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TRADE, FOREIGN DIRECT INVESTMENT AND SPILLOVER EFFECT: AN EMPIRICAL ANALYSIS ON FDI AND IMPORT FROM G7 TO CHINA

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ABSTRACT

The recent theories of economic growth indicated a country's productivity depends not only on the domestic R&D but also on Foreign R&D capital. Especially, the developing countries can benefit from R&D that is performed in the industrial countries by trading with the industrial countries or by receiving FDI from the industrial countries. The purpose of this paper is to test the spillover effect through import and FDI from the developed countries to China. The empirical results, support the beneficial spillover effect both through import and FDI.

Key words: *Trade, Foreign Direct Investment, G7, China, Spillover Effect*
JEL Classification: F2, O5

TRADE, FOREIGN DIRECT INVESTMENT AND SPILLOVER EFFECT: AN EMPIRICAL ANALYSIS ON FDI AND IMPORT FROM G7 TO CHINA *

1. INTRODUCTION

The recent theories of economic growth indicated innovation effort is a major engine of technological progress and productivity growth. The R&D process is essentially a knowledge generation process in which one utilizes resources (scientists, engineers, technicians, research equipment, and so on) to create new knowledge. Innovation feeds on knowledge that results from cumulative R&D experience and contributes to this stock of knowledge. The innovative activities of firms not only lead to new products (whose benefits the firm can appropriate), but also contribute to a general stock of knowledge upon which subsequent innovators can be built. So the benefit of innovation accrues not only to the innovators, but spillover to other firms by raising the level of knowledge upon which new innovations can be based. This is referred to as “knowledge spillover”.

Some studies have measured the extent to which growth in total factor productivity in a country depends not only on the domestic R&D capital stocks but also on the foreign R&D capital stocks.

In a world with international trade in goods and services, foreign direct investment, and an international exchange of information and dissemination of knowledge, a country’s productivity depends on its own R&D as well as on the R&D effects of its transaction partners.[1]. As important channels for knowledge spillover, trade and inward FDI boost domestic productivity by making products available with the use of foreign knowledge and information that would otherwise be costly to acquire.

Some of the theoretical and empirical studies highlight the importance of trade as a vehicle for technological spillovers. (Coe and Helpman (1995), Coe, Helpman, Hoffmaister(1997), Branstetter(2001)). In particular by trading with industrial countries, the less developed countries can benefit from the industrial countries’ R&D efforts. Coe, Helpman and Hoffmaister (1997) based on data for 77 developing countries suggest that the total factor productivity in developing countries is positively and significantly related to R&D in their industrial country trade partners.

Hejazi and Safarian (1999) considered foreign direct investment to foreign trade as diffusion channels linking total factor productivity, and their research diffusion effect for G6 to the OECD countries showed that the coefficient estimates for FDI are higher than those for trade.

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[1] See,Coe and Helpman (1995)

There are a great number of studies on the transfer of technology from FDI to host countries. Most of the studies find that there are positive effects from FDI flow to host country firms in advanced economies. But the result of the case of FDI flow to developing economies is mixed[2]. In particular, a number of studies for developing countries document that a foreign investment presents higher in host country sectors while other studies point out to limited or no significant efficiency spillovers.[3]

As China's Economic growth has been remarkable since the reform started in 1978, the empirical literature on FDI in China is growing rapidly. Most studies conclude FDI has played a positive role in promoting trade, economic growth. Recently some studies investigate whether FDI generates technology spillover from foreign-investment firms to local ones. Liu(2002), using the industrial data for 93-98 in Shengzhen special economic Zone of China, finds that FDI has large and significant spillover effects in raising the productivity of manufacturing industries.

This paper, which examines the technology spillover effect from G7 countries[4] to China, contributes to the existing literature by providing international spillovers measures for both trade and FDI from developed countries to less developed countries.

The panel analysis is based on provincial–level data in China for the period from 1990-2002[5]. This studying support that the developing countries can benefit from R&D that is performed in the industrial countries by trading with the industrial countries or by receiving FDI from the industrial countries.

