Comparing and contrasting growth of India with China

Gupta, Abhay

University of British Columbia

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Comparing and Contrasting Growth of India with China

Abhay Gupta

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Abstract

This paper compares and contrasts the growth experience of India with that of China. Chinese economy has grown at much faster rate than Indian, but India seems to be catching up. The average estimated productivity growth rate of China (5.9%) is more than double that of India (2.4%). The difference between *same-deflator* average growth rates of India and China reduces significantly (by as much as 70%) for manufacturing sector.

While increased growth of spending are accompanied by increase the growth rate of productivity in China, in India the correlation is negative. For India, service sector growth trend is more strongly correlated with government spending and infrastructure.

1 Introduction

One of the most noticeable and interesting economic events of last few years is impressive GDP growth rates of Indian and Chinese economies. Even though they followed different economic policies, those resulted in sustained high GDP growth rates.

Using constructed growth accounting data set for China [1], I compare the economic growth of Chinese economy with that of Indian economy. I consider the period between 1978 and 2004, since capital formation series for China is not available for earlier periods. I discuss the similarities and differences in the trends in growth rates of India and China.

Bosworth and Collins (2007) [**?**] do a similar exercise, but they concentrate on the contribution of factor accumulation and productivity in the growth. Their methodology is similar to mine, but they interpret the result by focusing more on the growth rate for each year. The problem with this kind of interpretation is that these estimates are very sensitive to measurement issues. Some of the input series used are generated from less frequent surveys by assuming values for in-between years. If we make assumption that factor accumulation varies say linearly, then the TFP estimates we get for those years are inaccurate and non-robust to the assumptions. Rather than interpreting the values, I concentrate on ***trends*** in input growth rates, output growth rates and growth rates of the residuals. I decompose the series into trend and non-smoothed part based on Hodrick and Prescott (1997) [**?**].

Another argument in favor of using trends-comparison rather than period-wise averages (another interpretation stressed in Bosworth and Collins (2007) [**?**]) is that results in later approach are sensitive to choice of sub-periods. This becomes more controversial in international comparison studies because putting high growth year into a particular sub-period changes the results drastically (average growth rate difference might even change the sign). While there are some objections about using HP-filter for developing countries, it is one of the most used smoothing techniques.

Chinese economy has grown at much faster rate than Indian, but India seems to be catching up. Even though the average estimated productivity growth rate of China (5.9%) is more than double that of India (2.4%), the differnce is shrinking. Indian productivity growth rate has been increasing while Chinese rate has remained constant.

There is huge difference in official (implicit) deflator series for India and China. In manufacturing sector, Chinese deflator inflation averages around

[1] Most of the data comes from http://chinadataonline.org , which compiles it from yearly statistical handbooks and other official sources.

-1% between 1997-2002 compared to Indian average of 4.5%. I compare the estimated growth rates using the same deflator for both economies and generate two non-observed series. The difference between *same-deflator* average growth rates of India and China reduces significantly (by as much as 70%) for manufacturing sector compared to difference in official growth rates.

2 Capital Accumulation and Output Growth Comparison

The GDP data for Chinese economy is available only in current values along with an index series. There seems to be some argument about the deflator used to generate the index series. Maddison (1998) [**?**] reduces the Chinese GDP growth by an average of 2.4% per year for the 1952-1995 period. Holz (2006) [**?**] criticizes this revision citing various problems (including the use of incorrect deflator).

I use the Official GDP Index for my calculations. I compare the growth rates of this series with the growth rates of Penn-World Table estimates of China's real GDP. I also calculate growth rates of GDP deflated by retail price index. Appendix **??** mentions how these series are generated.

Figure 1 shows the growth rates of Chinese GDP using different deflators. For the period under study (1978-2004), the official and PWT growth rates are almost same, both averaging 9.6% per year.[2]. However for the sub-period 2000-2004, the official GDP index grew at 9.2% compared to 8.4% average annual growth rate of the PWT series. Using retail price index as GDP deflator gives higher growth rates, averaging 10.2% between 1978-2004 and 12.5% for subperiod 2000-2004.

