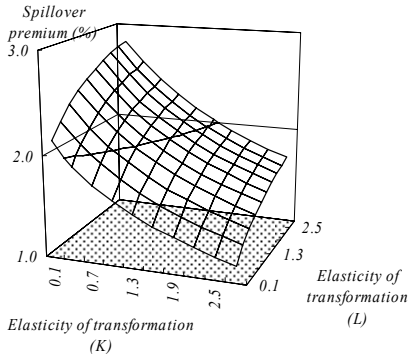
(a) Positive spillover premium of national total output (%)



(b) Positive spillover premium of SOEs' output (%)



(c) Positive spillover premium of Private enterprises' output (%)



(d) Negative spillover premium of FIEs' output (%)

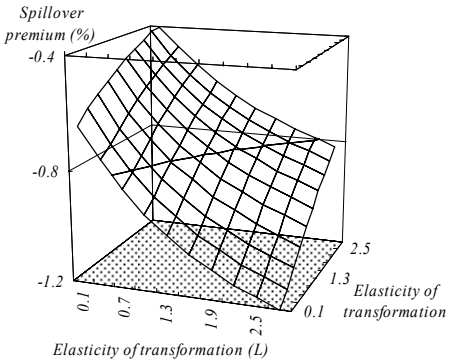
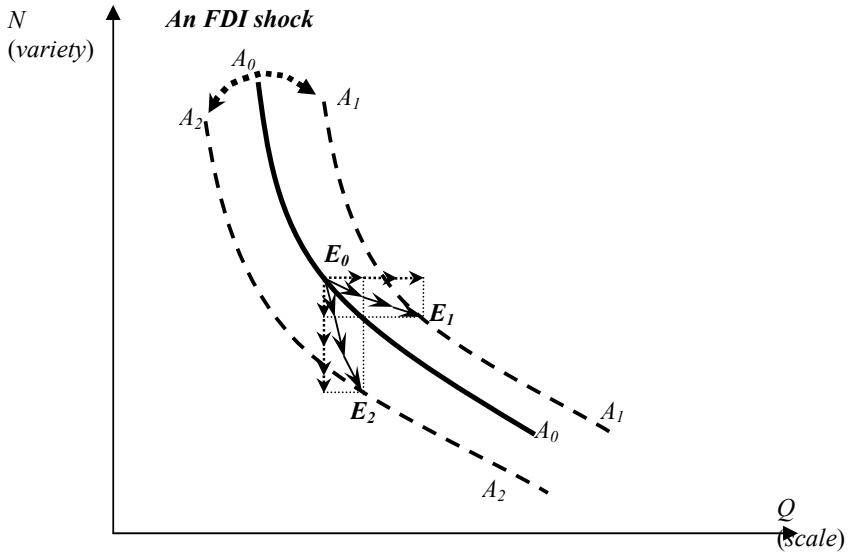


Figure 4. Impact of FDI shock on output: spillover premium.

