

China's Industrial Productivity Revolution

**A Stochastic Frontier Production Function
Analysis of China's Large and Medium Industrial
Enterprises during 1995-2002**

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TFP Growth and its Decomposition

- Production Function with Frontier and Technical Inefficiency:

$$y_{it} = f(x_{it}, t) \exp(-u_{it})$$

- Total Factor Productivity (TFP) due to:
 - Frontier Technology Progress (FTP)
 - Changes in Technical Efficiency (TE) Relative to the Frontier
 - Allocating Efficiency (AE)
 - Scale Economy (SE)

Growth of TFP

- y : actual output
- S_j : share of costs by input x_j
- growth accounting:

$$TFP = \dot{y} - \sum_j S_j \dot{x}_j$$

Frontier Technology Progress (FTP)

- $f(x, t)$: frontier production function
- X : vector of inputs
- t : time trend
- FTP: output increase due to broadly defined technology progress such as the use of new technology, new management, new institutions, etc. given the same levels of inputs

$$FTP = \partial \ln f(x, t) / \partial t$$

Technical Efficiency (TE) Relative to Frontier and its Change

- **TE: Ratio of actual output to frontier output:**

$$TE_{i\tau} = \exp(-u_{i\tau})$$

- **Change of TE:**

$$\dot{TE} = -du / dt$$

Allocative Efficiency (AE) of Inputs

- λ_j : output elasticity of input j
- S_j : share of costs by input j
- x_j : input j
- AE: Allocative Efficiency due to more cost-effective use of inputs

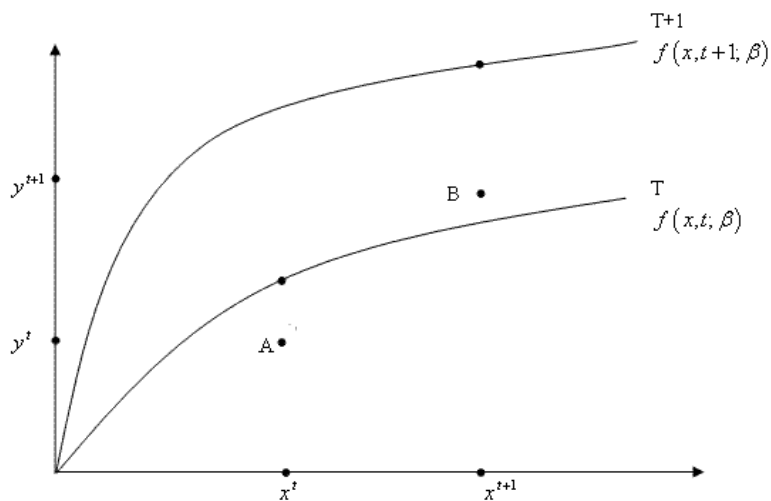
$$AE = \sum_j (\lambda_j - S_j) \dot{x}_j$$

Scale Economy

- RTS: output elasticity of scale or return to scale
- λ_j : output elasticity of input j
- x_j : input j

$$SE = (RTS - 1) \sum_j \lambda_j \dot{x}_j$$

FTP and TE: An Illustration



图一、全要素生产率分解示意图

Time-Varying Log Stochastic Frontier Production Function

$$\ln y_{it} = \alpha_0 + \sum_j \alpha_j \ln x_{jit} + \alpha_T t + \frac{1}{2} \sum_j \sum_l \beta_{jl} \ln x_{lit} \ln x_{jit} + \frac{1}{2} \beta_{TT} t^2 + \sum_j \beta_{Tj} t \ln x_{jit} + v_{it} - u_{it}, \quad j,l = L,k,$$

$$v_{it} \sim iid N(0, \sigma_v^2)$$

$$u_{it} = u_i \exp[-\eta(t - T)] \quad u_i \sim N^+(\mu, \sigma_u^2)$$

Data Sources

- National Bureau of Statistics annual survey on large and medium industrial enterprises during 1995-2002 with about 22,000 firms each year
- After screening out observations with incomplete data, negative value added, data with input errors, etc., the total observations for the imbalanced panel data set is 177,086 with about 21,000 for each year
- The significance of sample enterprises in the Chinese economy:
 - Number of enterprises is about 12% of all industrial enterprises with sales above 5 million RMB
 - About 16.7% of the total industrial employment
 - About 40% of the total industrial value added
 - Total value added is about 14% to 19% of GDP
- Price deflators
 - Estimated output deflator
 - Estimated fixed capital deflator

