Intra-industry Technology Spillovers of FDI and Its Determinants: Evidence from China

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Introduction

- The technological impact of FDI has been examined widely both theoretically and empirically.
- However, the results are quite mixed, e.g. some find positive spillovers, while others find negative.
- This paper tries to test the technology spillovers effect from FDI inflow in China and its determinants by using an industry level data and an approach that is different from the conventional one

Introduction (cont.)

- In regard to China, most of studies found positive technology spillovers effect by FDI, e.g. Li et. al. (2001), Liu (2002), Buckley, Clegg, & Wang (2002), Chuang & Hsu (2004) .

Conventional Approach

- The traditional method is to regress the proxy of technology (the labour productivity or the total factor productivity) against the proxy for FDI (usually called foreign presence)
- Results sensitive to choice of foreign presence

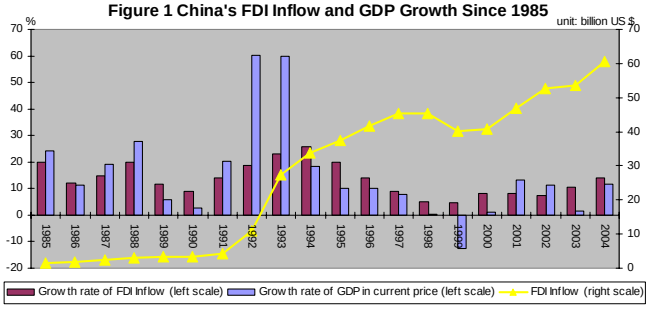
Conventional Approach (cont.)

- At the aspect of data set, either the cross-sectional or panel data sets is used in empirical studies, and these data sets are either on a firm level or on an industry level
- Panel data set is preferable to cross-sectional data set
- Spillovers at a lower aggregating level may be internalized at a higher aggregating level (Caballero and Lyons, 1989)

Overview of FDI in China (1)

- Since the opening and reform in 1979, China has become a major recipient of FDI inflow.

Figure 1 China's FDI Inflow and GDP Growth Since 1985

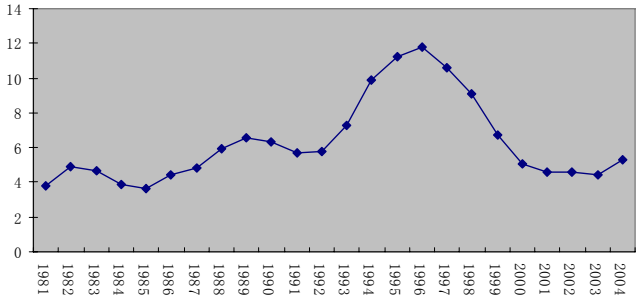


Source: *China Statistical Yearbook* , 2005

Overview of FDI in China (2)

- FDI is also an important part in the formation of fixed capital asset.

Figure 2 Proportion of Foreign Capital in Fixed Capital Asset Formation (%)

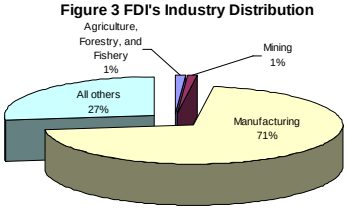


Source: *China Statistical Yearbook*, 2005

Overview of FDI in China (3)

- FDI mainly focuses on the manufacturing sector

Figure 3 FDI's Industry Distribution



Source: MOFCOM, 2005

- One of the reasons may be attributed to the government's policy emphasis
- This also brings the potential problem for empirical FDI studies in China, namely the endogeneity problem

Overview of FDI in China (4)

- Problem of round-tripping FDI
- According to World Bank's estimation (2002, from Xiao, 2004), the round-tripping FDI inflow could be as high as one quarter of total FDI inflow.
- And the estimate of Xiao (2004) is even much higher, 40% of total FDI inflow.
- This may exaggerate the technological impact of FDI

Analytical Framework (1)