(a) *Without* spilllovers



(b) *With* spillovers

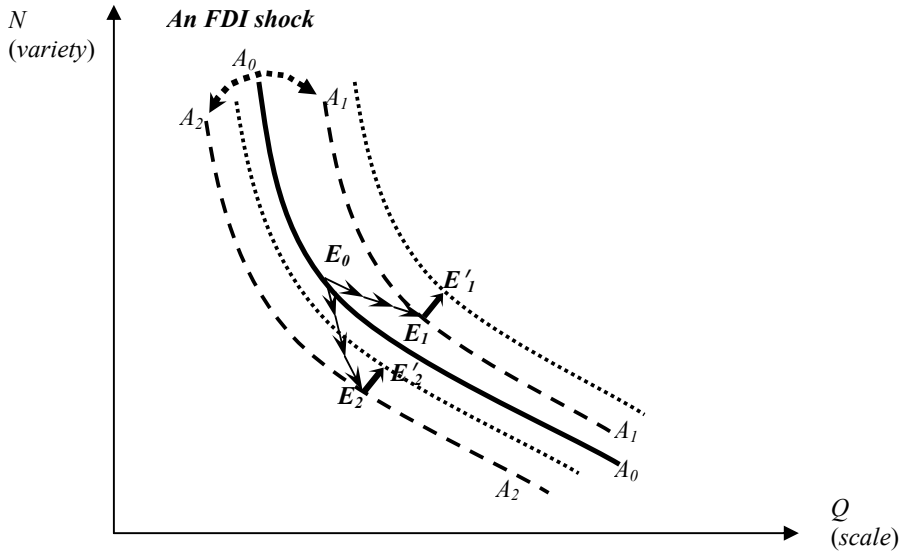


Figure 5. The impact of FDI shocks on the variety and scale of domestic enterprises.

Tables

Table 1. FDI to China by aggregated sectors in 2003 ($ million).

Groups	Sectors	FDI	% of total
*Mining**	Resource manufacturing (Coal, petroleum and gas)	2,779	0.6
	Ferrous metals mining and dressing	0	0.0
	Nonferrous metals mining and dressing	0	0.0
	Mining of non-metal, other minerals, and other ores	0	0.0
*Manufacturing**	Food, beverage, and tobacco manufacturing	11,206	2.5
	Textile industry	**22,591**	**5.1**
	Garments and other fibre products	**19,653**	**4.4**
	Leather, furs, down and related products	14,344	3.2
	Timber processing, bamboo, cane, palm fibre etc.	3,252	0.7
	Furniture manufacturing	4,438	1.0
	Papermaking and paper products	9,807	2.2
	Printing and record medium reproduction	4,268	1.0
	Cultural, educational and sports goods	7,083	1.6
	Petroleum processing and coking	2,354	0.5
	Raw chemical materials and chemical products	**21,518**	**4.9**
	Medical and pharmaceutical products	7,864	1.8
	Chemical fibre	3,595	0.8
	Rubber products	5,966	1.3
	Plastic products	16,201	3.7
	Non-metal mineral products	13,615	3.1
	Smelting and pressing of ferrous metals	10,809	2.4
	Smelting and pressing of nonferrous metals	5,836	1.3
	Metal products	16,635	3.8
	Ordinary machinery	12,906	2.9
	Special purpose equipment	10,128	2.3
	Transport equipment	**19,622**	**4.4**
	Electronic and electric products	**52,490**	**11.9**
	Instruments, meters, cultural and office machinery	13,671	3.1
*Utilities**	Production of electric power, steam and hot water	4,549	1.0
	Production of gas	3,919	0.9
	Production of tap water	2,244	0.5
Agriculture	Farming, forestry, animal husbandry & fishing	8,278	1.9
Construction	Construction	5,061	1.1
Banking and Insurance	Banking and insurance	1,919	0.4
Real Estate	Real estate	43,302	9.8
Other services	Geological perambulation & water conservancy; transport, storage, post & telecommunication services; wholesale & retail trade & catering; social services; healthcare, sports & social welfare; education, culture, radio, films & television; scientific and technical services	60,578	13.7
	Public administration & other services	0	0.0
Subtotal	All manufacturing	309,852	69.9
Total	All sectors	442,481	100

Note: (a) Categories marked * (MMU) can be further disaggregated by three types of ownership – FIE, SOE and Private. (b) Data source: Ministry of Commerce of China; *China Industrial Economy Statistical Yearbook 2004* (National Bureau of Statistics of China, 2004). Compilations by the authors.

Table 2. Shares of output and value added of SOEs, FIEs, and Private enterprises in each sector of MMU (%).

