Regional Disparities of Industrial Productivity Growth in China

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Motivations (1)- Previous studies

- Regional income disparities in China – increasing or decreasing?
- Regional income – converging (conditionally)? i.e. growth of a province is inversely related to its initial level. [Based on Solow's growth model.]
- There are limitations.

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Motivations (2) – the importance of sectoral analysis

- Some studies use GDP per capita for analysis. However, underlying the growth models are production functions – it is more appropriate to analyze output per worker (labour productivity) instead of output per capita.
- Sectoral analysis of labour productivity is very useful for understanding economic growth. For stance, Bernard and Jones (1996, AER) found that convergence in labour productivity across countries is not driven by the manufacturing sector.
- This paper attempts to analyze the regional disparities in the productivity (TFP and labour productivity) of China's industrial sector.

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Motivations (3) – methodological issues

- The Barro-regressions cannot distinguish different patterns of distribution dynamics, e.g. from a uni-modal to a bimodal distribution (twin peaks), the overtaking of some economies by others, etc. [Criticisms raised by Quah (1993, 1996, 1997)]
- Färe et al. (1994, AER) propose a new perspective to tackle the issue – technical change pushes up production frontier while technical efficiency changes reflect the catch-up phenomenon.

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Motivations (4) – new perspectives

- Kumar and Russell (2002, AER)
  - Further extends Färe et al. – decompose labour productivity into technical changes, technological catch-up and capital deepening
  - Conduct analysis of distribution dynamics in the spirit of Quah.
- This paper is an application of Kumar and Russell (2002) to the provincial data of China's industrial sector.

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Methodology (1) – Definitions

•Each province is treated as a production unit.
•The production technology can be represented by

$$T_t = \left\{ (Y, L, K) \in R_+^3 \middle| Y \le \sum_j z^j Y_t^j, L \ge \sum_j z^j L_t^j, K \ge \sum_j z^j K_t^j, z^j \ge 0 \forall j \right\}$$

The technical efficiency can be represented by the following output distance function

$$E_t\,(Y_t^j, L_t^j, K_t^j) = \min\left\{ \lambda \middle| \left\langle Y_t^j / \lambda, L_t^j, K_t^j \right\rangle \in T_t \right\}$$

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Methodology (2) – DEA estimation

- We used Data Envelopment Analysis (DEA) to estimate the distance function.
- It involves solving linear programs for each unit:

$$\min_{\lambda, z^i, \ldots, z^J} \lambda \textit{ subject to}$$

$$Y^j / \lambda \leq \sum_k z^k Y_t^k \qquad L^j \geq \sum_k z^k L_t^k$$

$$K^j \geq \sum_k z^k K_t^k \qquad z^k \geq 0, \forall k$$

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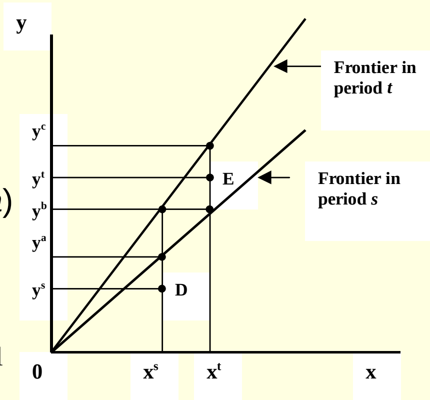
Methodology (3) - Färe *et al.* (1994)

- Produce at D in period s;
- Produce at E in period t
- TE(s) = ys/ya
- TE(t) = yt/yc)
- Productivity (TFP) index
- = *(yt/ys)*/*(yb/ya)* =*(yt/yb)*/*(ys/ya)*
- = [*(yt/yc)/(ys/ya)*] / (*yb/yc*)



TFP index (*TFP*) = technological catch up (*EFF*) × technical change (*TECH*)

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Methodology (4a)
- Kumar and Russell (2002)

A production unit produces at point A

(k_b, y_b)) in the base year

It produces at point B

(k_c, y_c) in current year.

