MEIDE
Rio de Janeiro, May 2009

Towards an Innovation Nation

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University of Oxford


CCTV 4
直播
LIVE
航天员成功出舱
推进舱

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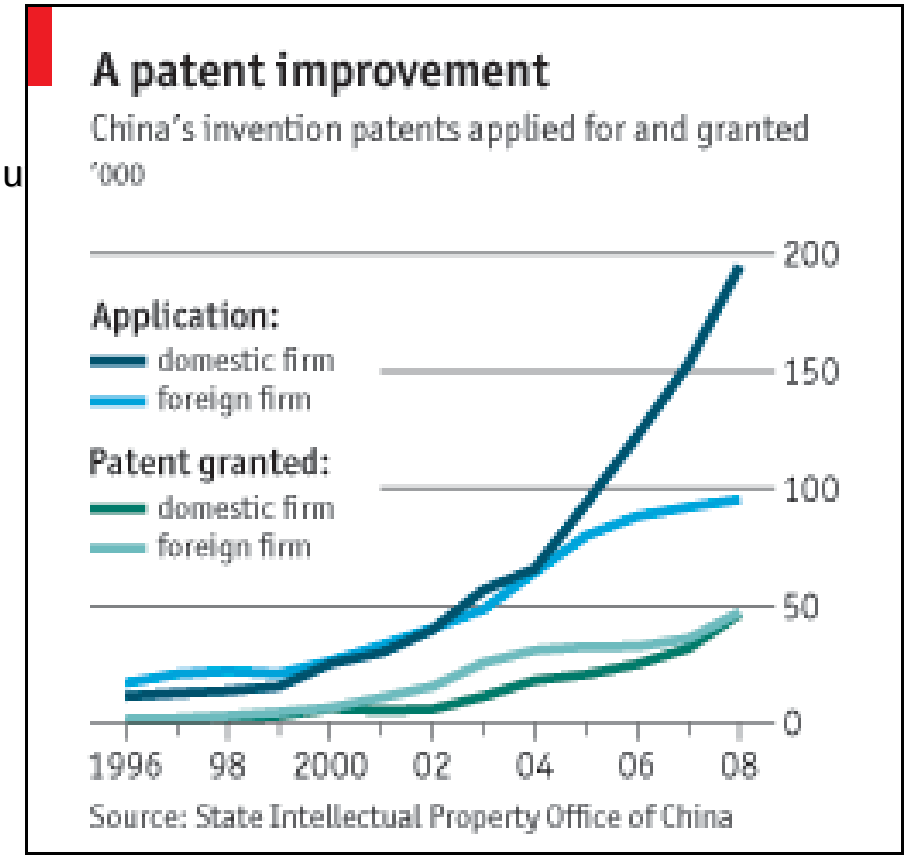
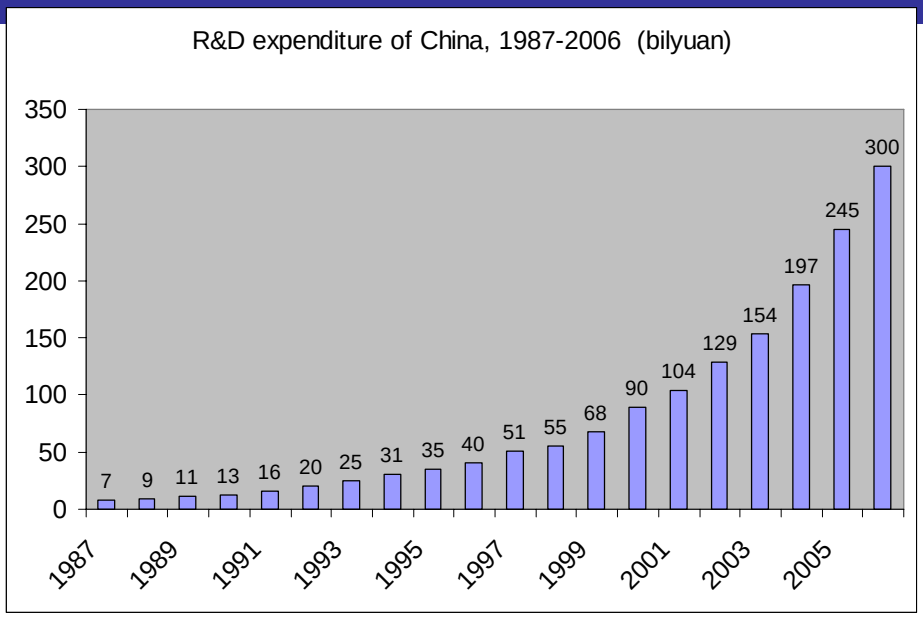
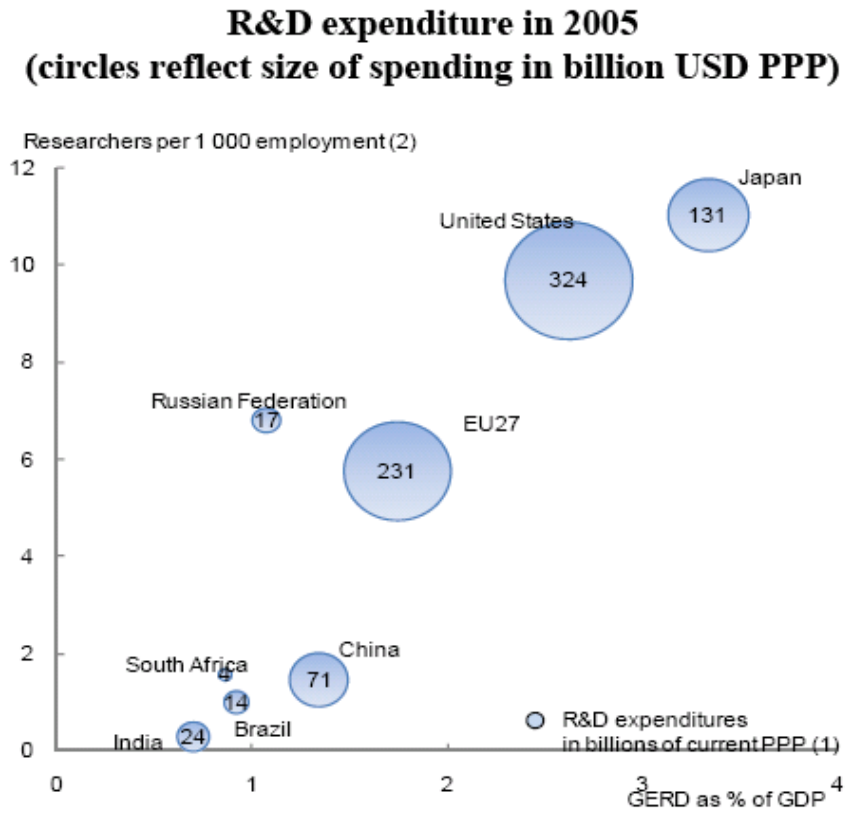