Sector Name	SOEs		FIEs		Private	
	Y	***VA***	***Y***	***VA***	***Y***	***VA***
Resource manufacturing (coal, petroleum, and gas)	29.5	13.6	5.2	3.9	65.3	82.5
Ferrous metals mining and dressing	6.0	3.8	0.5	0.3	93.5	95.9
Nonferrous metals mining and dressing	13.3	9.8	1.3	0.9	85.4	89.3
Mining of non-metal, other minerals, and other ores	4.7	2.9	1.7	1.0	93.7	96.0
Food, beverage, and tobacco manufacturing	21.0	19.7	34.8	31.8	44.2	48.4
Textile industry	8.2	9.7	24.8	24.2	67.0	66.1
Garments and other fibre products	1.4	1.5	51.2	47.5	47.4	51.0
Leather, furs, down and related products	0.9	1.3	60.1	72.5	39.0	26.1
Timber processing, bamboo, cane, palm fibre etc.	2.1	2.2	12.7	11.0	85.2	86.8
Furniture manufacturing	0.7	0.8	29.2	29.2	70.1	70.1
Papermaking and paper products	5.7	5.6	30.5	28.8	63.9	65.6
Printing and record medium reproduction	8.4	5.8	20.0	15.1	71.7	79.1
Cultural, educational and sports goods	1.2	1.2	53.0	44.0	45.7	54.8
Petroleum processing and coking	27.3	46.4	12.7	15.9	60.0	37.8
Raw chemical materials and chemical products	15.1	17.5	24.0	25.5	60.9	57.0
Medical and pharmaceutical products	15.9	12.0	29.7	28.4	54.4	59.7
Chemical fibre	11.8	16.0	38.2	39.6	50.0	44.4
Rubber products	11.1	11.8	39.0	39.8	49.8	48.5
Plastic products	1.5	1.8	30.5	32.1	68.0	66.1
Non-metal mineral products	10.0	8.9	23.4	20.8	66.5	70.3
Smelting and pressing of ferrous metals	24.6	27.6	6.8	5.9	68.5	66.5
Smelting and pressing of nonferrous metals	15.9	23.5	13.1	13.0	71.0	63.5
Metal products	3.0	3.7	31.3	31.9	65.7	64.5
Ordinary machinery	9.9	10.2	19.8	19.1	70.3	70.7
Special purpose equipment	14.1	14.9	17.4	17.7	68.4	67.4
Transport equipment	25.8	28.8	43.7	45.2	30.4	26.0
Electronic and electric products	6.4	8.5	81.5	78.7	12.1	12.8
Instruments, meters, cultural and office machinery	5.5	6.3	63.3	51.4	31.1	42.3
Production of electric power, steam and hot water	32.2	18.8	21.7	22.9	46.1	58.3
Production of gas	22.5	32.2	27.7	14.0	49.9	53.8
Production of tap water	29.5	17.2	3.9	3.0	66.7	79.8

Note: "*Y*" and "*VA*" denote output and value added, respectively.

Source: Authors' estimation based on the data from National Bureau of Statistics of China (2006); Girma and Gong (2008).

Table 3. Industry-level data.

Variables and coefficients	**Symbols**	**Source**	**Years**
Value added	*VA*	*CIESY*	2001-2003, 2005-2006
Net fixed assets	*K*	*CIESY*	2001-2003, 2005-2006
Total employment	*L*	*CIESY*	2001-2003, 2005-2006
Input-output coefficients	$\gamma_{j,k}$; $\eta_{k,j}$	*I/O*	2002
Backward linkages	$BL_j = \sum_k \gamma_{j,k} * HZDS_k$	*CIESY, I/O*	2002
Forward linkages	$FL_j = \sum_k \eta_{k,j} * HZDS_k$	*CIESY, I/O*	2002
Horizontal demonstration	*HZDS*	*CIESY*	2001-2003, 2005-2006
Export concentration	*EXCO*	*CIESY*	2001-2003, 2005-2006

Note: *CIESY* is the *China Industrial Economy Statistical Yearbook* (2001-2003 and 2005-2006); *I/O* denotes *China Input-output Table* for 2002. Value added *VA* is deflated with an "ex-factory or wholesale price index". Net fixed assets *K* are deflated with a "fixed asset investment price index". Both indexes are obtained from *China Statistical Yearbook* (National Bureau of Statistics of China, 2007).