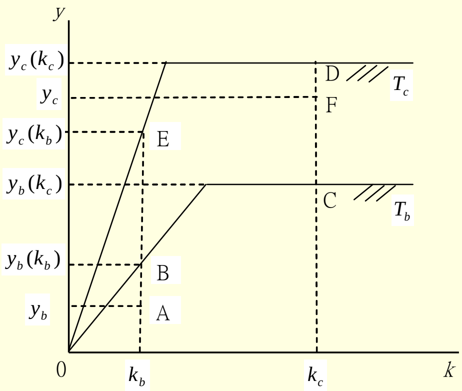
Then, the frontier outputs are

$$\overline{y_b}(k_b) = y_b / e_b$$

$$\overline{y_c}(k_c) = y_c / e_c$$

respectively, where e_b and e_c

are the technical efficiencies.

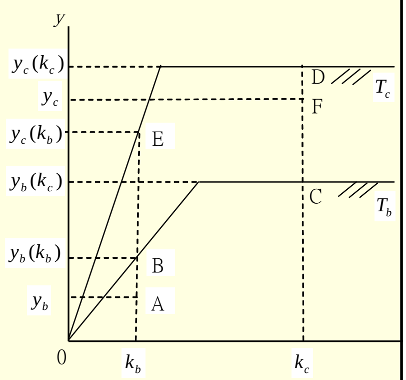


Methodology (4b)
- Kumar and Russell (2002)

- The growth of labour productivity can be represented by

$$\frac{y_c}{y_b} = \frac{e_c \times \overline{y_c}(k_c)}{e_b \times \overline{y_b}(k_b)}$$

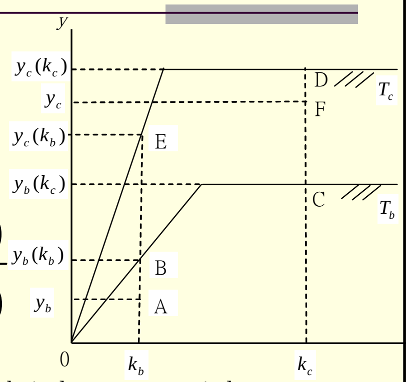
Multiply both the nominator and denominator by $\overline{y_b}(k_c)$



$$\frac{y_c}{y_b} = \frac{e_c}{e_b} \times \frac{\overline{y_c}(k_c)}{\overline{y_b}(k_c)} \times \frac{\overline{y_b}(k_c)}{\overline{y_b}(k_b)}$$

Labour productivity growth	=	technological catch-up	×	technical progress	×	capital deepening
(*LABP*)		(*EFF*)		(*TECH*)		(*KACC*)

- Alternatively, multiply both the nominator and denominator by $\overline{y_c}(k_b)$



$$\frac{y_c}{y_b} = \frac{e_c}{e_b} \times \frac{\overline{y_c}(k_b)}{\overline{y_b}(k_b)} \times \frac{\overline{y_c}(k_c)}{\overline{y_c}(k_b)}$$

Labour productivity growth	=	technological catch-up	×	technical progress	×	capital deepening
(*LABP*)		(*EFF*)		(*TECH*)		(*KACC*)

Methodology (4c) - Kumar and Russell (2002)

Taking the geometric mean of the above two indexes:

$$\frac{y_c}{y_b} = \frac{e_c}{e_b} \times \left(\frac{\overline{y_c}(k_c)}{\overline{y_b}(k_c)} \times \frac{\overline{y_c}(k_b)}{\overline{y_b}(k_b)} \right)^{0.5} \times \left(\frac{\overline{y_b}(k_c)}{\overline{y_b}(k_b)} \times \frac{\overline{y_c}(k_c)}{\overline{y_c}(k_b)} \right)^{0.5}$$

