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Explaining Spatial Convergence of China's Industrial Productivity*

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Abstract

This article investigates the conditions that may auger a reversal of China's increasingly unequal levels of regional industrial productivity during China's first two decades of economic reform. Using international and Chinese firm and industry data over the period 1995–2004, we estimate a productivity growth–technology gap reaction function. We find that as China's coastal industry has closed the technology gap with the international frontier, labour productivity growth in the coastal region has begun to slow in relation to the interior. This may serve as an early indicator of China's initial movement towards reversing growth in spatial income inequality.

I. Introduction

During much of the first two decades of China's economic reforms beginning in 1980, levels of industrial productivity across regions became increasingly unequal with the advantage accruing to the coastal provinces that captured most of the surge in foreign direct investment and led the way in enterprise restructuring. However, recent research has shown a tendency for industrial productivity levels across China's regions to converge. This article investigates the underlying conditions that may be driving a spatial convergence of productivity levels within China. The article specifically investigates the importance of the technology gap between industrial productivity in different industries and provinces and the international frontier as defined by counterpart US industries. Under Gerchenkrone's thesis of the 'advantages of backwardness',[1] we might expect China's interior industries over time to close the efficiency gap with their counterpart coastal industries. Our findings provide support for this expectation.

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[1] Gerchenkron (1962).

This article adopts elements of the empirical research strategy used by Jefferson, Hu and Su (2006, JHS for short hereafter). However, to test our hypothesis, we employ a substantially different dataset. We support our argument with empirical evidence using industry-province level data. Our empirical analysis includes 14 major industrial branches in 31 provinces and municipalities (including autonomous regions) from 1995 to 2004. The industrial branch data were constructed by regrouping the Standard Industrial Classification (SIC) 2-digit industry level data for each of China's 31 provinces. We use the set of industry-province observations to estimate how the initial productivity gap with the international frontier affects future labour productivity growth. Unlike previous work, we also employ constant price and PPP-adjusted data to test how the hypothesis holds up when we control for price and exchange rate differences across the Chinese and US economies.

The remainder of the article is organized as follows: in the next section, we provide an overview of the patterns of industrial productivity growth across China's main regions. In sections III and IV, we first outline our regression model and then describe the data used for its estimation. Section V presents our empirical results. The final section presents our conclusions.

II. Overview of China's productivity growth

Based on China's industrial large and medium-size enterprises (LMEs), this section compares the *level* and *growth* of China's industrial labour productivity across different regions.[2] In Table 1, panel 3, we show China's industrial labour productivity and growth rate by region, measured in current Yuan, from 1995 to 2004. First, the table shows that large disparities exist in levels of productivity across regions, with the coastal region positioned well ahead of other regions. For example, in 1995, industrial labour productivity in the coastal region is around 32,150 Yuan per employee-year compared with 17,730 Yuan per employee-year in the western region, a ratio of 2.15 : 1. That is, labour productivity in the west is only about 46% of the east (see Table 2 for more details). This gap, however, declines in subsequent years. For instance, in 2004, labour productivity in the coastal region rises to 119,830 Yuan compared with 91,340 Yuan per employee-year in the west, resulting in a smaller ratio of 1.4 : 1. In terms of relative productivity to the coastal region, labour productivity in the west increased from 46% of that in the coastal region in 1995 to 71% in 2004 (again refer to Table 2 for details).

As implied by the above inter-temporal comparisons, the interior regions have enjoyed much faster rates of productivity growth than the coastal region. For example, in constant Yuan terms, from 1995 to 2004, the central region experienced a staggering 379% increase in its labour productivity, while the growth in the coastal region was much slower, at 273%, or two-thirds of the growth rate in the central region. In Table 1, we also report levels and rates of growth of productivity in constant prices and purchasing power parity; the results are qualitatively unchanged relative to the picture we see for current Yuan measures. In general, during the 1995–2004 period, among all four regions, the northeastern region grew the fastest; it was followed by the western region and central region. In

[2]The distribution of China's provinces and autonomous municipalities across the four regions is shown in appendix B.

