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The Productivity Spillover of Foreign Direct Investment: A Computable General Equilibrium Model of China

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Abstract

We have constructed a computable general equilibrium (CGE) model to capture the endogenous productivity spillover from foreign-invested firms to domestic firms in China. This paper summarizes the main results we have found so far. There are four contributions we have made to the literature. Firstly, we have disaggregated 31 industries into 31*3=93 sectors by ownerships. Secondly we have estimated and compared the importance of four spillover channels with a micro dataset. Thirdly, we have successfully introduced the endogenous TFP growth caused by the FDI inflow into a Chinese CGE model. The last contribution is to introduce the monopolistic competition into the model and makes the number of firms change endogenously. But there are still some jobs that need to be done to make this model more appealing, i.e. the FDI policy assessment, and inclusion of labour mobility as a spillover channel into our CGE model.

Keywords: productivity spillover, foreign direct investment (FDI), FDI policies in China, computable general equilibrium (CGE) modelling

JEL Classifications: O33, F21, E60, C68

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1. Research Question

FDI plays a significant role in the global economic system for both the firms and the countries involved in FDI activities. Productivity spillover effects are arguably some of the most important aspects of FDI. The productivity spillovers are economic externalities which the presence of FDI brings to the host country's domestic firms. These spillovers take place through four channels, namely, labour mobility (Fosfuri, Motta, and Ronde 2001; Glass and Saggi 2002; Görg and Strobl 2005), industry linkages (Girma and Gong 2007; Javorcik 2004; Markusen and Venables 1999; Pack and Saggi 2001), exports (Aitken, Hanson, and Harrison 1997; Clerides, Lach, and Tybout 1998; Greenaway, Sousa, and Wakelin 2004), and demonstration effects (Findlay 1978; Koizumi and Kopecky 1977; Wang and Blomström 1992).

In exploring the actual spillover effects of FDI, there has been a rich emerging literature, both theoretical and empirical, on the FDI productivity spillover channels and effects since the 1990s. But the conventional econometric analyses tend to underestimate or ignore one of the most important features of spillover effects, i.e. the spillover is a nation-wide and cross-industry phenomenon rather than a region- and sector-specific one.

In addition, there have also been doubts as to whether spillovers have positive effects on host countries, which are supported by some recent empirical studies (Aitken and Harrison 1999). In host countries FDI might bring strong competitive effects and poses a serious threat to the survival of domestic firms whose capability to absorb the positive externalities brought by FDI is low.

By doing firm-level productivity spillover estimations, integrating Chinese input-output table with industry-level data by ownerships, and constructing a new computable general equilibrium (CGE) model of China, we tried to answer the following research question: has the presence of multinational firms improved the productivity of domestic manufacturing firms via productivity spillovers?

2. Methodology and Data

2.1 Basic CGE modelling framework and data

The research on the productivity spillover effects of FDI is conducted in a CGE framework which involves estimating key FDI productivity spillover coefficients with econometric analysis first and then implementing computer-based simulations of various scenarios to evaluate the overall impact of productivity spillover.

This CGE model only contains China and the rest of the world as a single region. There are 31 industrial sectors and 8 non-industrial sectors (e.g. agricultural, services).

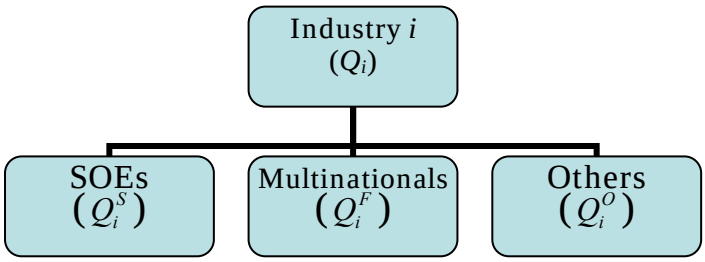
The CGE model aims to providing a more complete and accurate measure of the productivity spillover effects of FDI on domestic firms in a structural way by scrutinizing all the four spillover channels, with a focus on the manufacturing sectors. The research is done in the China context given the success of China in attracting FDI with favourable "swap market access for technology" policies, and the fact that the inflow of FDI to China has fundamentally affected the development path of domestic firms.