A patent improvement
China's invention patents applied for and granted
'000
Application:
domestic firm
foreign firm
Patent granted:
domestic firm
foreign firm
200
150
100
50
0
1996
98
2000
02
04
06
08
Source: State Intellectual Property Office of China

R&D in China: 1987-2006

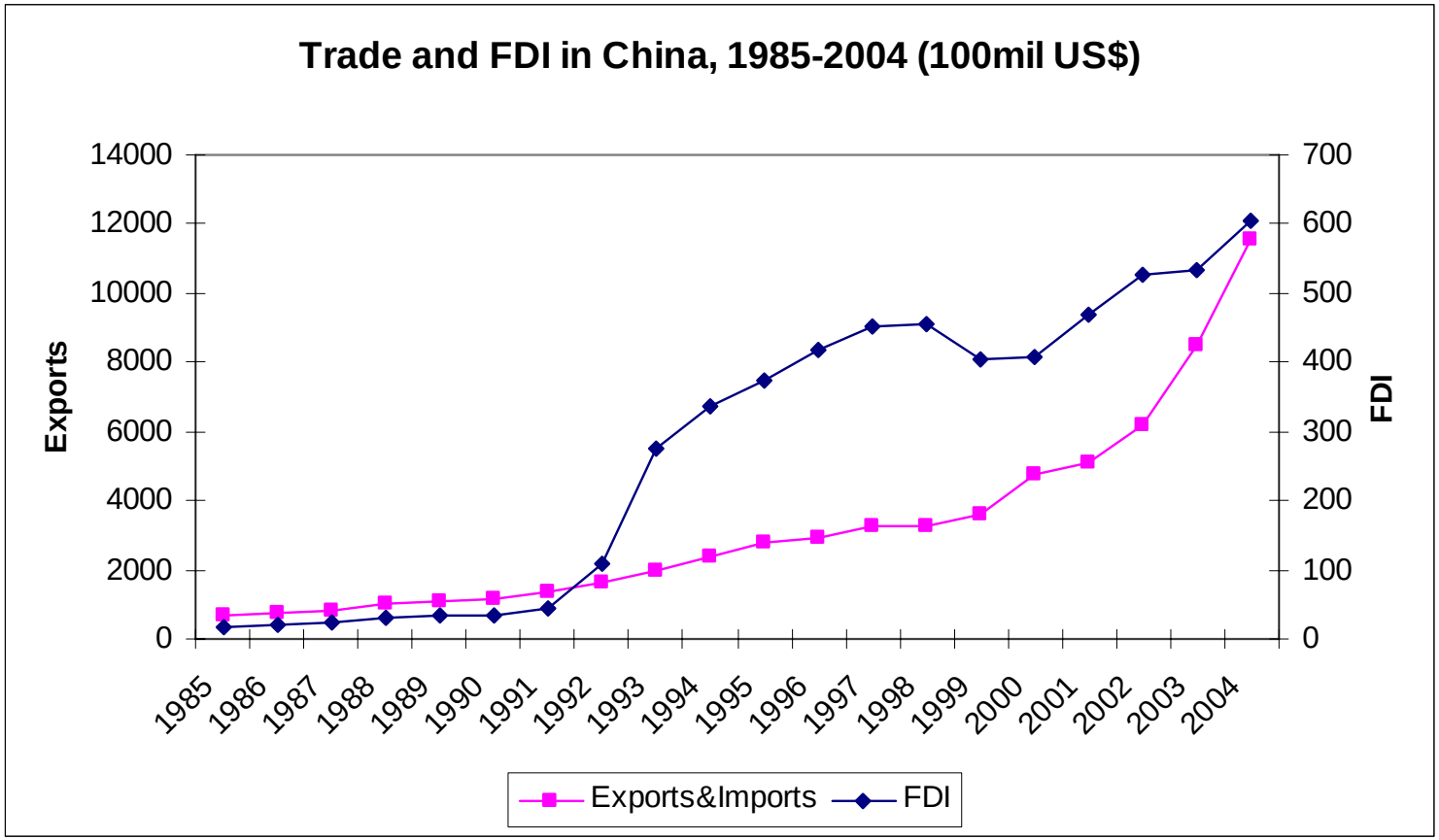


Source: China Statistical Yearbook



Source: Tojo (2008)

Trade and FDI in China



Source: China Statistical Yearbook

Research Questions

- Indigenous and foreign innovation efforts and drivers of technological upgrading
- The effects of country origin of FDI
- Absorptive capacity and benefits from global reservoirs of knowledge

Contributions of the papers

1. LDCs, especially middle income countries, as creator of technology
2. Extends the existing theory to industry level and allows for a diverse mixture of industries in an economy
3. Considers 3 levels of R&D efforts;

   international industry specific R&D stock is linked explicitly to the Chinese firm-level data

Outline

I. Introduction

II. Theoretical framework

III. Methodology

IV. Data

V. Results

VI. Conclusions

Theoretical framework

1. Technologies are designed to make optimal use of the conditions and factor suppliers in the country where the technology is developed (Acemoglu, 2002)
2. Most new technologies are invented and developed in industrial countries whose factor endowments are significantly different from those in the LDCs. These technologies are often capital or skilled-labour augmenting
3. These advanced technologies, acquired through import and FDI, may not be “appropriate” to the needs of LDCs

Drivers of Productivity Growth

P1a: Labour-abundant countries may have the comparative advantage in creating un-skilled labour augmenting technology. The low-tech sector uses this factor intensively, indigenous technology may be more efficient than foreign technology.