Table 4. Estimation of value added.

Firm types	**constant**	***K***	***L***	**Obs.**	R^2
SOEs	0.13 (0.04)***	0.91 (0.02)***	0.09 (0.03)***	155	0.99
Private	1.01 (0.19)***	0.39 (0.06)***	0.70 (0.04)***	62	0.97

Note: (a) Estimation of equation (2). (b) Standard errors in parentheses. *, **, *** denote statistically significant at 10%, 5%, and 1% level, respectively. (c) "SOEs" stands for state-owned enterprises; "Private" denotes domestic private enterprises.

Table 5. Estimation of productivity spillovers.

Firm types	**constant**	***BL***	***FL***	***HZDS***	***EXCO***	**Obs.**	R^2
SOEs	0.91 (0.05)***	0.40 (0.42)	0.29 (0.15)*	0.33 (0.17)*	0.04 (0.07)	155	0.31
Private	2.21 (0.32)***	0.15 (2.73)	2.58 (0.97)***	2.88 (1.11)***	-1.74 (0.47)***	62	0.30

Note: (a) Estimation of equation (3). (b) and (c): same as Table 4.

Table 6. Effects of FDI shocks to the benchmark economy.

Variables	**Change (%) (Without spillovers)**	**Change (%) (With spillovers)**
National output	5.9	6.8
GDP	5.7	7.1
Output of foreign-invested enterprises in MMU	20.8	14.9
Output of domestic enterprises (SOEs + private) in MMU	-1.9	1.3
-- SOEs	-0.6	1.9
-- private enterprises	-2.3	1.2
Output of non-MMU sectors (*both* foreign and domestic)	6.3	7.9
Welfare (equivalent variation)	2.5	3.6

Note: (a) "MMU" refers to mining, manufacturing, and utilities. (b) Elasticity of transformation of capital and labour (τ_K, τ_L) = (2.0, 0.5).

Table 7. Impacts of FDI inflow on enterprises of different ownerships in the top 5 recipient sectors in manufacturing (%) (without spillovers)

		Export	**Output**	P_L	P_K
Textile	FIEs	46.1	39.9	7.7	-39.3
	SOEs	-7.9	-4.0	-4.6	-1.3
	Private	-8.8	-4.7	-5.4	-2.4
Garments	FIEs	43.4	31.9	5.2	-34.4
	SOEs	-5.9	-9.1	-9.0	-4.6
	Private	-5.9	-9.1	-9.0	-4.6
Chemicals	FIEs	41.6	32.7	6.5	-29.2
	SOEs	-5.5	-3.2	-2.6	-0.5
	Private	-6.0	-3.6	-3.0	-1.2
Transport	FIEs	31.0	16.1	-2.2	-24.6
	SOEs	0.5	-4.6	-7.5	-2.3
	Private	-0.9	-5.5	-8.5	-3.7
Electronics	FIEs	15.7	12.0	4.7	-12.5
	SOEs	-5.2	-4.6	-0.8	0.0
	Private	-5.3	-4.7	-0.9	-0.1

Note: P_L and P_K denote prices of labour and capital, respectively.

Table 8. Impact of FDI shock on national output with and without spillovers.