This paper proceeds as follows. Section 2 highlights the general trend and characteristics of FDI and Import from G7 countries to China. In section 3, we set out our econometric models that are based on a production function theory. The data are discussed briefly in section 4. Estimation results are presented and discussed in section 5, the estimates underline the importance of the interaction between the international trade, FDI and the foreign R&D. The Last section contains some concluding remarks.

2. AN OVERVIEW OF FOREIGN DIRECT INVESTMENT AND IMPORT FROM G7 TO CHINA

In this Section we briefly introduce the general trend and characteristics of FDI and international trade in China.

[2] For review of the relevant literature, see Blomstr m, Globerman and Ari Kokko (2000),
[3] See Keller(2004) for recent review on FDI spillovers.
[4] Almost the entire R&D activity in the world economy is concentrated in the industrial countries, especially in the seven largest countries. For example, in 1990, the industrial countries accounted for 96% of total world R&D expenditures(UNESCO,1993), and G7 countries account 92% of R&D in 1991. (see Coe, Helpman and Hoffmaister, 1997).
[5] It is since the 1990s that inward FDI to China has been consistently on a large scale (see fig1). So we choose the time period of 1990-2002 in this analysis.

Figure 1 presents realized FDI[6] flows in China. In the early 1990s FDI took off with rapid economy growth. The increase in 1992 and 1993 resulted from Deng Xiaoping's tour of Southern China when he reaffirmed the open-door policy and encouraged the faster reform. Realized FDI continued to increase at 10 percent growth rate. But in 1999, Realized FDI became quite flat, partly because of the East Asian currency crisis. Despite the slowdown, Realized FDI in 2002 is 15 times the level of 1990. The FDI from G7 countries was 23% in total FDI flows averagely during 1990s.

The distribution of FDI by region is uneven as presented. Most FDIS is located in the south and coastal areas despite efforts by the government to diversify the locations of foreign direct investment and lure FDI inland and toward the central and western regions. In 2002, more than 87 percent of the total stock of realized FDI was concentrated in the eastern part of China. (See Figure2)

Figure 3 shows the total import and the Import from G7 countries to China. The average share of G7's import in total import is around 40%. Moreover, in 2002, among the G7 countries, Japan is the biggest source country for China's imports with a share of almost 50% followed by the United States.

3. THE MODEL

Based on the recent theoretical models of innovation–driven growth, R&D activity is one of the major engines of technological progress and productivity growth. (Helpman, 1992). Consequently, cumulative domestic R&D is an important determinant of productivity. In a world of international trade and foreign investment, a country's productivity depends on its own R&D as well as on the R&D efforts of its foreign partners. Especially developing countries can benefit from R&D that is performed in the industrial sector by trading with industrial countries or by attracting foreign investment.

As is well recognized in the literature, there are several important channels through which import can benefit the importer country. In summary, there are three broad ways in which international trade can boost domestic productivity. Firstly, by International trade, the import country can employ a large variety of intermediate products and capital equipment. Secondly, international trade provides channels of communication that stimulate cross-border learning of production methods, product design, organizational methods and market conditions. Thirdly, International trade will indirectly affect the domestic country's productivity through demonstration effect, by imitating the import products, or copying foreign technologies and adjusting them to domestic use.

FDI, as another channel, may facilitate technology spillover. For example, local firms may increase their productivity by observing or modifying foreign firms or becoming their suppliers or customers or attracting employees to move from foreign firms to local ones.

We estimate equations in which variations in TFP are explained by variables in both domestic and foreign R&D capital stocks.

[6] Contracted Investment refers to the amount of investment committed in signed contracts. Realized investment refers to the total amount of FDI that actually materializes and arrives in China.

Our simplest equation has the following specification

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^d + \beta_{ft} \ln S_{i,t}^f + \varepsilon_{i,t} \qquad (1)$$

where i is a province index, lnF is the log of total factor productivity (equal to lnY-blnK-(1-b)lnL), $S_{i,t}^d$ represents the domestic R&D capital stock, and $S_{i,t}^f$ represents the foreign R&D capital stocks of trade partners or investment countries.

Two variables are utilized, namely trade weighted and FDI weighted stocks of foreign R&D.