P1b: In the high-technology sector that uses technology intensively, foreign technology may be more efficient than indigenous technology.

Drivers of Productivity Growth

The middle-income economies are more likely to generate innovations in medium-level technology (Findlay, 1978).

P2: Given the significant disparities within these large economies, the intermediate technology is likely to be generated by the relatively skill- and capital-rich groups in the economy.

Indigenous technology made optimal use of local contents and factors and easy to be absorbed, hence

P3: Indigenous technology is likely to generate positive spillovers effect on the technical progress of local firms.

Technology transfer & spillovers

P4a: FDI is likely to contribute to static technological capabilities through imports of machineries & equipments

P4b: FDI by MNEs from industrialised countries, which are the major force of global innovation activities, are more likely to bring in greater technological spillovers from international knowledge base.

P5: Firms with greater absorptive capacity are likely to benefit more from international knowledge spillovers.

Model

Jones (1995 and 1999)

$$Y = K^{1-\alpha}(AL_y)^{\alpha}$$

$$\frac{\dot{A}}{A} = \delta L_A$$

$$\frac{\dot{A}}{A} = \delta L_A^{\lambda} A^{\varphi-1}$$

$$\frac{\dot{A}}{A} = \delta(L_{Af}^{\lambda} L_{Asd}^{\lambda} L_{Asf}^{\lambda}) A^{\varphi-1}$$

$$L_{Asd}^{\lambda} = \eta l(R_d) S$$

$$L_{Asf}^{\lambda} = \eta l(R_f) PS$$

Empirical Model

1. Indigenous vs foreign R&D

$$\dot{p} = \delta' + \lambda_1' L_{Af} + \lambda_2' L_{Asd} + \lambda_3' L_{Asf} + \psi p_{t-1} + \tau_1 X + \tau_2 D + \varepsilon$$

2. Diaspora vs OECD FDI

$$\dot{p} = \delta' + \lambda_1' L_{Af} + \lambda_2' L_{Asd} + \lambda_3' L_{Asf}^{oc} + \lambda' L_{Asf\ 4}^{f} + \psi p_{t-1} + \tau_1 X + \tau_2 D + \varepsilon$$

3. Absorptive capacity

$$\dot{p} = \delta' + \lambda_1' R_d + \lambda_2' l(R_d) S + \lambda_3' l(R_f) PS + \psi p_{t-1} + \tau_1 X + \tau_2 D + \varepsilon$$

- X is a vector of control variables consists of age, firm size, export, intangible assets, labour training, market concentration
- D is the full set of time, sector dummies and e is a random error term

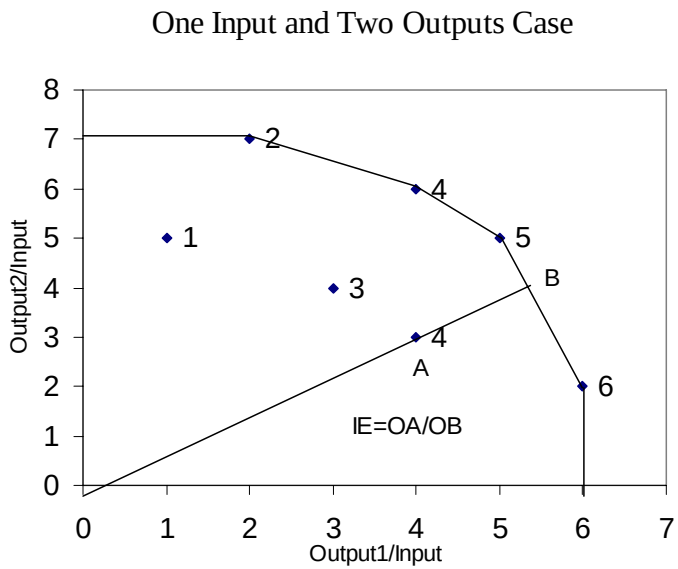
Methodology (1)

1. Non-parametric frontier technique is used to decompose TFP growth of firms into technical change and efficiency improvement
2. Identify the firms that stand on the technology frontier measured by firm's technical efficiency
3. Simultaneous equation systems are employed to estimate the drivers of TFP, technical change and efficiency improvement
4. International industry specific R&D stock is linked explicitly to the Chinese firm-level data

Estimation of Productive Efficiency

- **Frontier Analysis**: Benchmark a firm's productive efficiency against the best practice.