Indian and Chinese economies grew at different rates between 1978-2004. I plot the distribution of these growth rates and their period wise averages in figure 2.

Panel A and B show the difference in the growth rates distribution. China's GDP per worker growth has averaged around 7% (annual growth rate was 9% for 6 times) while for India the average GDP per worker growth rate is 3% (with maximum annual growth rate of 8%, for 2 times). Similarly, the PWT series estimates for GDP per capita growth rates for India are centered between 4% and 5% compared to 8% and 9% for China.

Period-wise average GDP growth rates show the similar pattern of China registering a higher average than India in each sub-period. But what is

[2]Holz's concern was that "Maddisons revisions were subsequently incorporated into the Penn World Table and thus, have found their way into numerous cross-country studies".

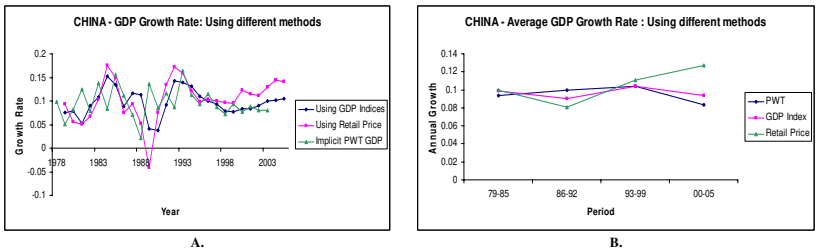

Figure 1: China GDP Growth Rate Different Measures

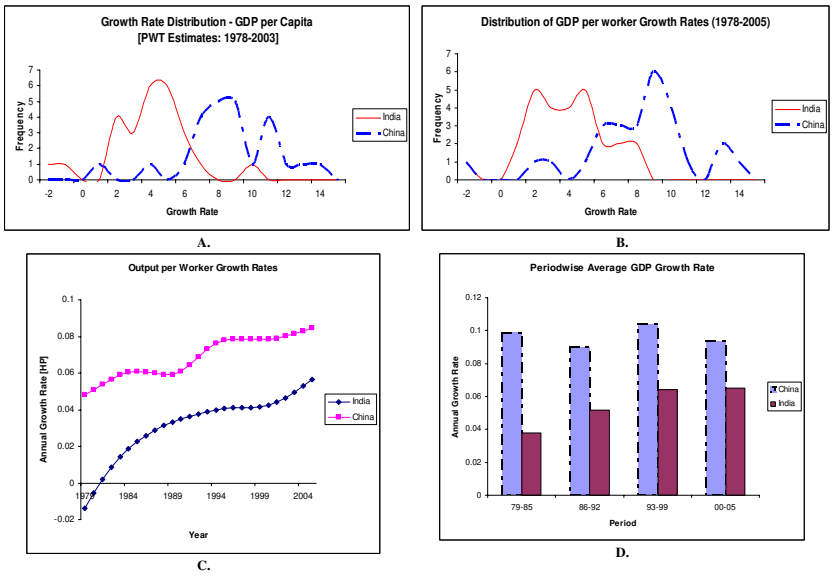

Figure 2: India & China: Growth Rate Distribution

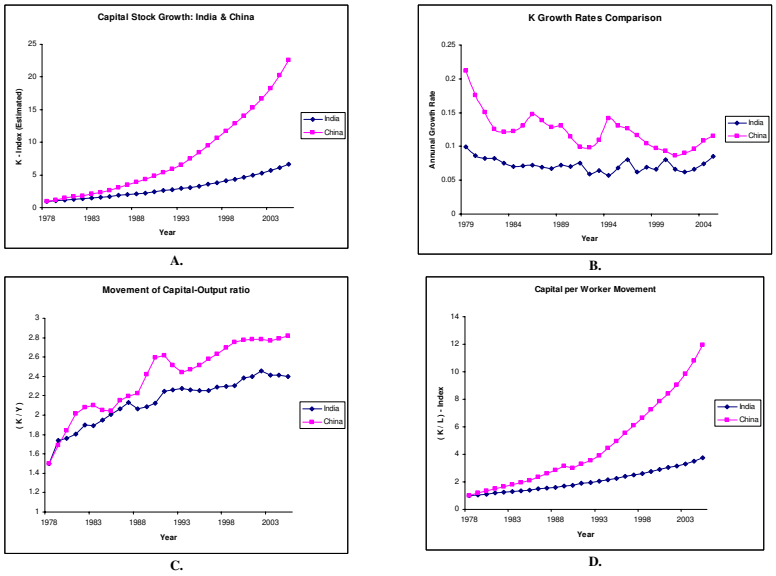

Figure 3: Capital Accumulation and $\frac{K}{Y}$ & $\frac{K}{L}$ ratio

interesting to see is the difference in their average growth rates. While the Indian average growth rates have been increasing, Chinese average growth rates have been almost same. Panel C shows that India is "catching up" with China in average GDP growth rate.

The trends in output-per-worker growth rates (panel D) point to same pattern. Chinese growth rates have been consistently higher than Indian. But the growth rates have been growing at faster pace in India as shown by more steep curve compared to relatively flatter Chinese growth rate trends. Period between late 80s and early 90s shows something interesting. The output-per-worker growth started increasing at the faster rate in China while for India the growth rate became stagnant. In late 90s Indian output-per-worker growth rate started increasing again, while Chinese growth rates remained almost constant.