TABLE 1

China's industrial labour productivity and growth by region

Area	1995	2000	2004	Percentage change of 1995–2000	2000–2004	1995–2004
(a) In 1997 PPP, thousands of US$ per employee						
Coastal	6.06	12.53	20.47	106.8	63.4	237.8
Northeast	2.57	8.05	17.45	213.2	116.8	579.0
Centre	3.15	5.67	12.53	80.0	121.0	297.8
West	2.79	6.57	14.58	135.5	121.9	422.6
(b) In 1997 constant Chinese Yuan (thousands) per employee						
Coastal	29.82	66.76	108.24	123.9	62.1	263.0
Northeast	18.96	61.04	142.89	222.0	134.1	653.7
Centre	16.16	30.89	80.58	91.2	160.8	398.8
West	16.46	39.40	96.45	139.4	144.8	486.1
(c) In current Chinese Yuan (thousands) per employee						
Coastal	32.15	70.57	119.83	119.5	69.8	272.8
Northeast	20.81	58.02	127.35	178.8	119.5	512.0
Centre	17.48	32.90	83.73	88.2	154.5	379.0
West	17.73	39.97	91.34	125.4	128.5	415.1

TABLE 2

China's industrial labour productivity by region (PPP measures normalized by the coastal region)

Area	1995	2000	2004
Coastal	1.00	1.00	1.00
Northeast	0.42	0.64	0.85
Centre	0.52	0.45	0.61
West	0.46	0.52	0.71

relation to labour productivity growth, the coastal region lagged the other three regions. These results are robust for all three productivity measures: current prices, constant prices and PPP measures.

III. The estimation model

Our basic model, shown in equation (1) below is similar to that developed by JHS (2006). However, the data employed and econometric implementation of the two versions exhibit substantial differences. We explain these below.

$$\begin{aligned}[\ln (\mathrm{VA}/L)_{i,j,2004} - \ln (\mathrm{VA}/L)_{i,j,1995}] &= \alpha_0 + \alpha_1 \ln (\mathrm{GAP\_Front})_{i,j,1995}) \\ &+ \alpha_2 \ln (\mathrm{GAP\_Front})_{i,j,1995}{}^*\mathrm{regional\_dummies} \\ &+ \alpha_3 [\ln (\mathrm{GAP\_Front})_{i,j,1995}]^2 \\ &+ \alpha_4 [\ln (\mathrm{VA}/L)_{\mathrm{Front},j,2004} - \ln (\mathrm{VA}/L)_{\mathrm{Front},j,1995}] + \varepsilon_{ij}. \end{aligned} \quad (1)$$

The variables in equation (1) are indexed at industry i, province j and year t. The dependent variable is the growth of labour productivity, at industry-province level for the period from 1995 to 2004. Labour productivity is measured by the value-added per person-year. The main explanatory variable is Gap_Front, or productivity gap between Chinese industries and the international frontier, with the productivity level of the corresponding US industry serving as the proxy. The gap with the frontier is the initial gap at the beginning year, 1995.

We expect the coefficient of the initial productivity gap, or α_1, to be positive. Our hypothesis is that consistent with the 'advantages of backwardness' posited by Gershenkron (1962). Chinese industries with productivity levels farther from the international frontier will exhibit relatively faster productivity growth rates in subsequent years than those with smaller productivity gaps. A central implication of this hypothesis is that these differences in productivity growth across different industry-provinces tend to converge over time. Why do we focus our productivity gap measure on the international frontier? Why do we not conduct the same analysis within China, using the Chinese industries that define China's national industrial technology frontier? There are several reasons.

First, from the analytical perspective, our approach of expressing the initial productivity gap with respect to the international frontier enables us to conduct analysis in international perspective. As our analysis focuses on 'the advantages of backwardness', we need to make a judgment regarding the relative backwardness of China's industries in relation to a relevant frontier. What is the relevant technology frontier? Given that China is an exceedingly open economy with a great deal of capital and technology inflow and international trade, we observe that Chinese industry's productivity growth is significantly influenced by international technology flows. Hence, the relative gap of China's industries and regions with this international technology frontier should be an effective measure of the relative ease with which Chinese enterprises are able to access and absorb these technologies from abroad or from other enterprises, both foreign and Chinese, operating in China that have already absorbed aspects of the foreign technologies. In addition, from an econometric perspective, if we were to measure the productivity gap between China's coastal region and interior regions, we would lose the observations in our regression analysis pertaining to the distances between the coastal industries and the international frontier; such a potential loss of coastal observations will render impossible an analysis on the productivity responses of coastal industries to the frontier productivity gap.

In addition to the linear frontier gap measure represented by the coefficient α_1 shown in equation (1), we posit that the relationship between the gap and the rate of productivity growth may be nonlinear. To model and estimate the possible nonlinearity of the relationship between the frontier gap and the rate of productivity growth, we include a quadratic version of the gap. A negative estimate of $\alpha_3$would show that the relationship is concave, that is, increases in the magnitude of the frontier gap exert positive but diminishing effects on the growth of labour productivity. A positive estimate would imply that rates of productivity growth increase proportionately greater than increases in the magnitude of the gap.