In detail, when we analyze the relationship between the R&D and international trade, $S_{i,t}^f$ is defined as the import-share-weighted average of the domestic R&D capital stocks of trader partners.

$$S_{i,t}^{f,TRADE} = \sum_h m_{hi,t} S_h^d$$

here, $m_{hi,t}$ is the imports weight, these weights are fractions and add up to one.

So we get the equation (2)as following.

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^d + \beta_{ft} \ln S_{i,t}^{f,TRADE} + \varepsilon_{i,t} \qquad (2)$$

We assume the country is more open to world economy may be benefit more from the foreign R&D. so we add the import shares in equation (2),and estimate

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^d + \beta_{ft} \ln(m_{i,t} * S_{i,t}^{f,TRADE}) + \varepsilon_{i,t} \qquad (3)$$

where m stands for the fraction of imports in GDP.

On the other hand, when we analyze the R&D and FDI, $S_{i,t}^f$ is defined as follows

$$S_{i,t}^{f,FDI} = \sum_h f_{hi,t} S_h^d$$

$f_{hi,t}$ is the FDI weight from investor countries, these weights are fractions and add up to one.

So we can change equation (1) into equation (4) as following.

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^d + \beta_{ff} \ln S_{i,t}^{f,FDI} + \varepsilon_{i,t} \qquad (4)$$

Provinces attracting more FDI are supposed to benefit more from foreign R&D, so we add $f_{i,t}$ to equation (4) and get equation (5)

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^d + \beta_{ff} * \ln(f_{i,t} * S_{i,t}^{f,FDI}) + \varepsilon_{it} \qquad (5)$$

where $f_{i,t}$ is the foreign investment share in gross fixed capital formation.

Finally, taking into account FDI and trade as channel of technology transfer, the regression are as follows.

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^d + \beta_{ft} \ln S_{i,t}^{f,TRADE} + \beta_{ff} \ln S_{i,t}^{f,FDI} + \varepsilon_{i,t} \qquad (6)$$

$$\ln F_{i,t} = \alpha_i + \beta_d \ln S_{i,t}^{d} + \beta_{ft} \ln(m_{i,t} * S_{i,t}^{f,TRADE}) + \beta\beta_{ff} * \ln(f_{i,t} * S_{i,t}^{f,FDI}) + \varepsilon_{it} \quad (7)$$

4. DATA

The data covers three municipalities (Beijing, Shanghai, Tianjin)[7]and 26 provinces for the period from 1990-2002.Tibet is excluded in our analysis because most of the import and FDI data for it is either not available or zero during the time period examined.

4-1 Total Factor Productivity

Total factor productivity is defined as the log of output minus a weighted average of the logs of labor and capital inputs, where the weights equal factor shares. LNF=lnY-blnK-(1-b)lnL. The coefficient b, which is the share of capital income in GDP, is set to 0.4.(following Coe, Helpman &Hoffmaister(1997)).

Y is the provincial real GDP. The GDP data and implicated GDP deflator for 1990-2002 come from the China Statistics Yearbooks.

K is the capital stock. We estimate the real capital stock using the standard perpetual inventory approach. The investment series used is the total social fixed asset investment from the China statistics Yearbooks for 1991-2003.Since 1991,the Chinese statistical sources began to report the price indices for fixed assets investment .So we used that deflate to construct the time series of physical capital stock from investment flows. We adopt an overall depreciation rate of 10%.

L is the labor from “Total labor force of society by the end of year” which is reported annually in the China statistics Yearbooks. We used the annual average total labor force of society.

As show in Table 1,total factor productivity (TFP) increased over the period of 1990 to 2002 in all provinces. Jiangsu, Zhejiang, Fujian, Shangdong, Hainan and Shangdong experienced the greater increase in productivity of more than 20%, respectively, and all of these provinces are located in south and coastal region of China. While Guizhou’s TFP increase rate is the lowest. Almost all the provinces had the intermediate values, and averagely in the western region the TFP increase rate is a little lower than that in other regions.

4-2 R&D Capital Stock from G7 Countries

The R&D expenditures data are from the OECD’s “Main Science and Technology Indicators”. We used the perpetual inventory approach to calculate the R&D capital stocks .The depreciation rate is

[7] Chongqing was established in 1997, so it is included in Sichuan province for the consistency of the data.

defined at 10% a year. As shown in Table 1, overall changes in foreign R&D capital stocks were not so dramatic.