- Data Envelopment Analysis
- TE = OA/OB



Methodology (2)

Decomposing TFP growth (Malmquist index):

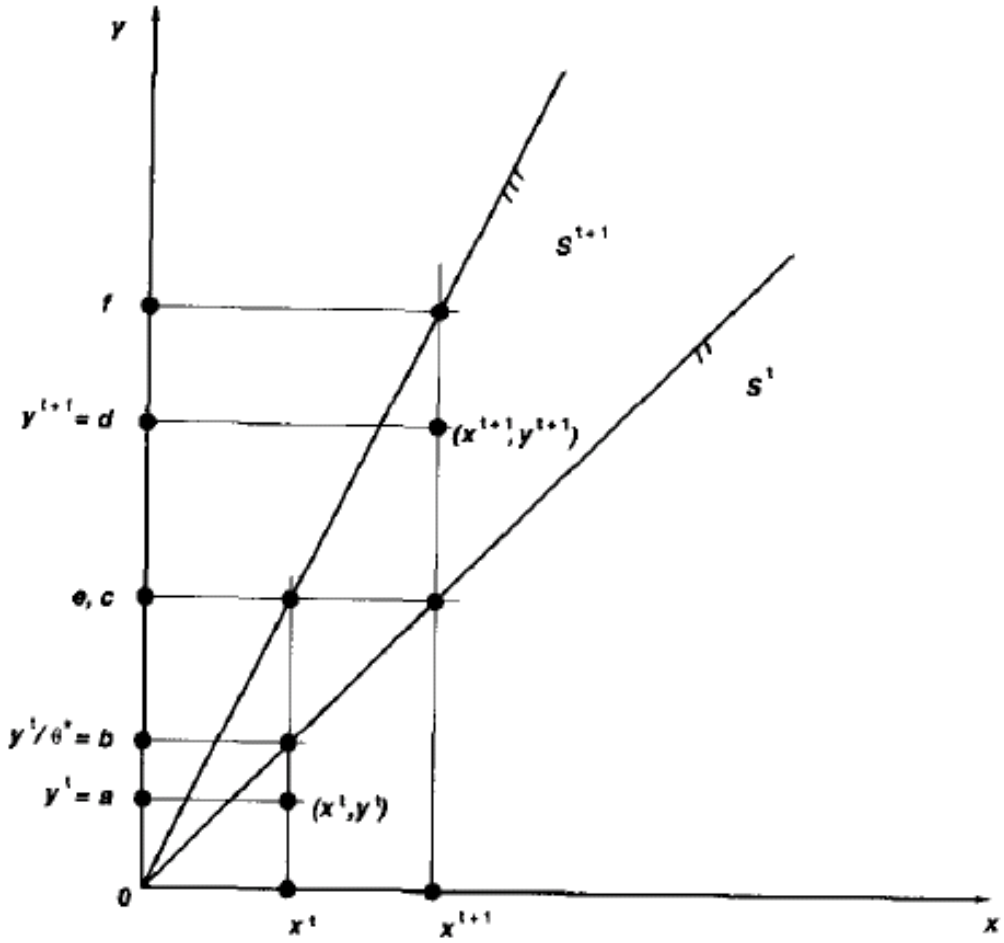
$$M_0\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} \times \left[\left(\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}\right)\left(\frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right)\right]^{\frac{1}{2}}$$

$$= \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \qquad \text{Efficiency change}$$

$$\times\left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right]^{1/2} \qquad \text{Technical change}$$

- Efficiency change: movement towards frontier
- Technical change: shift of the frontier
- D is the output-based distance function, which measures technical efficiency (Fare et al, 1994)
- Inputs of the DEA model : Labour, capital and variable costs; Output: Sales

Malmquist TFP



Empirical Model

1. Indigenous vs foreign R&D

$$\dot{p} = \delta' + \lambda_1' L_{Af} + \lambda_2' L_{Asd} + \lambda_3' L_{Asf} + \psi p_{t-1} + \tau_1 X + \tau_2 D + \varepsilon$$

2. Diaspora vs OECD FDI

$$\dot{p} = \delta' + \lambda_1' L_{Af} + \lambda_2' L_{Asd} + \lambda_3' L_{Asf}^{oc} + \lambda' L_{Asf\ 4}^{f} + \psi p_{t-1} + \tau_1 X + \tau_2 D + \varepsilon$$

3. Absorptive capacity

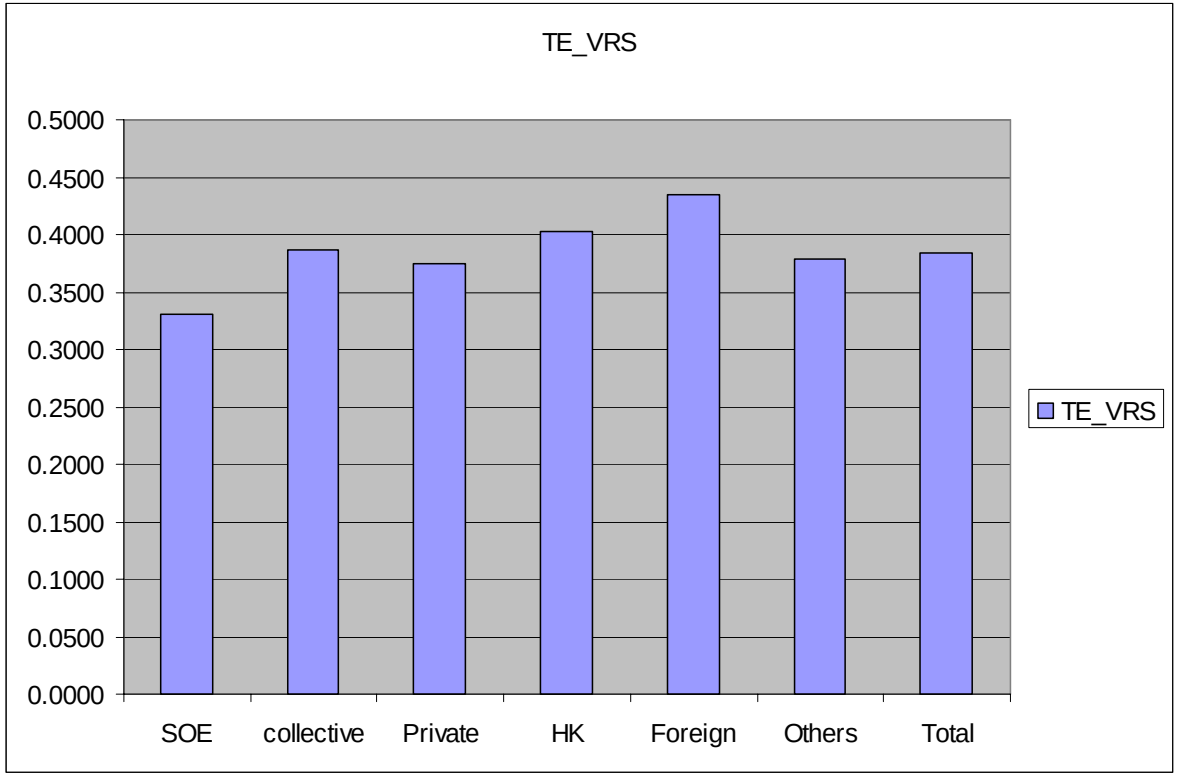
$$\dot{p} = \delta' + \lambda_1' R_d + \lambda_2' l(R_d) S + \lambda_3' l(R_f) PS + \psi p_{t-1} + \tau_1 X + \tau_2 D + \varepsilon$$