Another main variable we include in our regression is the *growth* of frontier productivity itself. As productivity at the frontier is constantly moving, this variable serves as a control variable and will be useful in our analysis of international productivity convergence. Indeed, the likelihood of China catching up with the US is a function of at least two variables: How fast China is moving up the existing technological ladder, and how fast the US is moving into the next new frontier. The expected sign of the coefficient, α_4, could be either positive or negative. A positive sign would indicate a world of less friction in technology's international spillover or transfer. In contrast, a negative sign may indicate that Chinese industries have increased their specialization in lower-end manufacturing as the international frontier advances forward.

Our model also includes a set of interactive terms between the productivity gap and the regional dummies. These are intended to capture any regional observations that substantially deviate from the productivity reaction function that best fits the overall pattern of data.

Compared with the JHS (2006) paper, we employ a significantly different dataset and different econometric methods to estimate equation (1) above. One notable difference is that the variable GAP_Front, or the initial productivity gap with the international frontier, was derived using industry-level PPPs, instead of a uniform market exchange rate. The common argument for using PPPs vs. market exchange rate is that the former can avoid large fluctuations or volatilities in market exchange rates due to, for example, short-term international capital flows, which tends to greatly distort international productivity comparisons. Since China's official exchange rate remained almost unchanged during 1995–2004, the volatility in the current market was not our major concern. However, under China's fixed exchange rate system, the government set the official exchange rate very arbitrarily. The official exchange rate was fixed at about 8.27 Yuan per US Dollar during 1995–2004. These non-market rates were unable to reflect the relative price and productivity changes between the two countries and tend to distort Yuan-based measures of China's real productivity growth. In addition, when it comes to the use of a PPP exchange rate in international productivity comparisons, there is a strong case to be made for using industry-level PPPs (also called industry-of-origin PPPs) over the regular PPP measure and the official exchange rate. Advantages of the PPP approach are well documented in Maddison and Van Ark (1988) and Van Ark (1993). In a nutshell, industry-of-origin PPPs better capture the industry-specific dynamics, including market structure, technological changes, which are unique to the industry, and it makes industry-specific performance comparisons across countries possible and more accurate.

A second difference with the JHS approach is that this article focuses on the 14 major branches of China's manufacturing industry. The main reason for using 14 industrial branches vs. more detailed two-digit industry classifications as in JHS (2006) is that the ex-factory price index at the two-digit industry level is only available from 2003. But the index for the 14 major industrial branches can be traced back all the way to 1980. Since ex-factory price is vital in deriving our industry-of-origin PPPs, we decided to map our more detailed two-digit industries in LME database into the 14 major industrial branches.

IV. Data

In this section, we describe our datasets and the methods used to calculate the variables in our regression analysis. We use two main datasets in our empirical work. The first dataset is the Large and Medium Enterprises database (LME) from China's National Bureau of

Statistics. This is a rich firm-level dataset that, on average, includes around 20,000 firms per year, from 1995 to 2004. According to our calculation, during these years, this LME dataset covers approximately 60% of China's total industrial output.[3] We drive all industry-province-level variables from the aggregation of the firm-level variables within the LME dataset.

The second dataset is drawn from the European Union's (EU) KLEMS database. The EU KLEMS database is an improved version of the previous *60-industry Database* for international productivity comparison hosted at the University of Groningen.[4] This dataset includes measures of labour productivity at the industry level for all EU countries and the US. Using our self-constructed industry-level PPPs between China and the US, we establish a link between industry-level productivities in China and the EU KLEMS dataset. The method we use to construct these PPP measures is described in Appendix C. Through this linkage, we can easily expand our research scope in the future to include more countries, making it possible to undertake international comparisons of productivities at the industry-level between China and other countries.

Table 1 uses these aggregated data to show comparisons of the output per employee by each of the four regions by year and rate of growth of output per employee by period. Note that the PPP measures show the coastal region with consistently higher productivity levels over the 1995–2004 period. In contrast, the constant and current Chinese Yuan measures show labour productivity in the Northeast, the section with significant raw material production, overtaking the coast in 2004. Using the PPP data, Table 2 normalizes the comparative measures.