Table 1 also provides data on import shares in GDP and FDI shares in total fixed investment. There exist substantial differences in import shares and FDI shares between the coastal provinces and the inland provinces, which indicated the coastal region is more open to the foreign countries and depends more on the foreign economy.

4-3 China's Domestic R&D

We used patent application to stand for the domestic R&D stock in China. The data are taken from the China's statistical yearbook and China's Statistical Yearbooks on Science and Technology from 1991 to 2003.

From 1990 to 2002, the total of patent applications increased significantly in most provinces. The coastal provinces, which take amount of 75% of the total of patent applications in 2002, have the fastest growing. In Gouangdong, Shanghai and Fujian, in particular, it increased by a factor of 17, 13 and 12 respectively. Comparing with the coastal provinces, the central and western provinces experienced the slower expansion of patent applications about four fold larger between 1990 and 2002. The distribution of patent applications across provinces, as shown in Table2, exhibits a large discrepancy between the coastal region and the other inland (central and western) provinces.

5. RESULTS AND DISCUSSION

The model developed in section 3 was estimated for a panel of data for 29 provinces over the period of 1990 to 2002.

The regression equations are shown in Table 3. Both domestic and foreign R&D variables are statistically significant determinants to the domestic TFP .The coefficient on the trade weighted foreign R&D variable $S_{i,t}^{f,TRADE}$ in eq(2)is smaller than the coefficient on $S_{i,t}^{f,FDI}$ in eq(4), and the R^2 is larger when $S_{i,t}^{f,FDI}$ is used. Furthermore, in eq(6), when both variables are used , the point of $S_{i,t}^{f,FDI}$ is 0.193, larger than the point of $S_{i,t}^{f,TRADE}$ which(0.075).We used an F-test for an upper one tailed test[8] to examine the statistical significance of the difference. The null-hypothesis was rejected, which confirmed the estimation result.

[8] The F hypothesis test is defined as: H0: $\beta_{ff} = \beta_{ft}$, H1: $\beta_{ff} > \beta_{ft}$ (for an upper one tail test) Using the full sample and the sample of eastern region, the hypothesis was rejected at p=0.001.

f* $S_{i,t}^{f,FDI}$ and m* $S_{i,t}^{f,TRADE}$ are foreign R&D variables weighted by openness. In Table 3, the estimation coefficient of f* $S_{i,t}^{f,FDI}$ and m* $S_{i,t}^{f,TRADE}$ in equation (7) are positive and significant. This suggests the higher the ratio of FDI in the fixed capital formation, or the higher the import share in GDP the greater the technology transfer effect can be expected.

Since the FDI and import is concentrated in the coastal region in China, and the coastal region is the most open area to the foreign countries, we would expect to observe greater spillover effect through FDI and trade. So we estimated the equations reported in table 3 using only the observations of the eastern 12 provinces.

The results presented in Table4 are similar to those in Table 3.The statistic analysis is the same and the results provide some support for our expectation. The coefficient on $S_{i,t}^{f,FDI}$ is quite larger than that of $S_{i,t}^{f,TRADE}$, which implies the FDI channel identifies larger spillover.

In particular, the estimated coefficient on f* $S_{i,t}^{f,FDI}$ and m* $S_{i,t}^{f,TRADE}$ are positive and statistically significant, which implies that if an economy is more open to trade and FDI, greater technology transfer effect can be expected.