Using a depreciation rate of 4%, I calculate the capital stock for both countries using Gross Fixed Capital Formation and Change in Inventory Stock series. I take initial capital stock (K_0) as 1.5 times the GDP. Calculated capital stock series for India and China and their growth rates are plotted in figure 3. I also calculate Capital-Output and Capital-per-Worker ratios for both the economies.

Between 1978 and 2005 capital stock in India grew 6.6 times, but for China the stock became 22.6 times its starting value. The annual growth rate of capital stock has been higher in China during whole period (including initial periods when the Chinese capital stock growth rate was double the Indian rate). Movements of calculated Capital-Output ratios are shown in panel C.

Due to large capital accumulation in initial periods, Chinese $\frac{K}{Y}$ ratio has been higher than the Indian $\frac{K}{Y}$ ratio. But both the ratios show similar trend of flattening out in latest periods. The index of Capital-per-Worker is higher for China growing 12 times, while Indian $\frac{K}{L}$ ratio grew only 3.7 times. [3]

Using the Cobb-Douglas kind of production function, I use following two decompositions to get productivity estimates for each economy.

$$\frac{Y}{L} = A(\frac{K}{L})^{\alpha} \tag{1}$$

$$\frac{Y}{L} = A(\frac{K}{Y})^{\alpha} \tag{2}$$

Notice that A in equation 1 represents the Total Factor Productivity of the aggregate economy, while in equation 2 the residual A is a measure of Labor Productivity. Figure 4 plots this accounting by plotting HP Filtered trends in these for India and China.

As panel A and B show, Capital-Output ratio in China and India have stabilized and growth rate of $\frac{K}{Y}$ is almost zero in recent periods. But the Capital-per-Worker ($\frac{K}{L}$) ratios seem to be growing at constant rate lately (panel C and D). The rate of growth of $\frac{K}{L}$ in China (around 8.8%) exceeds that in India (around 5.4%).

Period-wise the trends are similar in both decompositions. The growth rate trends in China seem to flatten out between 1984-1990. For India, the flat period is almost the whole decade of 90s. Since these are the trends in *growth rates*, hence constant (positive value) still means that the productivity was growing during this period.