Definition of Key Variables

- y : deflated industrial value added
- K : deflated net value of fixed capital
- L : average number of employees
- S_K : interest expenses and current depreciation
- S_L : wages, bonuses, expenses on labor welfare and insurances

TFP Growth by Sector

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[37]Transport equipment	-5.4	-0.3	12.3	11.1	14.3	26.6	35.4	17.8
[42]Instruments	4.2	2.1	32.2	16.8	19.6	16.0	15.8	16.0
[23]Printing	19.4	9.4	16.2	17.1	4.7	21.1	9.5	13.8
Average	-4.3	-0.7	3.0	7.5	11.2	8.2	14.0	6.8
[46]Tap water	-5.4	-12.6	2.6	-1.8	-12.4	2.5	-3.1	-4.0
[44]Power	-13.0	-7.1	-9.6	-5.0	-4.1	-4.0	4.4	-4.1
[25]Petroleum processing	-22.6	-13.9	-22.1	-9.1	-8.6	8.4	17.9	-4.6

TFP Growth due to FTP

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[41]Electronics and telecom	13.68	16.87	20.04	23.11	26.56	29.84	33.25	26.33
[32]Pressing ferrous	3.29	9.48	15.65	21.88	28.15	34.41	40.73	24.43
[37]Transport equipment	1.31	7.13	13.07	19.00	25.07	31.15	37.19	23.03
Average	2.80	5.94	9.01	12.30	15.30	18.89	22.60	13.95
[25]Petroleum processing	-7.73	-5.35	-2.45	0.55	3.22	6.16	8.83	1.40
[7]Petroleum extraction	2.72	1.43	-0.11	1.06	3.57	0.22	-1.69	0.98
[44]Power	-5.19	-3.93	-2.30	-0.73	0.76	2.40	3.89	0.17

TE: Ratio of Actual Output to Frontier Output

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[16]Tobacco	0.60	0.57	0.57	0.55	0.53	0.51	0.50	0.55
[8]Ferrous mining	0.58	0.55	0.47	0.51	0.49	0.48	0.50	0.51
[22]Paper-making	0.49	0.47	0.48	0.47	0.45	0.44	0.42	0.46
Average	0.32	0.32	0.32	0.31	0.30	0.30	0.29	0.31
[40]Electric equipment	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.16
[42]Instruments	0.15	0.14	0.16	0.15	0.15	0.15	0.15	0.15
[41]Electronics and telecom	0.13	0.13	0.14	0.13	0.11	0.11	0.10	0.12

TFP Growth due to TE

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[46]Tap water	0.6	0.6	0.6	0.6	0.8	0.8	0.8	0.7
[44]Power	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
[10]Non-metal mining	-2.4	-2.3	-2.4	-2.3	-2.2	-2.2	-2.4	-2.3
Average	-6.4	-6.5	-6.6	-6.7	-7.0	-7.4	-7.9	-7.1
[15]Beverage	-10.7	-11.0	-11.1	-11.5	-11.8	-12.1	-12.6	-11.6
[29]Rubber	-9.6	-10.5	-11.3	-11.1	-12.3	-13.2	-15.3	-12.1
[41]Electronics and telecom	-14.5	-14.3	-13.9	-14.6	-15.2	-15.2	-15.9	-15.0

TFP Growth due to AE

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[7]Petroleum extraction	7.594	3.733	6.594	4.172	4.867	1.753	4.435	4.440
[23]Printing	6.426	5.464	4.784	4.797	2.374	3.699	2.373	3.976
[8]Ferrous mining	0.263	0.940	1.134	-0.143	2.836	3.404	9.573	3.062
Average	-0.412	0.198	-0.205	-0.046	0.370	-0.260	0.285	0.019
[15]Beverage	-2.664	-2.070	-2.476	-3.098	-0.951	-1.195	-1.213	-1.874
[25]Petroleum processing	-6.626	-2.700	-2.989	-3.405	-1.977	-0.257	0.145	-2.229
[44]Power	-3.747	-0.158	-4.459	-2.808	-2.993	-2.680	-0.647	-2.378