The results of industry-level 1997 PPPs are presented in Table 3. The PPP exchange rate for total manufacturing is 5.47 Yuan per US Dollar. In contrast, the official exchange rate in 1997 was set at 8.29.[5] This non-market-based peg used for China's fixed exchange rate system greatly distorts China's relative level of productivity when compared with that of the US – the principal reason for using a different exchange rate to convert China's labour productivity into US dollar equivalents. As shown in Table 3, in general, we observe that those industries with larger degrees of openness to the world trade, that is, those dominating the tradable sectors, tend to have lower PPP exchange rates relative to the average. For example, the PPP for textiles is 1.16 and clothing industry is 1.99. In contrast, those industries that largely remain local, or the non-tradable sectors, tend to have a very high PPP values relative to the 5.47 industry average. For example, the PPP for coal industry is 11.63, petroleum stands at 15.42 and the power industry is 15.9. The higher the value in our production-approach PPP means, the higher relative production cost per unit in that industry, indicating these industries are relatively less cost-efficient.

With industry-level PPPs in hand, we convert China's industrial productivities into US dollars and compare China's productivity level with the international frontier. Table 4 presents our international comparison of productivities between China's total manufacturing in different regions and the US. In 1995, China's total manufacturing productivity was only 6% of the US; by 2004, it had risen to 16%, an increase of 167%. The coastal region leads the international comparison amongst all regions: in 1995, the average productivity

[3]From our own calculation for the year of 2002.
[4]For details, please refer to the description of the new dataset by Timmer, Ympa and Van Ark (2007).
[5]In fact, China fixed its exchange rate to 8.27 Yuan per US dollar during the entire period 1997–2004.

TABLE 3

1997 *PPPs by major Chinese industry branches, Yuan per US dollar*

Branch	*PPPs*
Food and beverages	3.48
Textile	1.16
Clothing	1.99
Leather	4.16
Timber, wood products	6.97
Paper and printing	5.50
Coal	11.63
Petroleum	15.42
Chemicals	6.08
Building materials	3.53
Metallurgical	7.76
Machinery	5.77
Power	15.90
Other manufacturing	3.86
Total manufacturing	5.47

TABLE 4

China's industrial labour productivity vs. international frontier (PPP comparisons)

		Region			
Year	*Whole China*	*Coastal*	*Northeast*	*Centre*	*West*
Ratio of productivity in China to frontier productivity					
1995	0.06	0.08	0.03	0.04	0.04
2000	0.10	0.14	0.09	0.06	0.07
2004	0.16	0.18	0.16	0.11	0.13

in the coastal area was about 8% of the US level, while the western and central regions were only about 4%. In 2004, the coastal region still had higher comparative productivity, 18% of the US level, but the interior regions had narrowed the gap significantly, with the west rising to 13 % and the central region to 11% of the US level.

In Table 5, we report detailed comparisons of industrial productivities between China and the US. The comparative productivities shown in the table are relative productivities expressed in percentage terms with the US levels normalized at 100. In 1995, the most productive Chinese industries relative to the US were the textile and clothing industries, both at about 30% of the US productivity level. The least productive industries were the coal and power industries. Ten years later, in 2004, China further advanced its comparative advantage, with productivities in the textile and clothing industries increasing to 84% and 60% of the US level. Other notable advances include food and beverages industry at 25% of the US level, metallurgical industry at 17% and machinery industry at 16.5%. Our international productivity comparison at the industry level generally confirms certain conditions about China's manufacturing: namely, China enjoys comparative advantages in the lower-end manufacturing industries, whereas, in recent years, productivities in the

TABLE 5

Comparative productivity by manufacturing branch (China/USA, 1995–2004, USA = 100)