The latest 122-sector China input-output table for 2002 is employed. Data from other sources (primarily various Chinese statistical yearbooks), e.g. total output, value added, and export of industry-level production by foreign invested enterprises and domestic firms are also used.

2.2 Input-output table disaggragation

A benchmark CGE model is constructed at the first step to accommodate the input-output matrix among industries and the basic activity of multinational affiliates. Since the productivity spillover effect of FDI in manufacturing is the primary research target, each sector of manufacturing in the input-output table has been disaggregated into three sectors by ownership, namely state-owned, multinationals, and other (private domestic) sectors, as shown in Figure 1(Gillespie et al. 2001, 2002). The sectors in agriculture and services are not disaggregated by ownership.

Figure 1: Disaggregate Output and Value Added by Ownerships



2.3 Parameter estimations

The parameters of the four spillover channels are estimated with a firm-level database collected from a survey of 1000 manufacturing firms by the World Bank in 2000.

The following model specifications are employed:

$$\ln VA_{d,j} = \beta_0 + \beta_1 \ln K_{d,j} + \beta_2 \ln L_{d,j} + u_{d,j} + \varepsilon 1_{d,j} \tag{1}$$

With the estimates of $ln(TFP_{d,j})$, we can further test whether TFP can be attributed to the FDI spillover and other control variables.

$$\begin{aligned}\ln(TFP_{d,j}) = \beta_3 + \underbrace{\beta_4 BL_j + \beta_5 FL_j}_{\text{linkages(backward \& forward)}} + \underbrace{\beta_6 LT_{d,j}}_{\text{employees with FIE experience}} + \underbrace{\beta_7 EXCO_j}_{\text{FIE export concentration}} + \\ \underbrace{\beta_8 HZDS_j}_{\text{Demonstration(Horizontal)}} + \beta_9 R\&D_{d,j} + \beta_{10} Training_{d,j} \\ + \beta_{11} LT_{d,j} \times SOE_{d,j} + \beta_{12} R\&D_{d,j} \times SOE_{d,j} \\ + \beta_{13} Training_{d,j} \times SOE_{d,j} + \beta_{14} SOE_{d,j} + \varepsilon 4_{d,j}\end{aligned}$$

2.4 FDI productivity spillovers

Then the benchmark CGE model is expanded to endogenously incorporate all the four possible productivity spillover channels:

If $VA = TFP * G(K, L)$, then

$$\Delta VA = (TFP1 - TFP0) * G(K,L) = \left(\frac{TFP1}{TFP0} - 1\right)\left(TFP0 * G(K,L)\right) = \left(\frac{TFP1}{TFP0} - 1\right)VA0$$

Thus the endogenous TFP change, i.e. the corresponding variable used in CGE modelling should be denoted by:

$$NTFP = \frac{TFP1}{TFP0} - 1 = \frac{Exp[\beta_3 + \beta_4 BL + \beta_5 FL + \beta_6 LT + \beta_7 EXCO + \beta_8 HZDS]}{Exp[\beta_3 + \beta_4 BL0 + \beta_5 FL0 + \beta_6 LT0 + \beta_7 EXCO0 + \beta_8 HZDS0]} - 1$$
$$= Exp[\beta_4 (BL - BL0) + \beta_5 (FL - FL0) + \beta_6 (LT - LT0) + \beta_7 (EXCO - EXCO0)$$
$$+ \beta_8 (HZDS - HZDS0)] - 1$$

2.5 Monopolistic competition

Then the model is further upgraded to accommodate the imperfect competition underlying the strategic interplay of foreign invested enterprises and domestic firms.

The model design follows several robust models in the literature (Blake, Rayner, and Reed 1999; Francois and Roland-Holst 1997; Harrison, Rutherford, and Tarr 1994, 1995, 1997). The model employed here consists of three elements which differentiate itself from a classic model of general equilibrium: (1) increasing returns to scale (with fixed cost); (2) free entry and exit; (3) firm heterogeneity: firm produces differentiated goods (Dixit and Stiglitz 1977)**.**

For a firm with a certain market power,

$$TR = P(Q) * Q$$

$$MR = P + \frac{\partial P}{\partial Q} Q = P(1 - \frac{1}{|\varepsilon|})$$

$$MR = MC \Rightarrow \frac{1}{|\varepsilon|} = \frac{P - MC}{P} = markup(\%)$$

With this key information of markup rate (%)**,** it is then viable to code monopolistic competition in CGE modelling[1]. The next step is to identify the inverse of elasticity of demand.