- Aggregate industry production function:

$$Y = A\left[\left(sK^{\rho} + (1-s)D^{\rho}\right)^{1/\rho}\right]^{\alpha} L^{\beta}$$

- *Y* -- output; *K* -- stock of domestic physical capital; *D* -- stock of FDI; *A* -- technology; and *L* -- labor supply
- A hybrid Cobb-Douglas and CES production function

Analytical Framework (2)

- Technology accumulation function:

$$\dot{A} = \left(\frac{D}{K^w} A^w \right)^B A$$

- $\dot{A}$ denotes the technology increment in the industry; K^w is the world physical capital stock; A^w is the world technology stock.
- *B* can be used to measure the existence of technology spillover effect

Analytical Framework (3)

- A Sufficient Condition for Technology Spillovers Measurement
- Spillovers exist if and only if

$$\frac{\dot{A}}{A} - \frac{\dot{A}^f}{A^f}\Big|_{\bar{\kappa}} > 0$$

$$\Leftrightarrow \frac{\dot{A}}{A} - \ln A_t^f + \ln A_{t-1}^f > 0$$

$$\Leftrightarrow (B-1) > -\frac{\ln A_{t-1}^f}{\ln A_t^f}$$

Traditionally, spillovers exist if:

$$\frac{\partial A}{\partial FDI}\Big|_{\bar{\kappa}} > 0$$

- B>1 is the sufficient condition for the existence of technology spillovers
- The above two equations make the technology spillovers model

Analytical Framework (4)

- By further decomposing the coefficient B, the spillover determinants can be tested
- B is assumed to be determined by the interaction between domestic firms and FDI invested firms

$$B = f(x_1, x_2)$$

s.t $f_1^{'} < 0 \quad f_{11}^{''} \geq 0 \quad f_2^{'} > 0 \quad f_{22}^{''} \leq 0 \quad f_{12}^{''} \leq 0$

$$B = \log\left(x_2 / x_1\right)$$

x_1 is the research effort of FDI invested firm, x_2 is the research effort of domestic firm

Analytical Framework (5)

Domestic firm's optimal behaviour in setting its research efforts

- The industry's inverse demand function:

$$p = a - bQ$$

- Domestic firm's cost function:

$$C_2(q_2, x_1, x_2) = (c - x_2 - \omega x_1)q_2$$

- Domestic firm's profit function:

$$\pi_2 = (a - bQ - c + x_2 + \omega x_1)q_2 - \gamma \frac{x_2^2}{2}$$

Analytical Framework (6)

Domestic firm's optimal behaviour in setting its research efforts

- Domestic firm chooses its output and research effort to maximize its profit, given the output and research effort of FDI invested firm

$$q_2 = \frac{1}{2b}\left(a - bq_1 - c + x_2 + \omega x_1\right)$$

$$x_2 = \frac{1}{\gamma} q_2$$

Analytical Framework (7)

- Domestic firm's optimal behavior in deciding its R&D activity is to set the R&D effort proportional to its output
- Similarly, assume the parent firm of FDI invested firm also adopt same strategy, then:

$$B = -\log\left(\frac{A_w}{A_2}\right) + \alpha \log\left(\frac{K_2/L_2}{K_w/L_w}\right) + (\beta - \alpha)\log\left(\frac{L_2}{L_w}\right) + c$$

Technology Gap

Relative Factor Intensity

Relative labor supply

Econometric Specification (1)

- Make Taylor expansion in the production function and technology accumulation function:

$$\log Y = \log A + \alpha s \log K + \alpha(1-s)\log D + \frac{1}{2}\alpha\rho s(1-s)\left(\log\frac{K}{D}\right)^2 + \beta \log L + \Phi(K, D)$$

$$\frac{\dot{A}}{A} = 1 + B\log\left(\frac{D}{K^w}A^w\right) + \Gamma\left(\frac{D}{K^w}A^w, A\right)$$

$$\frac{\dot{Y}}{Y} = 1 + B\log\left(\frac{D}{K^w}A^w\right) + \alpha s\frac{\dot{K}}{K} + \alpha(1-s)\frac{\dot{D}}{D} + \alpha\rho s(1-s)\frac{(\dot{K}/D)}{K/D}\log\left(\frac{K}{D}\right) + \beta\frac{\dot{L}}{L} + \frac{\dot{\Phi}}{\Phi} + \Gamma$$