	(1) *Food and beverages*	(2) *Textile*	(3) *Clothing*	(4) *Leather*	(5) *Wood products*	(6) *Paper and printing*	(7) *Coal*	(8) *Petroleum*	(9) *Chemicals*	(10) *Building materials*	(11) *Metallur-gical*	(12) *Machinery*	(13) *Power*	(14) *Other manu-facturing*	(15) *Total manu-facturing*
1995	9.6	27.4	30.7	10.1	4.2	3.1	0.5	3.2	3.3	6.8	5.9	4.1	2.1	9.5	5.6
1996	11.5	29.3	41.1	15.3	5.2	5.2	0.7	2.3	4.0	6.6	5.6	4.5	2.5	11.9	6.5
1997	13.3	31.5	37.4	15.1	6.4	5.4	0.7	2.7	4.0	6.3	5.3	5.1	3.0	10.8	6.9
1998	13.0	30.7	36.5	17.3	5.8	5.0	0.7	5.0	4.2	6.6	5.4	6.3	3.9	12.0	7.4
1999	16.7	35.4	34.1	12.7	8.0	5.9	0.7	5.3	4.3	6.9	6.1	7.9	4.0	10.2	8.6
2000	18.2	43.2	38.8	12.2	10.2	6.0	0.8	15.5	4.2	7.6	7.5	9.8	3.6	12.3	10.4
2001	18.8	50.9	45.9	13.2	13.5	7.8	1.2	17.2	4.7	8.8	9.3	12.1	3.6	12.5	12.1
2002	19.4	54.0	43.5	17.2	10.6	8.7	1.5	22.8	4.9	9.3	10.1	13.8	4.4	10.0	12.7
2003	20.8	67.5	49.6	15.7	11.4	9.2	2.1	9.9	5.1	12.2	13.4	15.1	3.3	9.0	14.1
2004	24.6	83.5	59.9	12.6	10.3	9.5	3.1	8.7	5.4	14.0	17.2	16.5	3.5	9.6	15.8

metallurgical (steel making, for example) and machinery (including electric, electronics and transportation equipment) industries have achieved remarkable growth, narrowing down the productivity gap significantly.

V. Empirical results

In this section, we present and analyse our main regression results. Table 6 presents the summary statistics of the major variables used in the regression. The average growth rate of productivity growth among all industry-province observations was 152% over the 1995–2004 period; the average growth rate of capital–labour ratio over the same period was 106%. Our main independent variables, log of initial productivity gap in 1995, averaged 11, for which the anti-log conversion corresponds to 79,000 US dollar per employee-year.

Table 7 presents the regression results of equation (1) using the PPP dataset. Column (1) shows the basic results from the simple regression of labour productivity growth of industry-province observation from 1995 to 2004 on the initial productivity gap between the industry-province and the international frontier, or Gap_Front i,j, 1995. Columns (2)–(4) include more variables. As reported in the table, the coefficient on the initial productivity gap is highly significant and positive as expected, and it remains so throughout columns (1)–(4). These results render strong support for our hypothesis that the larger the initial productivity gap with the international frontier, the faster the subsequent productivity growth.

The coefficient on the square of the initial productivity gap to the frontier, as shown in columns (3) and (4), is negative and statistically significant. The negative sign indicates the second derivative of labour productivity growth on the initial gap is negative, suggesting that as the productivity gap increases, the rate at which labour productivity increases slows. This is consistent with the general economic theory of the law of diminishing returns.

The coefficient on the growth of frontier productivity, as shown in column (4), is positive and significant. This may well indicate, at least in China's case, the faster the international technological frontier advances, the faster the productivity growth for the respective industry in China. Given China's degree of openness to foreign direct investment and international trade, this result is not surprising.

With the exception of the coastal region, the coefficients on the interactive terms are statistically insignificant and therefore not reported. That the estimates for the coastal term are negative indicates that over our sample period, given the same productivity gap with the frontier, the coastal industries tend to grow slower than the industries in the interior regions. We will test to see if the negative sign remains in our later model configurations.[6]

TABLE 6

Descriptive statistics

	Mean	*SD*	*Min*	*Max*
Labour productivity growth	1.52	0.69	−1.22	5.17
ln(productivity gap to frontier)	11.08	0.66	9.21	12.26
Growth of frontier productivity	0.55	0.30	0.08	1.27
Growth of capital intensity	1.06	0.60	−2.10	2.86

[6]The coefficient on the interactive terms become not statistically significant when we test our model in a more robust panel data setting. See Table 5(4) for more details.

TABLE 7

Estimates of the response of labour productivity growth to the international productivity gap, 1995–2004*, labour productivity in* 1997 *USD using* 1997 *industry PPPs*

	Dependent var: growth of labour productivity$_{i,j,\ 1995\text{-}2004}$			
Independent variable	1	2	3	4
ln(Gap_Front$_{i,j,\ 1995}$), log of productivity gap to frontier	0.204***	0.197***	3.468***	3.105**
	(0.054)	(0.054)	(1.394)	(1.387)
ln(Gap_Front$_{i,j,1995}$) x coastal dummy		−0.018***	−0.017***	−0.017***
		(0.007)	(0.007)	(0.007)
ln(Gap_Front$_{i,j,1995}$)_square			−0.149***	−0.134**
			(0.063)	(0.063)
ln(VA/L) $_{front,j,2004}$ − ln(VA/L $_{front,j,1995}$, growth of productivity at international frontier				0.333***
				(0.118)
Constant	0.674***	−0.590	−18.515***	−16.508**
	(0.228)	(0.597)	(7.654)	(7.616)
Observations	368	368	368	368
Adjusted R^2	0.035	0.05	0.062	0.079

Notes: *** (**, *) Statistical significance at the 1 (5, 10)% level.