- X is a vector of control variables consists of age, firm size, export, intangible assets, labour training, market concentration
- D is the full set of time, sector dummies and e is a random error term

Data (1)

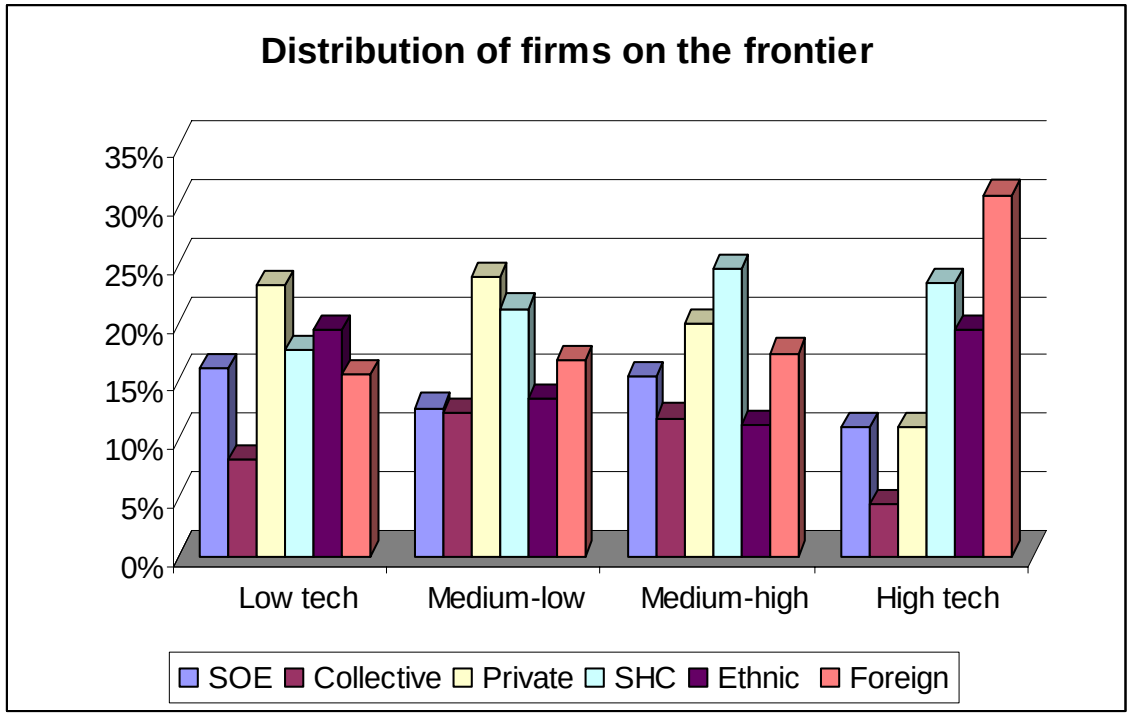
1. Annual Report of Industrial Enterprise Statistics compiled by the NSB of China
2. Covers all SOEs and other firms with annual sales of over five millions RMB during the period 2001-05
3. Final analysis is based on a balanced dataset with 53981 firms over the 2001-2005 period (269,905 observations)
4. International R&D stock: OECD STAN Indicator Database
5. R&D stock is deflated by an R&D price index (=0.5P+0.5W), and calculated based on the perpetual inventory model

Preliminary Results (1)



- Foreign firms are the most efficient, and SOEs are the most inefficient

Preliminary Results (2)