Econometric Specification (2)

- Econometric specification of technology spillover model:

$$y_{it} = \beta_0 + B\log\phi_{it} + \beta_1 k_{it} + \beta_2 d_{it} + \beta_3 \tau_{it} + \beta_4 l_{it} + v_{it}$$
$$v_{it} = \alpha_i + \lambda t + u_{it}$$

- Econometric specification of spillover determinant model:

$$y_{it} = \beta_0 + \delta_0 \log\phi_{it} + \delta_1 \log\phi_{it} \times \log rA_{it} + \delta_2 \log\phi_{it} \times \log rK_{it} + \delta_3 \log\phi_{it} \times \log rL_{it} + \beta_1 k_{it} + \beta_2 d_{it} + \beta_3 \tau_{it} + \beta_4 l_{it} + v_{it}$$
$$v_{it} = \alpha_i + \lambda t + u_{it}$$

The Data (1)

- The data set is a two-year balanced panel, which comes from *China Statistical Yearbook of Industrial Economy*, 2002, 2003, and 2004, and UNIDO INTSTAT3 database, 2004. It covers 22 industries.
- The original data is provided in nominal price, which is first converted to constant 1990 prices by using the implicit deflator that is reported directly in *China Statistical Yearbook of Industry Economy*, and the producer price index that comes from *International Financial Statistics*, 2004
- The world technology, which is proxied by industry value-added, the world capital stock, and the world labor supply are summation over eight countries and regions, namely China Hong Kong, the United States, Japan, South Korea, Singapore, Germany, the United Kingdom, France, and Australia

The Data (2)

- Correlation matrix: potential multicollinarity problem

Table 4 Correlation Matrix of Variables

	y	ln(fai)	k	d	tao	l	ln(fai)×ln(rv)	ln(fai)×ln(rkk)	ln(fai)×ln(rl)
y	1								
ln(fai)	0.45	1							
k	0.41	0.39	1						
d	0.45	0.45	0.59	1					
tao	-0.28	-0.27	-0.23	-0.84	1				
l	0.54	0.27	0.47	0.31	-0.03	1			
ln(fai)×ln(rv)	0.25	0.20	0.37	0.07	0.00	0.08	1		
ln(fai)×ln(rkk)	-0.21	-0.09	-0.29	-0.03	0.00	-0.01	-0.95	1	
ln(fai)×ln(rl)	-0.45	-0.56	-0.44	-0.26	0.13	-0.24	-0.89	0.80	1

Note: Shaded areas indicate potential multicollinearity.
Source: the author's calculation.

The Data (3)

- Correlation matrix: potential multicollinarity problem

Table 5 Correlation Matrix of Demeaned Variables

	y	ln(fai)	k	d	tao	l	ln(fai)×ln(rv)	ln(fai)×ln(rkk)	ln(fai)×ln(rl)
y	1								
ln(fai)	0.61	1							
k	0.39	0.14	1						
d	0.05	0.26	0.62	1					
tao	0.12	-0.21	-0.46	-0.94	1				
l	0.83	0.54	0.37	0.01	0.15	1			
ln(fai)×ln(rv)	-0.73	-0.70	-0.14	-0.13	0.02	-0.52	1		
ln(fai)×ln(rkk)	0.51	0.93	0.09	0.13	-0.11	0.49	-0.64	1	
ln(fai)×ln(rl)	0.25	-0.33	0.12	-0.15	0.24	0.29	-0.10	-0.36	1

Note: variables here are demeaned by their group mean.
Shaded areas indicate potential multicollinearity.
Source: the author's calculation.