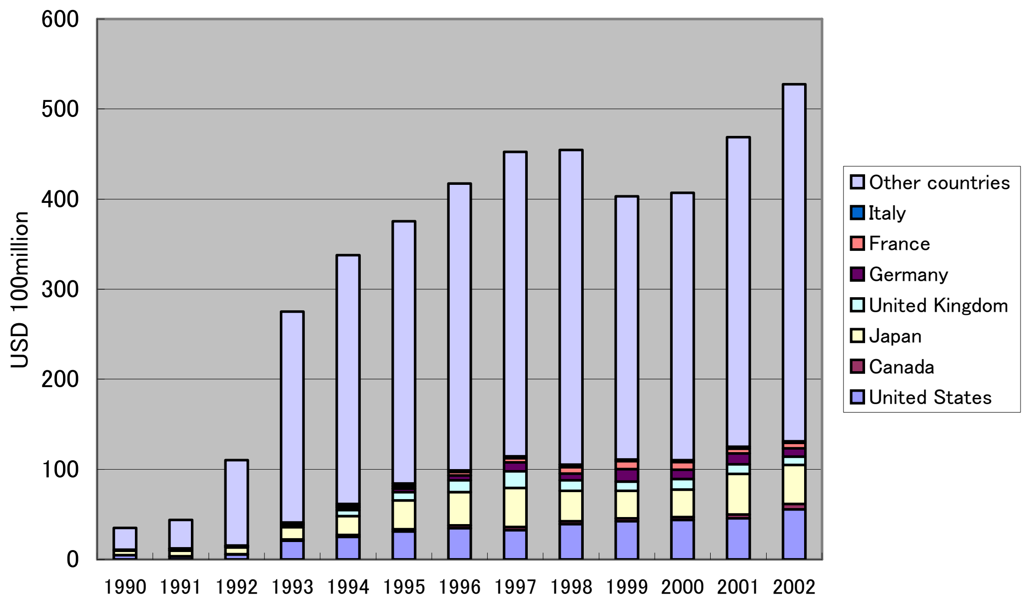
6. CONCLUDING REMARS

Using the provincial data for the period of 1990 to 2002, we estimated the spillover effect through Import and FDI. We found generally significant and positive spillover effect of foreign R&D stocks through trade and FDI. So this study empirically supports that both FDI and Import generates externalities in the form of technology transfer. In addition, the coefficient estimates for FDI are larger than those of trade, which suggest comparing with import, FDI is supposed to be the more important spillover channel in transferring the foreign R&D stocks. Furthermore, according to the estimation results on eastern region observations, the region with a high openness to the trade and FDI demonstrates high spillover effect from the foreign R&D. In line with the findings of this study, it implied that China might be better off if the government devises policies to attract more investments from technologically advanced countries.

This study is based on the macroeconomic data. If detailed and publicly available industrial data are available, we like to expand this study and to see whether these conclusions are further confirmed.

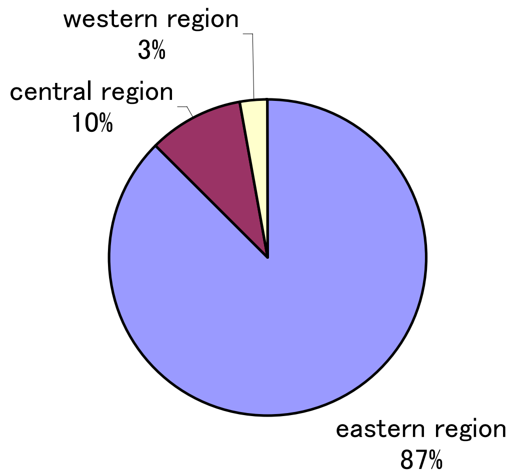
FIGURES AND TABLES

Fig1 Realized FDI flows in China,1990–2002



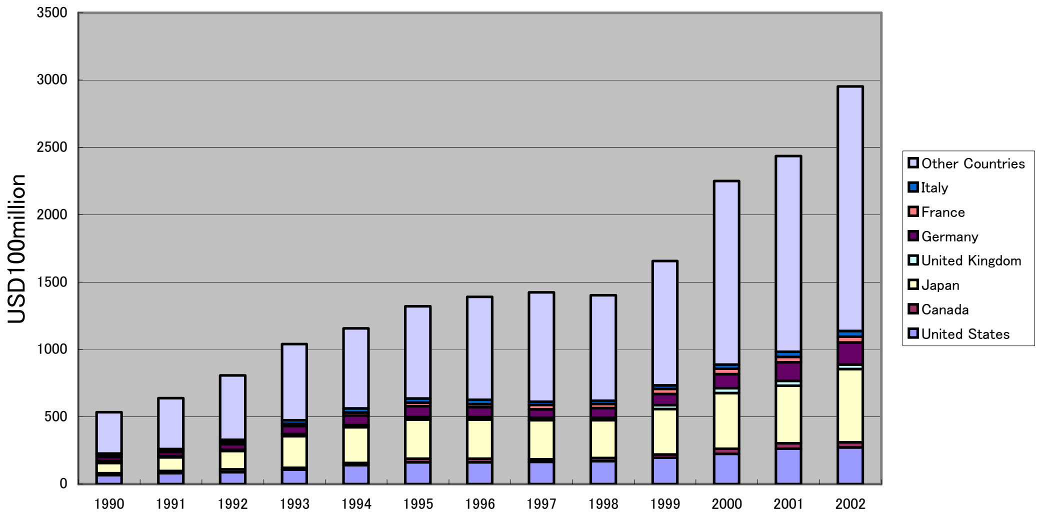
Source: SSS, China statistics Yearbook,1991-2003