To test the extent to which the results shown in Table 7 are sensitive to the choice of value measure, we redo the estimates using all three of the datasets. Columns (1) and (2) of Table 8 duplicate the regression results using the default industry-PPP approach as shown in Table 7; columns (3) and (4) present the estimation results with industrial productivities of China converted into US dollar values using the official exchange rate and the Yuan terms adjusted from current prices to constant 1997 prices; finally, columns (5) and (6) present the results with Chinese industry productivities converted to US dollars using the official exchange rate, but without adjusting for constant prices. The comparisons shown in Table 8 show that the results using the three different datasets are similar, thus demonstrating the robustness of our empirical results. The most noticeable inconsistency is that the constant price data concentrate their gap response effect in the linear specification; adding the quadratic terms diminishes the robustness of the estimate of the linear term. By comparison, estimates using the current dataset generate the most robust results when both the linear and quadratic gap variables are included.

To test the robustness of our results reported above from another perspective, we split the 10-year period from 1995 to 2004 into two separate periods, 1995–2000 and 2000–2005, and stack (pool) them to re-estimate equation (1). By adjusting the length of the time period from 10 years in equation (1) to 5 years, the number of observations doubles.

The results for this new cut at the data are shown in Table 9. In columns (1) through (3), the signs and robustness of the estimates for the gap coefficients remain unchanged as do those for the growth of frontier productivity. The most notable change is that the estimates of the interactive coastal term become statistically insignificant, although the sign still remains negative. Unlike the other estimates, the robustness of the coastal terms appears to depend on the time horizon of the observations used to estimate equation (1).

TABLE 8

Estimates of the response of labour productivity growth to the international productivity gap, with different prices and exchange rates, 1995–2004

	Dependent var: growth of labour productivity $_{i,j,1995\text{-}2004}$					
	1	2	3	4	5	6
Independent variable	*Constant* 1997 *Yuan using* 1997 *industry PPPs*		*Constant* 1997 *Yuan using official exchange rate*		*Current Yuan prices using official exchange rate*	
ln(Gap_Front$_{i,j,1995}$)	0.197***	3.106***	0.180***	2.873	−0.041	7.260***
	(0.054)	(1.387)	(0.060)	(1.965)	(0.057)	(1.970)
ln(Gap_Front$_{i,j,1995}$) × coastal	−0.018***	−0.017***	−0.019***	−0.019***	−0.018***	−0.019***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)
ln(Gap_Front$_{i,j,1995}$)_square		−0.134**		−0.123		−0.328***
		(0.063)		(0.088)		(0.088)
ln(VA/L)$_{\text{front},j,2004}$ − ln(VA/L) $_{\text{front},j,1995}$, growth of productivity at international frontier		0.333***		0.359***		0.126
		(0.118)		(0.119)		(0.121)
Constant	−0.589	−0.590	−0.398	−15.330	1.935***	−38.652***
	(0.597)	(0.597)	(0.674)	(10.923)	(0.643)	(10.971)
Observations	368	368	368	368	368	368
Adjusted R^2	0.05	0.05	0.045	0.065	0.017	0.048

Notes: *** (**, *) Statistical significance at the 1 (5, 10)% level.

One issue that arises from scrutiny of equation (1) is the possibility of an omitted variables problem. Specifically, this question arises if we view the estimation equation as having been derived as a rate-of-change version of an intensive production function. Equation (1) shows labour productivity growth as a function of the technology gap only. Within a production function context, however, we would expect output per capita in the intensive form of the production function to be driven not only by overall productivity or TFP but also to be driven by the capital–labour ratio, that is, by capital deepening.

What is the justification for omitting in equation (1) the rate of growth of the capital–labour ratio as an argument for determining the rate of productivity growth? Including the growth of the capital–labour ratio raises the question of the factors that drive the rate of capital deepening. To the extent that over the longer term growth of the capital–labour ratio is driven by the growth of TFP, inclusion of the capital–labour ratio will create potential problems of included variables mis-specification and endogeneity. This argument that the growth of the capital–labour ratio should be omitted from our estimation equation is more formally presented in Appendix A.