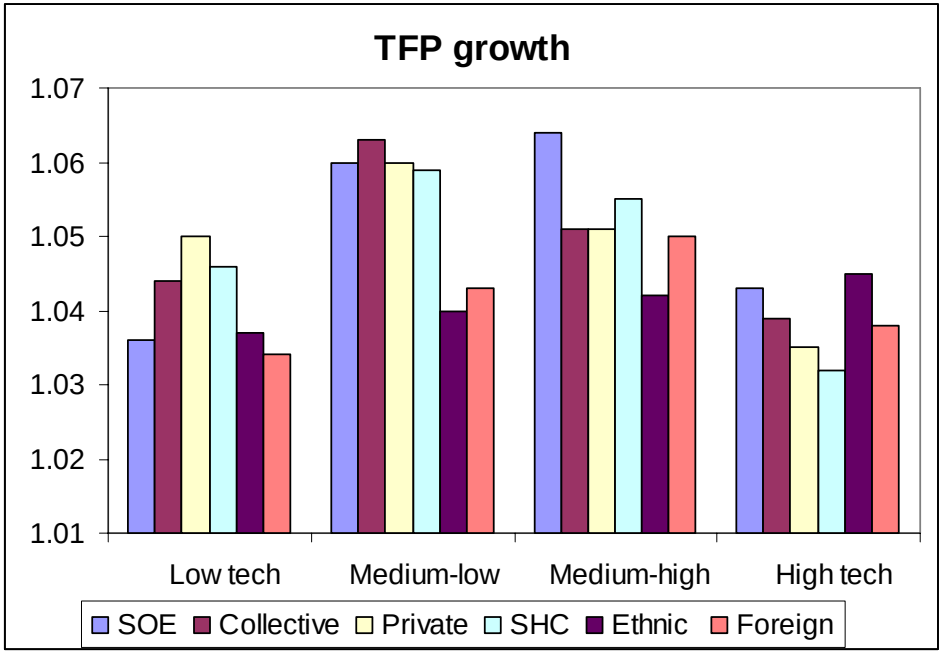


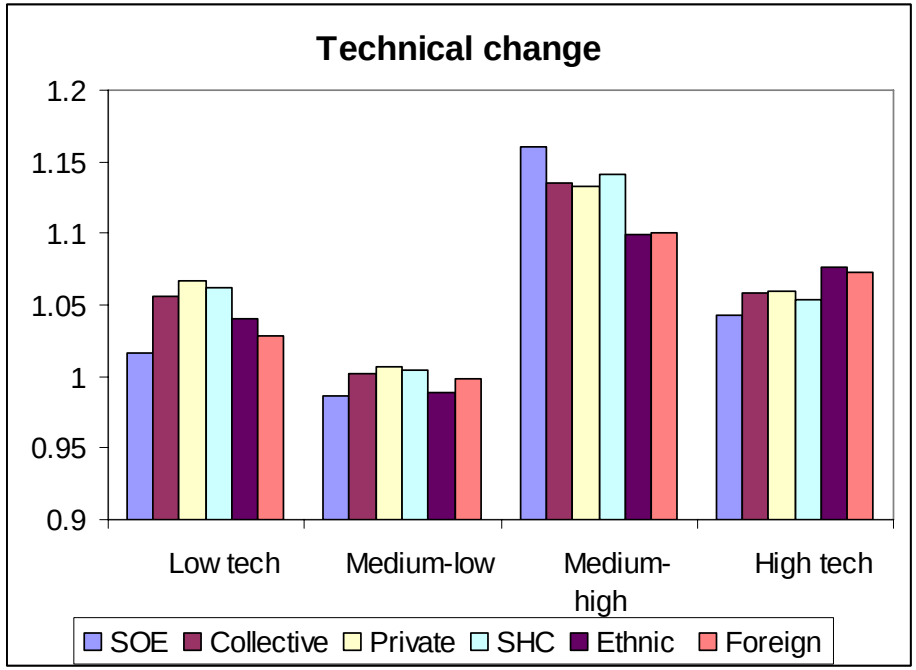
- More indigenous firms are on the frontier
- In high-tech industries, more foreign firms are on the frontier
- Overall, technological upgrading is not dominated by any single sector

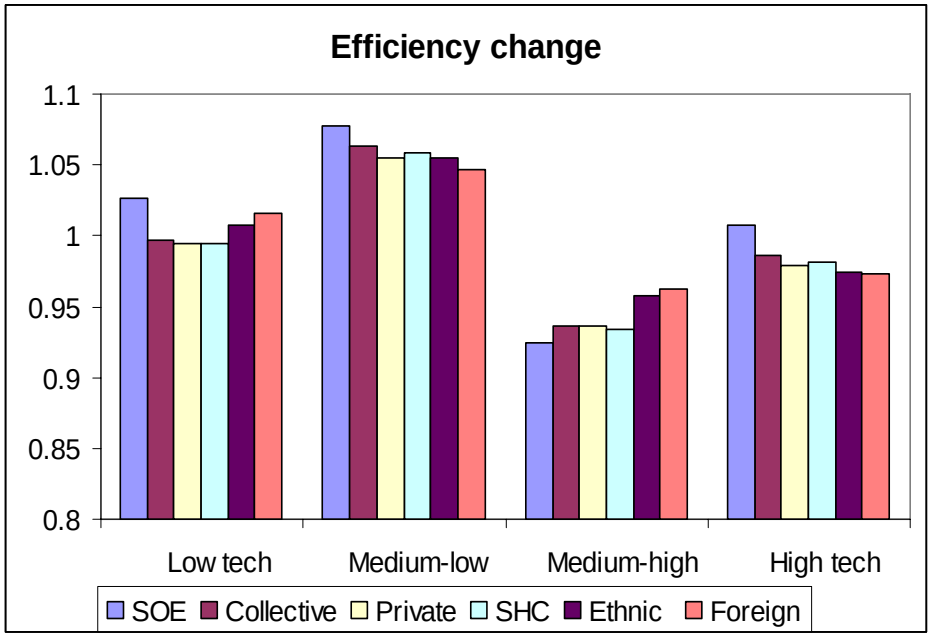
Preliminary Results (3)

Ownership type	Malmquist index (tfpch)	Technical Change (techch)	Efficiency Change (effch)	Scale Change (sech)
SOE	1.0517	1.0519	1.0105	1.0093
collective	1.0537	1.0527	1.0100	1.0071
Private	1.0530	1.0585	1.0039	0.9933
HK	1.0395	1.0388	1.0100	0.9923
Foreign	1.0405	1.0405	1.0085	0.9928
Others	1.0518	1.0635	0.9979	0.9996
Average	1.0484	1.0510	1.0068	0.9991

- All types of firms show TFP growth during the period of 2001 to 2005
- On average, TFP growth is due to technical progress rather than improvements in efficiency


TFP growth
1.07
1.06
1.05
1.04
1.03
1.02
1.01
Low tech
Medium-low
Medium-high
High tech
SOE
Collective
Private
SHC
Ethnic
Foreign


Technical change
1.2
1.15
1.1
1.05
1
0.95
0.9
Low tech
Medium-low
Medium-high
High tech
SOE
Collective
Private
SHC
Ethnic
Foreign


Efficiency change
1.1
1.05
1
0.95
0.9
0.85
0.8
Low tech
Medium-low
Medium-high
High tech
SOE
Collective
Private
SHC
Ethnic
Foreign