These growth rate trends are compared in figures 5. Growth rates (smoothed) of both $\frac{K}{L}$ and $\frac{K}{Y}$ are higher for China and Chinese productivity grew at a higher rate than Indian. Table 1 shows the period-wise averages of each of these growth rates.

Even though the output-per-worker growth rate for China is more than double that of India, India is catching up in the sense that this difference declines over time. The same is true for productivity growth rates. But rate

[3] I avoid making any claims on the VALUE of Capital-per-Worker ratio, because of the issues with exchange rates and its movements.

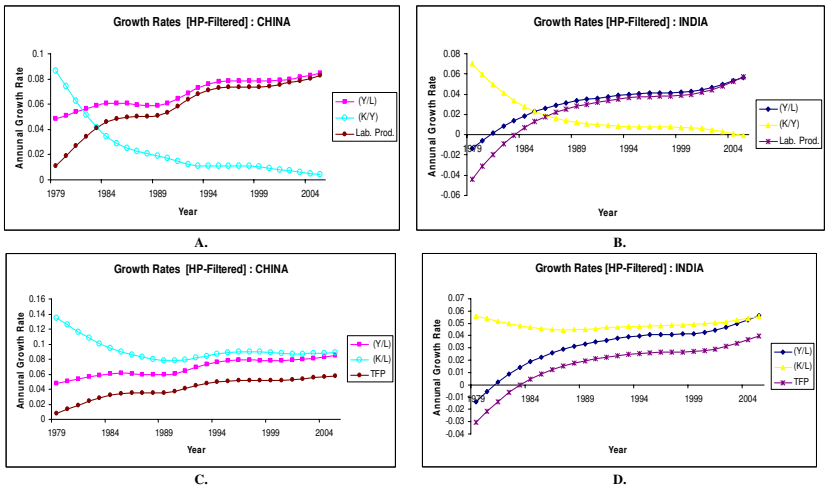

Figure 4: India & China: Growth Trends

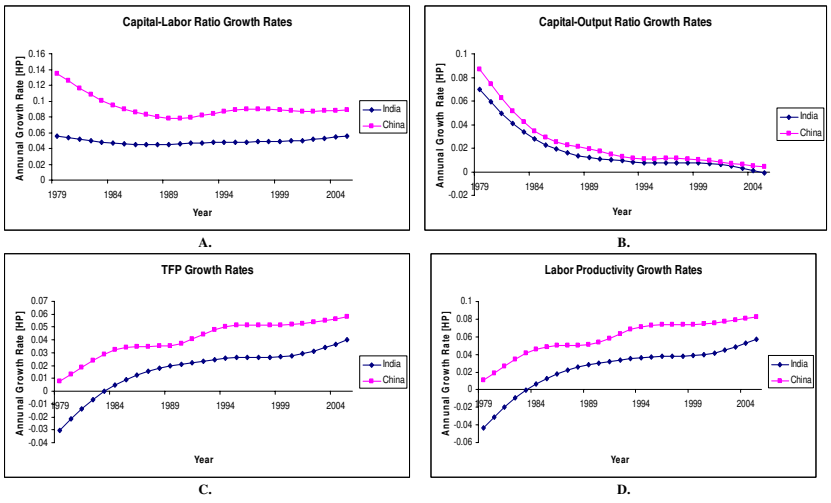

Figure 5: India & China: Growth Trends Comparison

	$(\frac{Output}{Worker})$		$\frac{K}{L}$		$\frac{K}{Y}$		**Lab.Prod.**		**TFP**	
	Ind.	**Chn.**	**Ind.**	**Chn.**	**Ind.**	**Chn.**	**Ind.**	**Chn.**	**Ind.**	**Chn.**
79-85	0.7%	5.6%	5%	11%	4.4%	5.4%	-1.2%	3.2%	-0.8%	2.3%
86-92	3.3%	6.2%	4.6%	8.1%	1.3%	1.9%	2.7%	5.4%	1.9%	3.8%
93-99	4.1%	7.7%	4.8%	8.8%	0.8%	1.1%	3.7%	7.3%	2.6%	5.1%
00-05	4.9%	8.1%	5.2%	8.8%	0.3%	0.7%	4.7%	7.8%	3.3%	5.5%
79-05	3.2%	6.9%	4.9%	9.2%	1.7%	2.3%	2.4%	5.9%	1.7%	4.1%