National output change (%)			**Elasticity of transformation (*L*)**									
			0.1	*0.4*	*0.7*	*1.0*	*1.3*	*1.6*	*1.9*	*2.2*	*2.5*	*2.8*
Elasticity of transformation (*K*)	*Without spillovers*	0.1	5.8	5.9	5.9	6.0	6.0	6.1	6.1	6.1	6.1	6.1
		0.4	5.7	5.8	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0
		0.7	5.7	5.7	5.8	5.8	5.9	5.9	5.9	5.9	6.0	6.0
		1.0	5.7	5.7	5.7	5.8	5.8	5.8	5.9	5.9	5.9	5.9
		1.3	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.9
		1.6	5.6	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8
		1.9	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.8	5.8	5.8
		2.2	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.8
		2.5	5.6	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7
		2.8	5.5	5.6	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7
	With spillovers	0.1	*7.7*	*7.8*	*8.0*	*8.1*	*8.2*	*8.2*	*8.3*	*8.4*	*8.4*	*8.4*
		0.4	*7.4*	*7.6*	*7.7*	*7.8*	*7.9*	*7.9*	*8.0*	*8.0*	*8.1*	*8.1*
		0.7	*7.2*	*7.4*	*7.5*	*7.6*	*7.6*	*7.7*	*7.7*	*7.8*	*7.8*	*7.9*
		1.0	*7.0*	*7.2*	*7.3*	*7.4*	*7.5*	*7.5*	*7.6*	*7.6*	*7.6*	*7.7*
		1.3	*6.9*	*7.1*	*7.2*	*7.2*	*7.3*	*7.4*	*7.4*	*7.4*	*7.5*	*7.5*
		1.6	*6.8*	*6.9*	*7.0*	*7.1*	*7.2*	*7.2*	*7.3*	*7.3*	*7.3*	*7.4*
		1.9	*6.7*	*6.9*	*6.9*	*7.0*	*7.1*	*7.1*	*7.2*	*7.2*	*7.2*	*7.2*
		2.2	*6.7*	*6.8*	*6.9*	*6.9*	*7.0*	*7.0*	*7.1*	*7.1*	*7.1*	*7.1*
		2.5	*6.6*	*6.7*	*6.8*	*6.8*	*6.9*	*6.9*	*7.0*	*7.0*	*7.0*	*7.1*
		2.8	*6.5*	*6.6*	*6.7*	*6.8*	*6.8*	*6.9*	*6.9*	*6.9*	*7.0*	*7.0*
	Spillover premium	0.1	**1.9**	**2.0**	**2.1**	**2.1**	**2.2**	**2.2**	**2.2**	**2.2**	**2.3**	**2.3**
		0.4	**1.7**	**1.8**	**1.8**	**1.9**	**1.9**	**2.0**	**2.0**	**2.0**	**2.0**	**2.1**
		0.7	**1.5**	**1.6**	**1.7**	**1.7**	**1.8**	**1.8**	**1.8**	**1.9**	**1.9**	**1.9**
		1.0	**1.4**	**1.5**	**1.6**	**1.6**	**1.6**	**1.7**	**1.7**	**1.7**	**1.7**	**1.8**
		1.3	**1.3**	**1.4**	**1.4**	**1.5**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
		1.6	**1.2**	**1.3**	**1.4**	**1.4**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**	**1.6**
		1.9	**1.1**	**1.2**	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**	**1.4**	**1.5**	**1.5**
		2.2	**1.1**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**
		2.5	**1.0**	**1.1**	**1.2**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**
		2.8	**1.0**	**1.1**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	**1.3**

Table 9. Impact (%) of FDI shocks on SOEs (with spillovers).