SIC 2-digit industry	Malmquist index (tfpch)	Technical Change (techch)	Efficiency change (effch)	Scale Change (sech)
13-Food Processing	1.0542	0.9698	1.0879	1.0347
14-Food Production	1.0321	0.9787	1.0604	1.0156
15-Beverage Industry	1.0510	1.0828	0.9723	0.9864
16-Tobacco Processing	1.0507	1.0432	1.0074	0.9963
17-Textile Industry	1.0438	1.1728	0.8916	0.9476
18-Garments and Other Fiber Products	1.0370	0.9074	1.1440	1.0040
19-Leather, Furs, Down and Related Products	1.0379	1.1274	0.9273	0.9378
20-Timber Processing	1.0427	1.0584	0.9885	0.9951
21-Furniture Manufacturing	1.0275	0.9247	1.1135	1.0160
22-Papermaking and Paper Products	1.0535	1.0664	0.9899	0.9902
23-Printing and Record Medium Reproduction	1.0213	1.0440	0.9793	0.9831
24-Cultural, Educational and Sports Goods	1.0277	0.9890	1.0393	1.0206
25-Petroleum Refining and Coking	1.0461	1.1272	0.9302	0.9824
26-Raw Chemical Materials and Chemical Products	1.0486	1.1372	0.9272	0.9825
27-Medical and Pharmaceutical Products	1.0339	1.0634	0.9735	0.9871
28-Chemical Fiber	1.0450	1.0510	0.9934	1.0011
29-Rubber Products	1.0514	1.0094	1.0411	1.0773
30-Plastic Products	1.0380	0.9891	1.0529	0.9848
31-Nonmetal Mineral Products	1.0698	1.0005	1.0693	1.0368
32-Smelting and Pressing of Ferrous Metals	1.0566	1.0646	0.9992	1.0177
33-Smelting and Pressing of Nonferrous Metals	1.0358	0.9690	1.0807	1.0838
34-Metal Products	1.0420	0.9536	1.0958	1.0043
35-Ordinary Machinery	1.0732	1.0207	1.0519	1.0189
36-Special Purposes Equipment	1.0555	1.1878	0.8895	0.9838
37-Transport Equipment	1.0578	1.2346	0.8622	0.9215
39-Electric Equipment and Machinery	1.0541	1.0149	1.0438	1.0343
40-Electronic and Telecommunications	1.0460	1.1088	0.9446	0.9737
41-Instruments and meters	1.0262	0.9497	1.0849	0.9947
42-Artifact and Other Manufacturing	1.0257	0.9667	1.0661	1.0374
Total	1.0450	1.0432	1.0074	0.9963

Technical change

	High tech	Medium-high	Medium-low	Low tech
Firm R&D Intensity	-0.0128	0.166	-0.479	-0.457
	(0.17)	(0.28)	(0.34)	(0.92)
SOE R&D share	0.0049**	0.0142***	-0.0020*	0.0012
	(0.0023)	(0.0018)	(0.0012)	(0.001)
POE R&D share	0.0071**	0.0172***	0.0045**	0.0137***
	(0.0031)	(0.0029)	(0.002)	(0.0022)
Collective R&D share	0.0098***	0.0108***	-0.0111***	0.0114***
	(0.0019)	(0.0013)	(0.0012)	(0.0011)
Ethnic R&D share	-0.0067**	0.0096***	-0.0028***	-0.0031*
	(0.0035)	(0.0016)	(0.001)	(0.0017)
Foreign R&D share	-0.0056	-0.0232***	0.0012	-0.0152***
	(0.004)	(0.0021)	(0.0013)	(0.0017)
SHC R&D share	0.0016	-0.0252	0.0084***	-0.0032
	(0.0044)	(0.0025)	(0.0018)	(0.002)
International R&D x Firm	-0.0086	0.0047	0.0267*	0.0040
	(0.0074)	(0.011)	(0.015)	(0.016)
International R&D x Industry	0.0043	-0.017***	0.0200***	0.0016
	(0.0056)	(0.0032)	(0.0029)	(0.0065)
Initial Technical Efficiency	0.00813	-0.222***	-0.222***	-0.176***
	(0.02)	(0.015)	(0.013)	(0.013)

Efficiency change

	High tech	Medium-high	Medium-low	Low tech
R&D Intensity	0.666*	1.229**	2.694***	3.404*
	(0.38)	(0.61)	(0.79)	(1.81)
SOE R&D share	-0.0055	-0.0001	-0.0036**	0.0025
	(0.0042)	(0.0025)	(0.0016)	(0.0016)
POE R&D share	-0.0159**	-0.0122***	-0.0098***	-0.0073***
	(0.0064)	(0.0033)	(0.0029)	(0.0027)
Collective R&D share	-0.0092***	-0.0044**	0.0031*	-0.0109***
	(0.0035)	(0.0021)	(0.0018)	(0.0014)
Ethnic R&D share	0.0002	-0.0082***	-0.0032**	0.0033
	(0.0054)	(0.0018)	(0.0015)	(0.0022)
Foreign R&D share	0.0171***	-0.0030	0.0096***	-0.0136***
	(0.0056)	(0.0026)	(0.0018)	(0.002)
SHC R&D share	-0.0076	0.0080**	0.0062**	0.0123***
	(0.0073)	(0.0034)	(0.003)	(0.0026)
Internation R&D_Firm	0.0002	-0.0287	-0.0468*	-0.0103
	(0.012)	(0.022)	(0.028)	(0.019)
Internation R&D_Industry	-0.0005	0.0453***	-0.0236***	0.0585***
	(0.0075)	(0.0042)	(0.0051)	(0.0077)
Initial Technical Efficiency	-0.373***	-0.243***	-0.652***	-0.501***
	(0.035)	(0.02)	(0.019)	(0.018)

Preliminary Result (5)