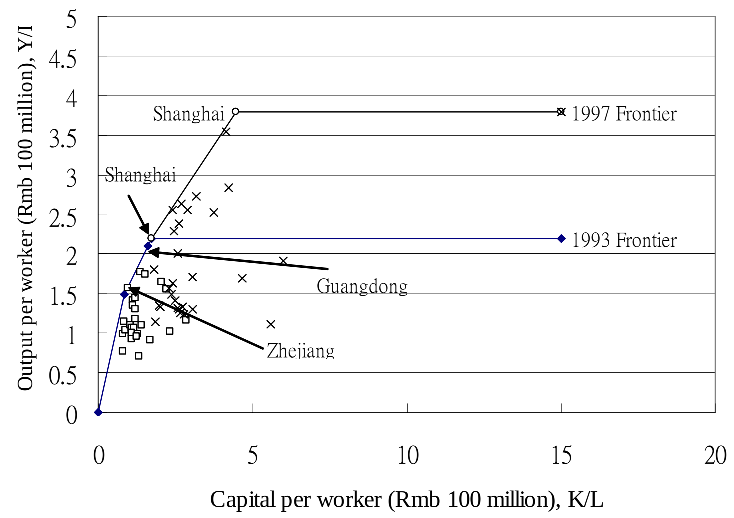
Labour productivity growth	=	technological catch-up	×	technical progress	×	capital deepening
(*LABP*)		(*EFF*)		(*TECH*)		(*KACC*)

Results (1)

	(I) 1993-1997					
	Industrial value-added *(INDVA)*	Total factor productivity *(TFP)*	Labour productivity (*LABPROD*)	Technological catch-up (*EFF*)	Technical change (*TECH*)	Capital deepening (*KACCUM*)
1 Beijing	1.292	1.386	1.716	1.031	1.345	1.238
2 Tianjin	2.107	1.460	2.367	1.176	1.241	1.622
3 Hebei	1.789	1.348	1.873	1.218	1.107	1.390
4 Shanxi	1.319	1.018	1.374	0.915	1.113	1.350
5 Inner Mongolia	1.587	1.338	1.769	1.184	1.130	1.322
6 Liaoning	1.046	0.812	1.121	0.733	1.107	1.381
7 Jilin	1.199	0.931	1.357	0.835	1.115	1.458
8 Heilongjiang	1.240	1.095	1.438	0.998	1.097	1.314
9 Shanghai	1.437	1.317	1.735	1.000	1.317	1.317
10 Jiangsu	1.494	1.079	1.626	0.994	1.085	1.507
11 Zhejiang	1.471	1.075	1.777	0.959	1.121	1.653
12 Anhui	1.598	1.030	1.569	1.023	1.007	1.524
13 Fujian	2.200	1.290	1.893	1.126	1.146	1.468
14 Jiangxi	1.114	0.723	1.161	0.713	1.015	1.605
15 Shandong	1.527	1.134	1.371	1.020	1.112	1.209
16 Henan	1.725	1.130	1.574	1.057	1.069	1.392
17 Hubei	1.646	1.170	1.625	1.072	1.091	1.389
18 Hunan	1.508	1.074	1.749	1.043	1.030	1.629
19 Guangdong	1.683	1.261	1.689	0.984	1.282	1.339
20 Guangxi	1.211	0.825	1.185	0.710	1.163	1.436
21 Hainan	1.289	0.990	1.232	0.709	1.395	1.244
22 Chongqing						
23 Sichuan	1.239	0.912	1.441	0.845	1.079	1.580
24 Guizhou	1.229	0.933	1.248	0.860	1.085	1.338
25 Yunnan	1.509	1.134	1.541	0.963	1.178	1.359
26 Shaanxi	1.300	0.877	1.221	0.847	1.036	1.391
27 Gansu	1.205	0.959	1.219	0.853	1.125	1.271
28 Qinghai	1.044	0.834	0.963	0.555	1.503	1.155
29 Ningxia	1.434	1.218	1.435	1.048	1.163	1.178
30 Xinjiang	1.653	1.372	1.680	0.970	1.415	1.224