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[1] $\frac{P - MC}{P} = \frac{(P - MC) \times Q}{P \times Q} = \frac{TC - VC}{TC} = \frac{FC}{TC}$ The markup rate is also equal to the proportion of fixed cost in total cost. This implies that in a monopolistic competitive market, each firm has to collect a markup to pay for the fixed cost. Collectively, the summed fixed cost can be understood as an "unrealized scale economy". Thus, this markup ratio is also referred as "cost disadvantage ratio". (Pratten 1988) As the number in a certain market decreases, the production of surviving firms can gain rationalization benefit by expanding production scale and push their average cost curve downwards.

In the FDI spillover model, the representative agent has a nested consumption structure, each of which can be represented by a CES function.

Level 1 (aggregation across sectors):

$$AG = \left[\sum_{i=1}^{101} \alpha_i AR_i^{\frac{\rho_1 - 1}{\rho_1}} \right]^{\frac{\rho_1}{\rho_1 - 1}}$$

Level 2 (Armington aggregate):

$$AR_i = \left[\sum_{j=1}^{2} \beta_{i,j} DI_{i,j}^{\frac{\rho_2 - 1}{\rho_2}} \right]^{\frac{\rho_2}{\rho_2 - 1}}$$

Level 3 (aggregation across ownerships

$$DI_{i,j} = \left[\sum_{k=1}^{3} \gamma_{i,j,k} MSO_{i,j,k}^{\frac{\rho_3 - 1}{\rho_3}} \right]^{\frac{\rho_3}{\rho_3 - 1}}$$

Level 4 (aggregation at firm level):

$$MSO_{i,j,k} = \left[\sum_{f=1}^{N_x} \varphi_{i,j,k,f} Q_{i,j,k,f}^{\frac{\rho_4 - 1}{\rho_4}} \right]^{\frac{\rho_4}{\rho_4 - 1}}$$

where $\sum_{i=1}^{101} \alpha_i = \sum_{j=1}^{2} \beta_{i,j} = \sum_{k=1}^{3} \gamma_{i,j,k} = \sum_{f=1}^{N_x} \varphi_{i,j,k,f} = 1$

we get the final expression of the firm level inverse elasticity of demand, which is also the firm-level markup rate, as discussed in equation (2):

$$mk(\%) = \left| \frac{1}{\varepsilon_{Q(i,j,k,f)}} \right| = \frac{1}{\rho_4} + \frac{1}{N_{i,j,k,f}} \left(\frac{1}{\rho_3} - \frac{1}{\rho_4} \right) + \frac{\gamma_{i,j,k}}{N_{i,j,k,f}} \left(\frac{1}{\rho_2} - \frac{1}{\rho_3} \right) + \frac{\beta_{i,j} \gamma_{i,j,k}}{N_{i,j,k,f}} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) + \frac{\alpha_i \beta_{i,j} \gamma_{i,j,k}}{N_{i,j,k,f}} \left(\frac{1}{\rho_1} - 1 \right)$$

Here a simplified assumption has been made for each ownership in every sector: the firm sizes are the same (*they produce heterogeneous products though*) in each sector and the market share of each firm in the corresponding sector is simply $\varphi_{i,j,k,f} = \frac{1}{N_{i,j,k,f}}$.

In the above equation, only the elasticities of substitution (ρ) are exogenous.

3. Basic Findings

3.1 Econometric part.

The TFP level of foreign-invested firms (FIE) is the highest in this sample. The TFP level of SOE is higher than that of domestic private firms, as shown in Table 1.

Table 1: A comparison of average TFP

	Pooled estimation			*Separate estimation*		
	L	*HC*	*HW*	*L*	*HC*	*HW*
FIE	**2.91**	**2.41**	**1.85**	**3.63**	**2.73**	**2.92**
SOE	2.59	1.96	1.56	3.17	2.72	2.11
Private	2.47	1.80	1.42	2.51	1.80	1.29

Note: *L* for pure labour input; *HC* for human capital with schooling years entered as weights; *HW* for human capital with economy-wide average wage entered as weights.