Notwithstanding our perspective that including the growth of the capital–labour ratio in equation (1) would cause equation (1) to be mis-specified, in Table 8, column (5), we test a specification of the productivity response function that incorporates the growth of the capital–labour ratio.[7] As suggested above, we would expect that the growth of the capital–labour ratio would be highly correlated with the international productivity gap and with

[7]Whether we use the K–L ratio as in the intensive form of the production function or capital–output ratio, we control for the capital intensity of production.

TABLE 9

Estimates of the response of labour productivity growth to the international productivity gap: 1995–2000 *and* 2000–2004*, pooled regressions, labour productivity converted using* 1997 *industry-PPPs*

	Dependent var: growth of labour productivity$_{i,j,(1995–2000\ or\ 2000–2004)}$				
Independent variable	1	2	3	4	5
ln(Gap_Front), log of productivity gap to frontier	0.118***	0.116***	1.895**	2.122**	1.617**
	(0.036)	(0.036)	(0.909)	(0.918)	(0.866)
ln(Gap_Front) x coastal		−0.007	−0.006	−0.006	−0.004
		(0.005)	(0.005)	(0.005)	(0.004)
ln(Gap_Front)_square			−0.080**	−0.091**	−0.069*
			(0.041)	(0.041)	(0.039)
Growth of frontier productivity				0.180*	0.200**
				(0.108)	(0.102)
Growth of capital–labour ratio					0.341***
					(0.035)
Constant	−0.570	−0.517	−10.357	−11.615**	−8.953**
	(0.408)	(0.409)	(5.037)	(5.088)	(4.801)
Observations	752	752	752	752	752
Adjusted R^2	0.013	0.014	0.020	0.020	0.130

Notes: *** (**, *) Statistical significance at the 1 (5, 10)% level.

the dependent variable, the growth of the output per worker. Indeed, the results in column (5) show that the estimate of the coefficient on the growth of the capital–labour ratio is highly robust. At the same time, while the gap coefficients become somewhat smaller in magnitude and lose some of their statistical robustness, they nonetheless retain statistical significance, at better than the 5% level for the linear measure of the gap and within the 10% level for the quadratic measure of the gap. Still, our view is that inclusion of the growth of the capital–labour ratio constitutes a mis-specification of the productivity growth dynamic that this article is attempting to represent and test.

VI. Concluding remarks

We present empirical evidence that China has been experiencing a convergence in labour productivity across different regions. The purpose of this article is to explain the dynamics that are driving this convergence. Over our sample period, productivity in the more advanced coastal region has tended to grow slower, whereas labour productivity in other regions has tended to grow much faster.

Using three alternative measures of labour productivity – measured in terms of current price Yuan values, constant price Yuan values and PPP US dollar measures – we find robust evidence in support of the central hypothesis of this article. That hypothesis is that the greater the distance between the level of labour productivity in a home industry located in a particular Chinese region and the level of labour productivity in the counterpart international frontier (US) industry, the greater the subsequent productivity growth of the home Chinese industry.

This finding carries intriguing implications for evolving patterns of regional income inequality in China. China's coastal region pioneered the opening of China's economy to international trade and Foreign Direct Investment (FDI), leading to a surge of investment, new enterprise entry and restructuring in the coastal provinces. As China's playing field has been made more uniform over the past decade and a half, the interior regions have gained more access to trade and foreign capital as well as advanced technologies that have become absorbed by coastal industry, thus providing channels for China's interior regions to gain more equal access to the industrial technologies that define the international technology frontier. As a result, we see that the advantages of backwardness have begun to assert themselves in favour of China's interior industrial enterprises.

The emerging growth patterns, such as those we document in this article, may offer China a way out of the traditional inequality-growth tradeoff: economic policies that encourage the faster growth in poorer regions may have the effect of reducing inequality and sustaining China's overall high growth rate simultaneously. We will welcome further research that investigates whether the dynamic process of China's productivity convergence that we document through the middle of the decade of the 2000s indeed continues into the present.

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Appendix A

To understand how inclusion of the growth of the capital–labour ratio might lead to included variables mis-specification, we enlist the steady-state equation in Solow's neoclassical growth model, that is, $sq = (n + \delta)k$, where s is the savings rate, q is output per capita, n

is the rate of population growth, δ is the rate of depreciation of the capital stock, and k is the capital–labour ratio. As a characterization of the steady-state capital ratio for a nation's economy, this expression is seemingly unrelated to the question at hand. However, we re-interpret the expression as characterizing the steady-state capital–labour ratio of the firm in which s represents the rate of investment out of output per worker, n as the rate of growth of the firm's labour force and δ is the rate of depreciation of the capital stock. Substituting q, the firm's intensive production function, that is, $q = Ak^{\alpha}$, for q in the firm-level version of the steady-state equation, and solving for k gives: $k = [sA/n + \delta)]^{1/(1-\alpha)}$.