	(II) 1999-2002					
	Industrial VA *(INDVA)*	Factor produc *(TFP)*	Labour productivity (*LABPROD*)	nological catc (*EFF*)	echnical chan (*TECH*)	apital deepenir (*KACCUM*)
1 Beijing	1.436	1.490	1.659	1.005	1.482	1.114
2 Tianjin	1.756	1.679	1.854	1.161	1.446	1.104
3 Hebei	1.402	1.236	1.501	0.784	1.577	1.214
4 Shanxi	1.515	1.266	1.573	0.806	1.571	1.242
5 Inner Mongolia	1.586	1.624	1.825	1.122	1.447	1.124
6 Liaoning	1.481	1.553	1.846	1.046	1.485	1.189
7 Jilin	1.557	1.703	2.003	1.097	1.552	1.177
8 Heilongjiang	1.320	1.158	1.708	0.756	1.532	1.475
9 Shanghai	1.464	1.467	1.532	1.000	1.467	1.044
10 Jiangsu	1.570	1.319	1.623	0.829	1.591	1.231
11 Zhejiang	1.967	1.386	1.460	0.844	1.641	1.054
12 Anhui	1.526	1.203	1.750	0.738	1.631	1.454
13 Fujian	1.737	1.366	1.436	0.893	1.529	1.051
14 Jiangxi	1.449	1.297	1.817	0.804	1.613	1.401
15 Shandong	2.134	1.640	2.051	1.000	1.640	1.251
16 Henan	1.348	1.078	1.497	0.663	1.627	1.388
17 Hubei	1.286	1.376	1.569	0.877	1.569	1.140
18 Hunan	1.570	1.324	1.835	0.824	1.606	1.387
19 Guangdong	1.575	1.351	1.355	0.867	1.559	1.002
20 Guangxi	1.422	1.501	1.681	1.000	1.500	1.121
21 Hainan	1.624	1.553	1.530	1.094	1.419	0.986
22 Chongqing	1.589	1.823	1.946	1.192	1.529	1.068
23 Sichuan	1.649	1.759	1.979	1.155	1.523	1.125
24 Guizhou	1.436	1.155	1.553	0.731	1.580	1.344
25 Yunnan	1.404	1.429	1.624	0.959	1.490	1.137
26 Shaanxi	1.479	1.301	1.767	0.827	1.574	1.357
27 Gansu	1.703	1.463	1.904	0.924	1.583	1.301
28 Qinghai	1.349	1.875	1.875	1.224	1.532	1.000
29 Ningxia	1.297	1.348	1.519	0.871	1.547	1.128
30 Xinjiang	1.251	1.634	1.855	1.091	1.497	1.136

(a) Frontiers of Chinese industry (1993 and 1997)



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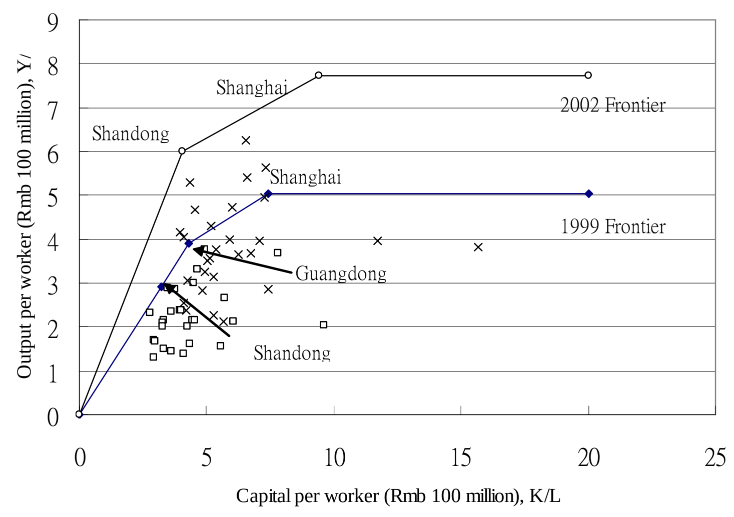
(b) Frontiers of Chinese industry (1999 and 2002)



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Results (2) - National averages

Table 2 Decomposition of Labour productivity

(Annualized growth, %)

		Industrial VA *(INDVA)*	Capital *(K)*	Labour *(L)*	Total Factor productivity *(TFP)*	Labour productivity (*LABPROD*)	technological catch-up (*EFF*)	Technical change (*TECH*)	Capital deepening (*KACCUM*)
(I)	*1993-1997*	10.2	21.3	-1.3	1.9	10.4	-1.7	3.7	8.4
(II)	*1999-2002*	16.9	7.8	-1.7	12.7	19.2	-2.5	15.6	5.8

Note: INDVA, K and L are simple averages while other variables are geometric means of provincial figures.