The productivity spillover effects via four channels estimated with the micro-level database are counterintuitive to some extent (Table 2). Spillover via labour turnover is generally negative, but the state-owned enterprises have gained positive benefits from recruiting those people with work experience in multinational firms. This is consistent with the fact that SOEs have stronger absorptive capability to benefit from the labour turnover.

The backward linkage is not a significant channel for productivity spillover, while the forward linkage, horizontal demonstration and multinational firms' export concentration degree tend to negatively affect the productivity level of domestic firms due to the competition effect. Finally the firm-level R&D expenditure negatively affects the productivity performance. This phenomenon coupled with the negative labour turnover impact is striking, reflecting the fact that the low efficiency of domestic Chinese firms in absorbing the advanced technology.

Table 2: Four Channels of FDI Productivity Spillover (pooled data) with "*Direct*" Measures of Backward and Forward Linkages

	L		*HumCap_S*		*HumCap_W*		*L*		*HumCap_S*		*HumCap_W*	
Constant	3.63 (0.47)***	3.58 (0.44)***	4.54 (0.47)***	4.51 (0.44)***	4.94 (0.47)***	4.89 (0.44)***	3.72 (0.49)***	3.67 (0.46)***	4.67 (0.48)***	4.63 (0.46)***	5.09 (0.48)***	5.01 (0.45)***
BL_Dirc$_j$*DM_Conpro	-0.04 (0.65)	-0.04 (0.65)	0.05 (0.66)	0.05 (0.66)	0.08 (0.66)	0.07 (0.66)	0.09 (0.67)	0.09 (0.67)	0.19 (0.67)	0.19 (0.67)	0.23 (0.67)	0.22 (0.67)
FL_Dirc$_j$	**-3.07 (1.00)**	**-3.41 (1.25)*****	**-5.81 (1.01)**	**-5.34 (1.26)*****	**-6.16 (1.01)*****	**-5.17 (1.26)*****	**-3.06 (1.02)*****	**-3.33 (1.27)*****	**-5.50 (1.02)*****	**-4.93 (1.27)*****	**-5.79 (1.02)*****	**-4.69 (1.27)*****
HZDS$_j$	0.62 (1.18)		-1.62 (1.19)		-3.35 (1.19)***		0.38 (1.21)		2.05 (1.21)*		-3.82 (1.20)***	
EXCO$_j$		0.63 (0.91)		-1.29 (0.92)		-2.68 (0.92)****		0.44 (0.94)		-1.61 (0.93)*		-3.03 (0.93)***
LT$_{d,j}$	**-22.90 (8.64)*****	**-22.93 (8.64)*****	**-24.41 (8.61)*****	**-24.39 (8.61)*****	**-26.10 (8.62)*****	**-26.05 (8.62)*****	**-26.38 (8.83)*****	**-26.40 (8.83)*****	**-27.21 (8.75)*****	**-27.18 (8.75)*****	**-28.69 (8.75)*****	**-28.64 (8.75)*****
Training $_{d,j}$							0.06 (0.10)	0.06 (0.10)	-0.01 (0.10)	-0.01 (0.10)	-0.03 (0.10)	-0.02 (0.10)
R&D$_{d,j}$							**-0.00 (0.00)****	**-0.00 (0.00)****	**-0.00 (0.00)****	**-0.00 (0.00)*****	**-0.00 (0.00)*****	**-0.00 (0.00)*****
LT$_{d,j}$ *SOE$_{d,j}$							**89.24 (42.94)****	**89.02 (42.94)****	**79.83 (42.58)***	**79.94 (42.57)***	**75.50 (42.56)***	**75.73 (42.54)***
Training $_{d,j}$*SOE$_{d,j}$							0.00 (0.12)	0.00 (0.12)	0.06 (0.12)	0.06 (0.12)	0.08 (0.12)	0.08 (0.12)
R&D$_{d,j}$*SOE$_{d,j}$							0.01 (0.01)**	0.01 (0.01)**	0.01 (0.01)*	0.01 (0.01)*	0.01 (0.01)	0.01 (0.01)
SOE$_{d,j}$							-0.07 (0.24)	-0.07 (0.24)	-0.08 (0.24)	-0.08 (0.24)	-0.10 (0.24)	-0.10 (0.24)
Observations	780	780	753	753	756	756	743	743	729	729	732	732
R squared	**0.03**	**0.03**	**0.13**	**0.13**	**0.18**	**0.18**	**0.05**	**0.05**	**0.15**	**0.15**	**0.20**	**0.20**