Fig2 FDI to China by Location(Realized Value,2002)



Source: SSS, China statistics Yearbook,2003

Fig3.China's import from G7, 1990-2002.



Source: SSS, China statistics Yearbook,1991-2003

Table1 Summary statistics

	lnF2002/lnF1990	Sd2002/Sd1990	Sf,FDI2002/1990	Sf,Trade2002/1990	m2002	f2002
Eastern Region						
Beijing	1.167	3.2	4.99	1.15	0.473	0.079
Fujian	1.222	12.1	4.19	5.35	0.211	0.254
Guangdong	1.192	17.6	2.52	4.14	0.750	0.244
Guangxi	1.143	3.0	2.47	7.22	0.038	0.046
Hainan	1.216	7.9	7.08	6.20	0.155	0.188
Hebei	1.180	3.6	3.12	2.89	0.036	0.032
Jiangsu	1.238	4.8	3.31	3.06	0.276	0.244
Liaoning	1.192	3.1	2.92	2.77	0.179	0.176
Shangdong	1.213	5.0	2.53	3.16	0.124	0.112
Shanghai	1.184	13.1	2.82	3.92	0.631	0.160
Tianjin	1.198	5.5	3.32	3.57	0.475	0.162
Zhejiang	1.229	7.7	2.91	3.24	0.157	0.073
Center Region						
Anhui	1.165	4.9	2.57	3.26	0.044	0.030
Heilongjiang	1.186	3.6	3.23	3.47	0.049	0.028
Henan	1.187	3.9	3.16	2.90	0.019	0.019
Hubei	1.157	4.0	3.07	2.90	0.042	0.074
Hunan	1.151	2.2	2.41	2.80	0.029	0.055
Inner Mongolia	1.167	3.5	3.30	2.90	0.077	0.021
Jiangxi	1.150	3.4	2.88	3.33	0.032	0.101
Jilin	1.186	3.4	3.07	2.90	0.081	0.024
Shanxi	1.182	2.5	1.41	3.33	0.035	0.022
Western Region						
Gansu	1.135	2.5	2.01	2.13	0.038	0.010
Guizhou	1.079	4.7	3.07	2.90	0.029	0.005
Ningxia	1.122	4.4	3.29	1.93	0.034	0.008
Qinghai	1.130	1.4	3.19	2.90	0.018	0.017
Shaanxi	1.167	2.5	3.99	3.42	0.048	0.033
Sichuan	1.157	4.4	2.00	2.95	0.033	0.022
Xinjiang	1.175	5.0	3.97	2.39	0.093	0.002
Yunnan	1.136	3.9	3.22	1.89	0.038	0.011

Source: author’s estimation

Table2: Domestic Patent Applications(1990-2002)