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Results (3) – Eastern/Central/Western

Table 3 Decomposition of Labour productivity (3-region analysis)

(Annualized growth, %)

	Industrial VA *(INDVA)*	Capital *(K)*	Labour *(L)*	Total Factor productivity *(TFP)*	Labour productivity (*LABPROD*)	technological catch-up (*EFF*)	Technical change (*TECH*)	Capital deepening (*KACCUM*)
	(I) 1993-1997							
Eastern	11.1	22.1	-1.4	4.2	13.2	-0.4	4.7	8.6
Central	9.9	20.0	-1.1	0.3	10.1	-1.3	1.6	9.8
Western	7.1	21.0	-1.5	0.6	7.8	-3.5	4.2	7.2
	(II) 1999-2002							
Eastern	18.7	8.1	1.2	13.2	17.2	-1.7	15.2	3.5
Central	12.3	8.3	-5.2	8.8	19.6	-6.7	16.6	9.9
Western	14.6	6.3	-5.8	14.8	20.8	-0.5	15.4	5.3

Note: INDVA, K and L are simple averages while other variables are geometric means of provincial figures.

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Results (4) – 8 Major regions

Region	Provincial units
1 Northeastern	Liaoning, Jilin, Heilongjiang
2 North coastal	Beijing, Tianjin, Hebei, Shantong
3 East coastal	Shanghai, Jiangsu, Zhejiang
4 South coastal	Fujian, Guangdong, Hainan
5 Middle Yellow River	Shanxi, Inner Mongolia, Henan and Shaanxi
6 Middle Yangzi River	Anhui, Jiangxi, Hubei, Hunan
7 Southwestern	Guangxi, Sichuan, Guizhou, Yunnan
8 Northwestern	Gansu, Qinghai, Ningxia, Xinjiang

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Table 4 Decomposition of Labour productivity (8-region analysis)

	Industrial VA *(INDVA)*	Capital *(K)*	Labour *(L)*	Total Factor productivity *(TFP)*	Labour productivity (*LABPROD*)	technological catch-up (*EFF*)	Technical change (*TECH*)	Capital deepening (*KACCUM*)
	(I) 1993-1997							
1 Northeastern	3.2	17.9	-2.6	-1.6	6.7	-4.0	2.6	8.4
2 North coastal	12.5	18.9	-0.5	7.3	15.8	2.6	4.6	7.9
3 East coastal	10.1	23.1	-3.3	3.6	14.4	-0.4	4.0	10.4
4 South coastal	15.2	27.5	0.9	4.1	12.1	-2.0	6.2	7.7
5 Middle Yellow River	10.9	20.3	0.6	1.9	10.1	-0.2	2.1	8.1
6 Middle Yangzi River	11.1	21.4	-1.0	-0.4	10.8	-1.3	0.9	11.3
7 Southwestern	6.4	23.4	-2.3	-1.4	7.7	-4.3	3.0	9.3
8 Northwestern	7.8	18.1	-0.1	1.8	6.7	-4.5	6.6	4.8
National	10.2	21.3	-1.3	1.9	10.4	-1.7	3.7	8.4
	(II) 1999-2002							
1 Northeastern	13.1	10.0	-7.7	13.2	22.7	-1.6	15.0	8.4
2 North coastal	22.2	8.1	-0.6	14.5	20.6	-0.7	15.3	5.3
3 East coastal	17.8	8.8	2.4	11.6	15.4	-3.9	16.1	3.4
4 South coastal	17.0	6.7	5.4	12.4	12.9	-1.8	14.5	0.4
5 Middle Yellow River	12.8	8.8	-3.4	9.2	18.4	-5.7	15.8	8.4
6 Middle Yangzi River	12.6	5.4	-5.8	9.1	20.3	-6.8	17.1	10.2
7 Southwestern	15.1	5.1	-5.4	14.8	20.5	-0.2	15.1	4.9
8 Northwestern	13.1	8.0	-7.0	16.2	21.2	0.6	15.5	4.3
National	16.9	7.8	-1.7	12.7	19.2	-2.5	15.6	5.8

Note: INDVA, K and L are simple averages while other variables are geometric means of provincial figures.

Further extensions

- The decomposition method of Kumar and Russell (2002) is used and regional averages are obtained.
- It is possible to do the analysis of the distribution dynamics of productivity changes. Since we have only small number of observations, bootstrap approximations is needed for reliable statistical inferences.

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