	TFP change			Technical Change			Efficicncy Change		
	firm level	industrial le	int'l level	firm level	industrial le	int'l level	firm level	industrial lev	int'l level
TE_init	-0.203***	-0.202***	-0.194***	-0.183***	-0.181***	-0.186***	-0.493***	-0.493***	-0.483***
lnage	0.001	0.000	0.001	0.00349*	0.00383*	0.00356*	0.003	0.002	0.004
lnemp	-0.0215***	-0.0223***	-0.0223***	0.0168***	0.0168***	0.0164***	0.000	0.000	0.001
Herfind	0.187***	0.105*	0.085	0.045	0.054	0.034	0.031	-0.097	-0.057
lnia_pp	0.00468***	0.00478***	0.00497***	-0.00413***	-0.00400***	-0.00448***	-0.001	-0.001	0.000
lnedu_pp	0.0731***	0.0724***	0.0722***	-0.0410***	-0.0399***	-0.0419***	0.0527***	0.0516***	0.0531***
lnexport	0.00101***	0.00111***	0.00130***	0.000	0.000	0.000	0.00116**	0.00116**	0.00110**
rd_int	0.936***	0.933***	0.941***	-0.225	-0.226	-0.219	1.383***	1.360***	1.388***
for_share	0.243***	0.243***	0.559***	-0.101	-0.091	-0.361*	0.141	0.137	0.447
hkm_share	0.161**	0.169**	0.183**	-0.137*	-0.123*	-0.127*	0.011	0.012	0.021

- Older and larger firms have greater technical change.
- Training & exports contribute to efficiency change, but not technical change.
- Foreign ownership contributes to TFP growth and efficiency improvement, but not technical change.

Ethnic and OECD FDI

	TECH		EFFCH	
	Intranational spillovers	international spillovers	Intranational spillovers	international spillovers
Domestic R&D share	0.0064***	0.0029**	-0.00551**	-0.0017
	(0.0013)	(0.0014)	(0.0016)	(0.0018)
Ethnic R&D share	-0.0005	0.0031***	0.0000	-0.0038***
	(0.0007)	(0.0008)	(0.0009)	(0.001)
Foreign R&D share	-0.0085***	-0.0083***	0.0031***	0.0027**
	(0.0008)	(0.0009)	(0.0011)	(0.0011)
Internation R&D_Foreign_Firm		0.0125*		-0.016
		(0.007)		(0.0098)
Internation R&D_Ethnic_Firm		0.0112		-0.0051
		(0.0088)		(0.011)
Internation R&D_Foreign_Industry		0.0064***		-0.0031
		(0.0022)		(0.003)
Internation R&D_Ethnic_Industry		-0.0193***		0.0182***
		(0.0021)		(0.0027)

Absorptive capacity

	Techch		Effch	
	R&D as AC	Edu as AC	R&D as AC	Edu as AC
	1	2	3	4
GlobalRD*foreign_firm*AC	-1.72E-05	-2.83E-07	2.41E-05	1.55E-07
	-1.21E-05	-4.06E-07	-1.74E-05	-5.07E-07
GlobalRD*Ethnic_firm*AC	-4.71E-06	-1.17E-07	-4.69E-06	-2.89E-07
	-9.26E-06	-7.71E-07	-1.57E-05	-6.10E-07
GlobalRD*foreign_industry*AC	0.0630***	0.0196***	-0.0357***	-0.0127***
	-0.0036	-0.0022	-0.0043	-0.0028
GlobalRD*Ethnic_industry*AC	-0.0729***	-0.0191***	0.0338***	0.0102***
	-0.0046	-0.0025	-0.0054	-0.0030
Observations	157693	156973	157693	156973
R-squared	0.689	0.689	0.407	0.409

The effects of R&D and training are consistent.

R&D shows greater effect in assimilation of international knowledge spillovers through openness of the industry.

Note: Control variables included

Robustness check: equation system results

	Techch		Effch	
	R&D as AC	Edu as AC	R&D as AC	Edu as AC
	1	2	3	4
	techch	techch	effch	effch
GlobalRD*foreign_firm*AC	-8.77E-06	2.33E-07	1.35E-05	-3.45E-07
	-1.25E-05	-5.08E-07	-1.61E-05	-6.52E-07
GlobalRD*Ethnic_firm*AC	-4.43E-07	3.94E-07	-6.81E-06	-5.15E-07
	-8.11E-06	-6.24E-07	-1.04E-05	-8.01E-07
GlobalRD*foreign_industry*AC	0.0631***	0.0197***	-0.0357***	-0.0126***
	-0.0037	-0.0021	-0.0048	-0.0027
GlobalRD*Ethnic_industry*AC	-0.0731***	-0.0192***	0.0338***	0.0100***
	-0.0044	-0.0023	-0.0057	-0.0030
Observations	157693	156973	157693	156973
R-squared	0.689	0.689	0.407	0.409

Note: Control variables included

Conclusions (1)

1. Neither the foreign nor the indigenous firms dominate the technological frontier in China
2. In low- and medium-technology sectors, more indigenous firms stand on the frontier; in the high-technology sector, foreign firms dominate the frontier
3. A period in the post-reform Chinese economy with productivity growth driven by technical change
4. Collective R&D in indigenous firms are the major drivers of indigenous technical change in China.

Conclusions (2)

1. FDI has contributed to the static technological capabilities of the economy
2. FDI from non-ethnic Chinese investors has serve as an effective vehicle of international transfer of technological knowledge.
3. R&D activities of foreign firms in China have exerted a significant productivity depression effects on indigenous firms.
4. R&D activities play a significant role in the assimilation of advanced technology spillovers through openness of the industry to FDI from OECD countries.

Policy implications

1. Developing countries are not only users of new tech., but also creators of certain new tech.
2. Upgrading with 'two-legs'
3. Encourage innovation by indigenous firms so as to build up dynamic indigenous technological capabilities, and better assimilation of knowledge spillovers.
4. Encourage FDI from industrialised countries to benefit from global technology advancement
5. Appropriateness of North vs South technology in LDCs

Reference

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Thanks

Comments and Suggestions are welcome!