Empirical Results (1)

- Technology Spillover Model

Table 6 Estimation of Technological Spillovers Model

	Pooled OLS	FE	RE
Ln(fai)	0.012*	0.069*	0.015*
	(0.006)	(0.03)	(0.008)
k	0.051	0.204**	0.071
	(0.17)	(0.119)	(0.106)
tao	-0.033	0.033***	-0.001
	(0.024)	(0.021)	(0.019)
l	0.328*	0.357*	0.442*
	(0.11)	(0.123)	(0.091)
constant	-0.158	-1.541*	-0.216
	(0.15)	(0.745)	(0.186)
R-square	0.43	0.31	0.39
	test statistics	p-value	
Fixed Effect Test	6.31	0.0001	
Random Effect Test	5.39	0.02	
Hausman Test	121.27	0.00	

Note: Total observations: 44.
Figures in bracket are standard error.
* indicates significance at 5% level.
** indicates marginally significant at 10% level.
*** indicates significant at 15% level.

Empirical Results (2)

- Technology Spillover Model
- Multicollinearity test, fixed effect test, random effect test, and Hausman test are conducted
- Some variables are dropped out due to multicollinearity problem
- FE estimation is selected as being most appropriate
- Two diagnostic tests are made to further examine the robustness of FE estimation

Empirical Results (3)

- From the FE estimation, the coefficient of ln(*fai*) is 0.069 and significant at 5% level. This indicates the technology brought over by FDI does have a positive impact on domestic technology accumulation
- 1% increase of technology brought by FDI will increase the domestic technology growth rate by 0.069%
- However we fail to find evidence of existence of technology spillovers effect

Empirical Results (4)

- Spillover Determinants Model

Table 7 Estimation of Spillovers Determinants Model

	Pooled OLS	FE	RE
ln(fai)×ln(rv)	-0.0007	-0.005*	-0.001*
	(0.0006)	(0.001)	(0.0008)
ln(fai)×ln(rl)	-0.001*	-0.0002	-0.001*
	(0.0005)	(0.002)	(0.0006)
k	0.028	0.17**	0.09
	(0.13)	(0.1)	(0.104)
tao	-0.034	0.02	0.004
	(0.024)	(0.017)	(0.02)
l	0.3*	0.35*	0.42*
	(0.11)	(0.09)	(0.09)
constant	-0.080	0.13	-0.170
	(0.11)	(0.61)	(0.13)
R-square	0.46	0.84	0.77
	test statistics	p-value	
Fixed Effect Test	8.27	0.00	
Random Effect Test	3.99	0.046	
Hausman Test	10.82	0.055	

Note: Total observations: 44.
Figures in bracket are standard error.
* indicates significance at 5% level.
** indicates marginally significant at 10% level.

Empirical Results (5)

- Spillover Determinants Model
- As before, different hypothesis tests are conducted to correct for multicollinearity problem, determine which estimation is most appropriate (FE estimation is chosen), and examine the robustness of the estimation
- The larger the technology gap is, the less efficiently the industry can make use of the technology brought over by FDI
- The relative labor supply does not play a significant role in the industry's efficiency in utilizing the technology brought over by FDI

Empirical Results (6)

Endogeneity Problem

- It is possible that FDI is endogenous, which can happen if there exists a reverse causality, or FDI is correlated with some unobserved and uncontrolled factors that also have impact on the industry's output growth
- Instrumental Variable: lagged market size, proxied by the industry's total sales revenue of previous year
- Endogeneity test find no evidence of endogeneity, which is consistent with Liu (2002)

Empirical Results (7)

Discussions:

- We do not incorporate any industry specific variables, which means we are estimating the average technology spillovers and its determinants across different industries.
- The domestic technology accumulation in the industry is only affected by FDI flowing into the industry, not by FDI that flows into the other industries.