	1990	1995	2000	2001	2002
Eastern Region					
Hebei	1477	2702	3848	4695	5390
Hainan	69	183	502	390	546
Jiangsu	2706	4078	8211	10352	13075
Shangdong	2553	4624	10019	11170	12856
Shanghai	1526	2456	11337	12777	19970
Tianjin	975	1648	2789	3081	5360
Fujian	540	1979	4211	4971	6522
Beijing	4284	6362	10344	12174	13842
Guangxi	650	1231	1762	1838	1927
Guangdong	1948	7729	21123	27596	34352
Zhejiang	2243	4042	10316	12828	17265
Liaoning	3153	4449	7151	7514	9851
Subtotal	22124	41483	91613	109386	140956
share of total	62.2%	64.9%	71.5%	73.3%	75.1%
Central Region					
Anhui	471	1026	1877	2045	2312
Henan	1133	2386	3823	4093	4441
Jilin	1017	1389	2501	2627	3413
Hunan	2190	2628	4117	4292	4859
Hubei	1238	2004	3486	4322	4960
Jiangxi	601	1008	1557	1778	2037
Shanxi	640	917	1475	1473	1630
Inner Mongolia	347	647	1138	1087	1202
Heilongjiang	1230	2569	3106	3670	4392
subtotal	8867	14574	23080	25387	29246
share of total	24.9%	22.8%	18.0%	17.0%	15.6%
Western Region					
Yunnan	461	959	1710	1793	1780
Gansu	307	546	798	734	781
Sichuan	2091	3186	6276	7086	9139
Xinjiang	250	609	1088	1086	1239
Qinghai	111	100	174	162	151
Ningxia	114	169	341	412	503
Guizhou	267	562	986	950	1260
Shaanxi	993	1721	2080	2326	2530
subtotal	4594	7852	13453	14549	17383
share of total	12.9%	12.3%	10.5%	9.7%	9.3%
Total	35585	63909	128146	149322	187585

Sourse:China's statistical yearbook, patent applications from Hongkong, Macau, and Taiwan are not included here.

Table3: Estimation results (panel data 1990-2002 for 29 provinces, 377 observations, OLS)

	Eq(2)	Eq(4)	Eq(6)	Eq(3)	Eq(5)	Eq(7)
Constant	0.127 (0.252)	-0.921 (-2.169) **	-1.732 (-3.380) ***	3.869 (39.674) ***	3.813 (40.912) ***	3.865 (40.574) ***
lnS^d	0.191 (15.197) ***	0.228 (20.024) ***	0.217 (18.192) ***	0.180 (13.289) ***	0.185 (14.508) ***	0.177 (13.338) ***
$lnS^{f,trade}$	0.187 (7.195) ***		0.075 (2.773) ***			
$m*lnS^{f,trade}$				0.028 (6.074) ***		0.013 (2.340) **
$lnS^{f,FDI}$		0.223 (11.105) ***	0.193 (8.466) ***			
$f*lnS^{f,FDI}$					0.05 (7.180) ***	0.038 (4.356) ***
R^2	0.487	0.561	0.570	0.468	0.487	0.494
R^2adjusted	0.484	0.559	0.566	0.466	0.484	0.490

Note: The dependent variable is lnF(ln total factor productivity)
Stand errors are presented in parentheses.
***,**,* denote significance at 1, 5,10 percent level respectively.

Table4: Estimation results (panel data 1990-2002 for 12 provinces,156 observations, OLS)

	Eq(2)	Eq(4)	Eq(6)	Eq(3)	Eq(5)	Eq(7)
Constant	-1.544 (-2.243) **	-3.921 (-4.945) ***	-4.963 (-6.262) ***	3.761 (22.229) ***	3.442 (20.436) *** (	3.490 (20.197) ***
lnS^d	0.163 (8.322) ***	0.159 (8.847) ***	0.143 (8.157) ***	0.202 (9.426) ***	0.233 (11.711) ***	0.225 (10.701) ***
$lnS^{f,trade}$	0.287 (7.839) ***		0.158 (4.208) ***			
$m*lnS^{f,trade}$				0.020 (3.511) ***		0.007 (1.201)
$lnS^{f,FDI}$		0.405 (9.790) ***	0.306 (6.702) ***			
$f*lnS^{f,FDI}$					0.050 (5.490) ***	0.044 (4.239) ***
R^2	0.573	0.632	0.671	0.447	0.500	0.505
R^2adjusted	0.567	0.627	0.664	0.439	0.494	0.495

Note: The dependent variable is lnF(ln total factor productivity)
Stand errors are presented in parentheses.
***,**,* denote significance at 1, 5,10 percent level.

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