Notes: 1. Dependent variable is logarithm of total factor productivity, **log($A_{d,j}$)=log($TFP_{d,j}$)**. It is equal to constant term plus the regression residual in a TFP estimation; 2. *LT* is measured by the number of **technicians** with foreign work experience; 3. "*HumCap_S*" means the TFP data are estimated with data of capital and human capital (calculated with schooling years); "*HumCap_W*" means the TFP data are estimated with data of capital and human capital (calculated with economy-wide wages); "*L*" means the TFP data are estimated with data of capital and labour input; 4. Standard errors in parentheses. *Statistically significant at 10%; **significant at 5%; ***significant at 1%.

3.2 CGE simulation of FDI productivity spillover and evaluations of FDI policies. Basically the introduction of FDI can generate positive effect in terms of economic growth, total exports and the upgrading of industry structure. However, the performance of domestic firms in certain industries e.g. electronics, has been negatively affected by the presence of FDI due to the competition effect. In those industries the market share of domestic firms are shrinking although their total output volume are increasing.

Table 3: Changes of national aggregate output and GDP (*Δ*%)

		(0)	(1)	(2)	(3)
		Benchmark	FDI shock (in perfect competition)	FDI shock + TFP spillover (in perfect competition)	FDI shock (in monopolistic competition)
National	**Gross output**	**0**	**1.303**	**↑ 1.306**	**1.222**
	GDP	**0**	**1.217**	**↑ 1.218**	**1.149**
FIEs	Gross output	0	2.427	↓ 2.422	2.498
	Value added	0	2.521	↓ 2.514	2.722
SOEs	Gross output	0	1.408	↑ 1.414	1.065
	Value added	0	1.197	↓ 1.192	0.938
Private	Gross output	0	1.610	↑ 1.617	1.558
	Value added	0	1.610	↓ 1.605	1.678

As displayed in the Table 3, when TFP spillover is embodied in FDI shock (column (2)), the economy will grow even more rapidly than otherwise (column (1)). The gross output and value added of domestic firms (both SOEs and private firms) will basically increase. But the foreign firms will slightly be negatively affected due to the resource constraint – with higher productivity, the domestic firms have absorbed more labour and capital from foreign firms.

When there is imperfect competition (column (3)), the results show that the average firm number increases by **2%** (evenly distributed among FIEs, SOEs, and Private firms), while the average markup rate decreases by **0.01%** (evenly distributed among FIEs, SOEs, and Private firms as well). The increase percentages of gross output and value added now become less than those in the scenario of perfect competition. This implies that the existence of monopolistic power and markup makes the economy benefit less from the FDI shock due to the waste of resources in the fixed cost, which can be understood as a necessary cost of the love of variety.

According to our CGE projections, this trend will continue due to the *de facto*

province-level tax competition for FDI regardless of the unification of domestic and foreign corporate taxes at the nation level from 1st January 2008.

4. Concluding Remarks

This paper summarizes the main results we have found so far. There are four contributions we have made to the literature. Firstly, we have disaggregated 31 industries into 31*3=93 sectors by ownerships. Secondly we have estimated and compared the importance of four spillover channels with a micro dataset. The results obtained from this dataset are rather striking, reflecting the fact that the Chinese domestic firms, especially private firms are still not prepared to absorb the productivity spillover from the foreign presence. Thirdly, we have successfully introduced the endogenous TFP growth caused by the FDI inflow into a Chinese CGE model. The last contribution is to introduce the monopolistic competition into the model and makes the number of firms change endogenously. This would make the model more realistic to reflect the interaction between FIEs and domestic firms. But there are still some jobs that need to be done to make this model more appealing. The first one is to do a comprehensive assessment on FDI policies including taxes and tax equivalence, which can be readily modelled in this CGE in the near future. The second direction for research is to capture the labour turnover as a spillover channel variable, which needs more theoretical work.

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