	FDI*	***BL***	***FL***	***HZDS***	***EXCO***	***NTFP***	***TFP***	***Export***	***Import***	***Output***	***P***
Coal, petroleum and gas	0.6	7.8	7.6	6.8	9.6	6.7	0.8	-4.5	8.8	1.3	2.0
Ferrous metals mining and dressing	0.0	7.2	18.0	-2.6	N.A.	11.2	1.2	-3.9	9.1	1.8	1.9
Nonferrous metals mining and dressing	0.0	8.8	19.7	-2.0	-2.9	12.3	1.3	-6.4	15.4	3.5	3.4
Mining of non-metal, other minerals, and other ores	0.0	9.6	13.9	-1.9	-2.5	9.6	0.8	-4.2	7.7	0.6	1.6
Food, beverage, and tobacco manufacturing	2.5	4.7	3.0	0.8	1.4	1.4	0.2	-16.2	22.2	0.0	6.1
Textile industry	**5.1**	**14.0**	**12.6**	**16.6**	**21.0**	**11.8**	**2.6**	**0.6**	**7.8**	**2.0**	**0.4**
Garments and other fibre products	**4.4**	**14.8**	**9.6**	**9.9**	**9.2**	**8.7**	**2.4**	**6.6**	**-7.5**	**0.3**	**-1.6**
Leather, furs, down and related products	3.2	9.5	10.4	10.2	10.5	7.1	2.8	5.7	4.0	4.2	-0.4
Timber processing, bamboo, cane, palm fibre etc.	0.7	13.3	13.9	17.4	23.6	13.3	1.6	-1.6	3.1	-0.6	0.3
Furniture manufacturing	1.0	13.5	8.9	17.4	17.3	13.6	2.3	6.4	-7.6	-0.3	-1.7
Papermaking and paper products	2.2	12.4	9.3	13.8	9.2	9.4	2.4	5.0	-3.0	-1.6	-2.2
Printing and record medium reproduction	1.0	12.9	7.6	11.9	9.3	10.0	1.7	5.7	-8.3	-3.6	-3.1
Cultural, educational and sports goods	1.6	10.5	8.7	9.8	8.5	7.6	2.3	4.3	-5.1	0.7	-0.9
Petroleum processing and coking	0.5	7.2	11.0	6.6	8.6	7.2	0.7	-1.9	6.9	1.8	1.8
Raw chemical materials and chemical products	**4.9**	**10.7**	**10.9**	**13.3**	**16.5**	**9.4**	**2.2**	**2.6**	**3.5**	**1.7**	**-0.3**
Medical and pharmaceutical products	1.8	9.8	9.9	10.2	14.3	8.4	1.6	-1.6	-3.6	-5.2	-1.1
Chemical fibre	0.8	11.0	11.8	10.1	12.8	8.1	2.5	9.4	-1.1	2.5	-2.0
Rubber products	1.3	12.2	7.8	12.4	14.3	8.7	2.3	1.5	0.3	-0.8	-0.7
Plastic products	3.7	12.7	7.0	14.1	12.3	8.5	2.5	7.7	-1.6	1.5	-1.8
Non-metal mineral products	3.1	10.9	6.8	14.7	14.2	10.2	1.7	8.0	-10.7	-3.9	-3.9
Smelting and pressing of ferrous metals	2.4	14.7	11.9	31.0	46.0	15.0	1.7	1.1	3.3	1.0	0.0
Smelting and pressing of nonferrous metals	1.3	16.1	6.8	24.4	38.3	10.4	2.1	0.4	7.5	2.8	0.6
Metal products	3.8	15.8	7.8	13.7	15.4	10.2	2.2	9.2	-5.2	1.5	-1.9
Ordinary machinery	2.9	9.9	8.2	12.9	13.6	8.7	1.7	3.9	-0.7	0.8	-0.7
Special purpose equipment	2.3	10.7	12.9	19.7	14.8	13.0	1.8	7.9	-6.1	-0.3	-1.9
Transport equipment	**4.4**	**7.9**	**6.1**	**5.6**	**5.7**	**4.9**	**1.5**	**9.7**	**-7.1**	**0.4**	**-2.0**
Electronic and electric products	**11.9**	**3.7**	**2.5**	**1.5**	**1.2**	**1.5**	**0.8**	**2.9**	**2.4**	**1.5**	**-0.3**
Instruments, meters, cultural and office machinery	3.1	5.6	7.9	11.4	8.4	6.2	2.7	1.4	3.1	0.8	-0.2
Production of electric power, steam and hot water	1.0	6.2	11.4	1.4	0.1	4.5	0.8	-3.7	12.5	4.2	2.8
Production of gas	0.9	9.3	10.2	20.8	51.1	14.2	2.3	7.7	-8.5	-1.6	-3.2
Production of tap water	0.5	9.0	10.9	160.2	N.A.	26.3	2.9	-4.3	-8.2	-13.0	-3.3

Note: (1) * *FDI*: percentage of total FDI in corresponding sectors; (2) *BL*: backward linkages; *FL*: forward linkages; *HZDS*: horizontal demonstration; *EXCO*: export concentration of FIEs; *SPL*: the percentage of TFP spillovers in total TFP; *NTFP*: the contribution of FDI productivity spillovers to total productivity; *TFP*: industry-level productivity; *Export*: export of SOEs. (3) (σ_K, σ_L) = (2.0, 0.5); (4) Some data are not available and marked "N.A." because the initial values are zero. So it is not possible to calculate the percentage changes.