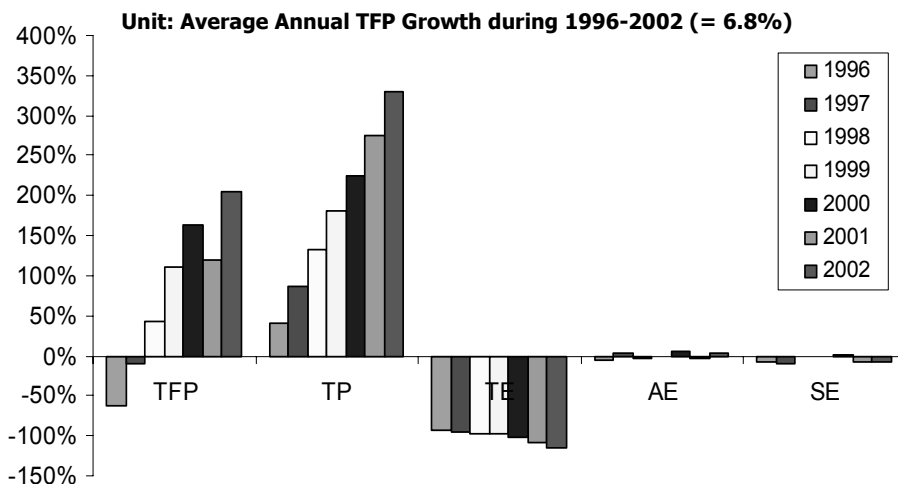
Return To Scale (RTS) by Sector

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[16]Tobacco	1.373	1.392	1.398	1.406	1.421	1.441	1.456	1.417
[15]Beverage	1.089	1.081	1.066	1.047	1.010	0.971	0.940	1.022
[18]Garments	0.958	0.966	0.978	0.993	1.004	1.006	1.012	0.993
Average	0.925	0.925	0.924	0.911	0.894	0.889	0.881	0.903
[42]Instruments	0.690	0.700	0.713	0.717	0.722	0.721	0.723	0.715
[20]Timber	0.665	0.677	0.693	0.708	0.713	0.728	0.724	0.708
[45]Gas production	0.524	0.548	0.588	0.630	0.674	0.688	0.714	0.657

TFP Growth due to SE

IND2 / %	1996	1997	1998	1999	2000	2001	2002	Average
[16]Tobacco	7.31	0.15	0.95	3.98	-0.15	-0.36	-1.61	1.07
[36]Special equipment	-2.40	-0.48	0.78	2.91	-0.55	2.77	0.75	0.59
[9]Nonferrous mining	0.78	-2.07	3.15	-0.05	-0.09	0.96	1.66	0.57
Average	-0.58	-0.63	-0.07	-0.04	0.06	-0.53	-0.52	-0.33
[21]Furniture	-7.79	-0.89	-2.21	-1.96	-0.41	-3.69	-2.20	-2.60
[45]Gas production	-7.05	-12.81	-6.77	-2.99	-6.69	2.55	-1.11	-3.35
[20]Timber	-11.21	-4.76	0.04	-4.67	-3.85	-2.98	-0.96	-3.53

Dynamics of TFP Growth



Summary of Major Findings:

- Average annual growth of TFP in China's large and medium industrial enterprises sector is as high as 6.8% with a rising trend during 1996-2002.
- The contribution to TFP growth by Frontier Technology Progress reached as much as 14 percentage points a year on average.
- The decline in Technical Efficiency (Relative to the Frontier) reduced the growth of TFP by 7.1 percentage points a year on average.
- Allocative Efficiency contributed on average only 0.02 percentage points a year to the growth of TFP.
- Scale Dis-Economy slowed the growth of TFP by 0.33 percentage points a year.
- **At the turn of the century, the most important part of China's industry is in the middle of an industrial productivity revolution driven by both frontier technological catching up and expanding gaps of technical efficiency among enterprises.**

Factors Driving FTP
(to be examined further)

- **Competition among enterprises in each sector**
- **FDI**
- **Privatization**
- **Business expansion or cycle**

Thank you