Taking the log form of this expression and differencing it to represent the rate of growth of the capital–labour ratio results in the cancellation of s, n and δ, assumed to be time-invariant variables, leaving the rate of growth of the firm's capital–labour ratio as a function of the differencing (or rate of growth) of the firm's productivity. With this interpretation, the capital–labour ratio would be redundant in equation (1), where the growth of the firm's overall productivity is assumed to be driven by the distance to the relevant international productivity frontier.

Appendix B

East	*Northeast*	*Centre*	*West*
Beijing	Liaoning	Shanxi	Sichuan
Tianjin	Jilin	Henan	Chongqing
Hebei	Heilongjiang	Anhui	Shaanxi
Shadong		Hubei	Gangsu
Jiangsu		Hunan	Ningxia
Shanghai		Jiangxi	Qinghai
Zhejiang			Yunnan
Fujian			Guizhou
Guangdong			Guangxi
Hainan			Inner Mongolia
			Xinjiang
			Xizang (Tibet)

Appendix C: method of constructing the PPP adjustments

One of the most difficult tasks in our research is to obtain the industry-level PPPs, which enables us to convert the labour productivity of each industry in Chinese Yuan to the US dollar equivalent in the corresponding US industry. To do this, we rely principally on data from the European Union's (EU) KLEMS database. The EU KLEMS database is an improved version of the previous *60-industry Database* for international productivity comparison hosted at the University of Groningen.[8] This dataset includes the labour productivity at industry level for all EU countries and the US. Through our self-constructed industry-level PPPs between China and the US, we establish a link between industry-level productivities in China and EU KLEMS dataset.

[8]For details, please refer to the description of the new dataset by Timmer, Ypma and Van Ark (2007).

We follow the production approach to calculate industry-of-origin PPPs. Under this approach, industry-level PPP is defined as the 'unit value ratio', or UVR, for each corresponding industry between China and the US. UVR is the average value per production unit in each industry. Wu (2001) and Szirmai and Ren (2000) each produced their version of industry PPPs based on China's Industrial Statistical Yearbook. Wu's version uses 1987 as the base year, whereas the Srimai-Ren version uses 1985 as the base year.

After careful comparison, we conclude that Wu's version is a better approach as it is more consistent with the methodology outlined by Maddion and Van Ark (1988) and Van Ark (1993). Since the base year in the EU KLEMS dataset is 1997, we need to first convert Wu's 1987 PPPs to 1997 PPPs, so that our comparisons of industrial productivities can match across countries. To do this, we construct a chained price index for each of the 14 major industrial branches from the ex-factory price index as reported in the Statistical Yearbooks (various years), which we use to link the 1987 PPPs in Wu (2001) to our 1997 PPPs. We also adjust all value-added in the Chinese industries to 1997 constant Yuan prices using the same chained price index.[9]

Another major task is to match China's 14 industrial branches with the industry classifications in the EU KLEMS database. To do this, we study the detailed descriptions of each industry in the EU KLEMS dataset, and assign each of the 60 industries in the EU KLEMS database to one of the corresponding 14 branches used in China's industrial classification. As described in the text of the article, industry and regional comparisons with the relevant frontiers are shown in Tables 1 through 5.

These industry-of-origin PPPs are not without shortcomings. One drawback is that although we adjust value-added from current prices to constant prices, the ex-factory price index used for the adjustment has been calculated for gross output, not for value-added. Ideally, we would want to have price-indices for intermediate inputs, so that we can calculate value-added in constant prices more accurately. Should we have access to market-based current prices, we would not encounter this problem; arguably value-added or labour productivity expressed in current prices is a better measure because current prices reflect the equilibrium of both price movement and technology advancement. But current price can sometimes seriously distort the productivity calculation. In our case, during the 1995–2004 period, China experienced a roller-coaster ride in inflation. The Consumer Price Index (CPI) rose by over 25%; it then rapidly declined into a period of deflation. These large movements in prices that can undermine the reliability of our calculations of China's productivity growth underscore the importance of using constant price or PPP measures of productivity change.

[9]See Deng (2009).