Table 10. Impact (%) of FDI shocks on private enterprises (with spillovers).

	FDI	***BL***	***FL***	***HZDS***	***EXCO***	***NTFP***	***TFP***	***Export***	***Import***	***Output***	***P***
Coal, petroleum and gas	0.6	7.8	7.6	6.8	9.6	6.0	1.5	-3.5	8.8	2.1	1.9
Ferrous metals mining and dressing	0.0	7.2	18.0	-2.6	N.A.	13.7	2.9	-1.9	9.1	3.5	1.8
Nonferrous metals mining and dressing	0.0	8.8	19.7	-2.0	-2.9	14.1	3.2	-5.5	15.4	4.3	3.3
Mining of non-metal, other minerals, and other ores	0.0	9.6	13.9	-1.9	-2.5	10.1	1.5	-2.9	7.7	1.6	1.5
Food, beverage, and tobacco manufacturing	2.5	4.7	3.0	0.8	1.4	1.2	0.6	-14.6	22.2	1.4	6.0
Textile industry	**5.1**	**14.0**	**12.6**	**16.6**	**21.0**	**9.3**	**5.0**	**0.2**	**7.8**	**1.7**	**0.4**
Garments and other fibre products	**4.4**	**14.8**	**9.6**	**9.9**	**9.2**	**5.1**	**2.9**	**6.3**	**-7.5**	**0.1**	**-1.6**
Leather, furs, down and related products	3.2	9.5	10.4	10.2	10.5	5.6	4.9	-6.1	4.0	-5.5	0.2
Timber processing, bamboo, cane, palm fibre etc.	0.7	13.3	13.9	17.4	23.6	11.7	3.6	-0.1	3.1	0.6	0.2
Furniture manufacturing	1.0	13.5	8.9	17.4	17.3	10.9	3.9	6.1	-7.6	-0.6	-1.7
Papermaking and paper products	2.2	12.4	9.3	13.8	9.2	6.6	4.9	6.8	-3.0	-0.3	-2.3
Printing and record medium reproduction	1.0	12.9	7.6	11.9	9.3	7.8	2.7	11.6	-8.3	0.5	-3.5
Cultural, educational and sports goods	1.6	10.5	8.7	9.8	8.5	5.6	2.9	5.3	-5.1	1.5	-1.0
Petroleum processing and coking	0.5	7.2	11.0	6.6	8.6	6.5	1.8	-2.2	6.9	1.6	1.8
Raw chemical materials and chemical products	**4.9**	**10.7**	**10.9**	**13.3**	**16.5**	**7.1**	**4.5**	**2.3**	**3.5**	**1.5**	**-0.2**
Medical and pharmaceutical products	1.8	9.8	9.9	10.2	14.3	6.6	3.0	5.7	-3.6	0.2	-1.6
Chemical fibre	0.8	11.0	11.8	10.1	12.8	5.5	5.0	5.1	-1.1	-0.6	-1.7
Rubber products	1.3	12.2	7.8	12.4	14.3	5.9	4.2	0.4	0.3	-1.7	-0.6
Plastic products	3.7	12.7	7.0	14.1	12.3	5.7	4.5	6.9	-1.6	0.9	-1.7
Non-metal mineral products	3.1	10.9	6.8	14.7	14.2	7.9	3.5	13.2	-10.7	-0.2	-4.3
Smelting and pressing of ferrous metals	2.4	14.7	11.9	31.0	46.0	12.9	4.0	2.6	3.3	2.1	-0.1
Smelting and pressing of nonferrous metals	1.3	16.1	6.8	24.4	38.3	7.0	4.3	-1.5	7.5	1.4	0.7
Metal products	3.8	15.8	7.8	13.7	15.4	6.6	4.0	7.2	-5.2	0.0	-1.8
Ordinary machinery	2.9	9.9	8.2	12.9	13.6	7.1	3.2	5.0	-0.7	1.6	-0.8
Special purpose equipment	2.3	10.7	12.9	19.7	14.8	13.4	3.9	9.5	-6.1	0.8	-2.0
Transport equipment	**4.4**	**7.9**	**6.1**	**5.6**	**5.7**	**3.1**	**2.3**	**7.5**	**-7.1**	**-1.0**	**-1.9**
Electronic and electric products	**11.9**	**3.7**	**2.5**	**1.5**	**1.2**	**0.7**	**1.0**	**2.2**	**2.4**	**1.0**	**-0.3**
Instruments, meters, cultural and office machinery	3.1	5.6	7.9	11.4	8.4	7.2	5.0	3.3	3.1	2.5	-0.2
Production of electric power, steam and hot water	1.0	6.2	11.4	1.4	0.1	3.4	1.5	-5.0	12.5	3.0	2.9
Production of gas	0.9	9.3	10.2	20.8	51.1	12.0	5.8	0.9	-8.5	-6.8	-2.8
Production of tap water	0.5	9.0	10.9	160.2	N.A.	40.7	8.1	21.3	-8.2	4.8	-5.1

Note: same as Table 9.

Table 11. Effects of an FDI shock under monopolistic competition.

	% change		***Perfect Competition***	***N=50***	***N=10***	***N=5***
With spillovers	*Total output*		6.8	6.9	7.2	7.5
	GDP		7.1	7.2	7.8	8.3
	welfare		3.6	3.8	4.4	5.0
	SOEs	*Output*	1.9	1.9	1.8	1.8
		Variety	n.a.	0.8	0.3	-0.1
		Scale	n.a.	0.2	0.5	0.75
	Private	*Output*	1.2	1.2	1.3	1.4
		Variety	n.a.	0.6	-0.2	-0.4
		Scale	n.a.	0.4	1.0	1.2
	FIEs	*Output*	14.9	15.0	15.3	15.6
		Variety	n.a.	15.1	13.3	12.5
		Scale	n.a.	0.7	2.0	2.7
Without spillovers	*Total output*		5.6	5.7	6.0	6.2
	GDP		5.6	5.7	6.2	6.6
	welfare		2.5	2.6	3.1	3.6
	SOEs	*Output*	1.3	1.3	1.3	1.3
		Variety	n.a.	0.2	-0.2	-0.4
		Scale	n.a.	0.1	0.4	0.6
	Private	*Output*	0.0	0.0	0.1	0.1
		Variety	n.a.	-0.9	-1.5	-1.7
		Scale	n.a.	0.4	0.9	1.1
	FIEs	*Output*	15.5	15.6	15.9	16.3
		Variety	n.a.	15.8	14.0	13.2
		Scale	n.a.	0.7	2.0	2.6
Spillover premium	*Total output*		1.1	1.2	1.2	1.3
	GDP		1.5	1.5	1.6	1.7
	welfare		1.2	1.2	1.3	1.4
	SOEs	*Output*	0.5	0.5	0.5	0.5
		Variety	n.a.	0.6	0.4	0.4
		Scale	n.a.	0.0	0.1	0.2
	Private	*Output*	1.2	1.2	1.2	1.3
		Variety	n.a.	1.5	1.3	1.3
		Scale	n.a.	0.0	0.1	0.2
	FIEs	*Output*	-0.6	-0.6	-0.6	-0.6
		Variety	n.a.	-0.7	-0.7	-0.7
		Scale	n.a.	0.0	0.0	0.1

Note: (a) Elasticity of transformation of capital and labour (τ_K, τ_L) = (2.0, 0.5). (b) "n.a." means that the variables are not applicable for perfect competition.

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