Table 1: Period-wise Average Growth Rates Comparison

of increase in productivity growth rates is higher for India (between last two sub-periods this increase is around 27% compared to just 7% for China).

3 Difference in prices

In growth accounting prices usually do not matter much since constant price series can be generated by pricing the output at some base year prices. But as I have mentioned in previous section, for Chinese GDP data there are some arguments about the deflator used in the official statistics. The other issue is that of "International Comparison". Prices become important when comparing the output across countries. World Bank ICP (2005) [**?**] mentions that PPP based method give different results from exchange rate based methods. Theoretically these differences should not matter much when considering the *growth rates* of the variables. But to be more precise, we should price each year's output of both the countries at the base year prices of one of the countries. In this section I do this by generating two hypothetical output series: Indian GDP at Chinese prices (deflator) and Chinese GDP at Indian prices (deflator).

Figure 6 shows the GDP deflator index for both the countries along with the trend (HP Filtered series) in inflation rate of GDP deflator. Between 1978-2005 (with deflator in 1978=100) Indian GDP deflator index grew to 770 while Chinese deflator index grew only to 420. The inflation trends in these two countries are also interesting. GDP deflator inflation in India has been going down, while in China it actually started going up and then reached the peak in mid 90s before coming back down to average around 3%. In 80s the average inflation rate of GDP deflator in India was 9.5% ,but India managed to slowly reduce that and in the last five years it averaged 3.5%.

Similarly I generate the Output deflator indexes for each sector. Figure

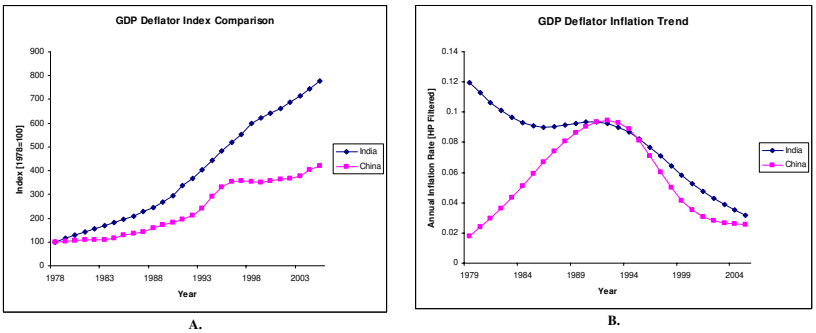

Figure 6: India & China: GDP Deflator

7 shows movement of these indexes over time for India (panel B) and China (panel A). Using 1978 as 1, the deflator indexes in India become 7.9 (Agriculture), 7.4 (Manufacturing) and 7.4 (Services) in 2005, but these are 6.7 (Agriculture), 2.8 (Manufacturing) and 5.4 (Services) for China. The most noticeable difference is in the manufacturing deflator index as shown in panel C. It seems that something interesting happened in China with respect to Manufacturing prices in mid-90s. The **retail** price index in China [4] grew only half the amount (3.6 times) compared to India's CPI (7.7 times) during this period.

What would have happened, had Indian prices (GDP deflator) evolved in the same way as Chinese but still producing the actual value of the output i.e. current GDP? Figure 8 shows the trends in GDP growth rates and Output-per-worker growth rates for this scenario (panel A and panel B). The results for the opposite scenario (China experiencing same deflator as India) are plotted in panel C and panel D.

In early period, *India's GDP growth rate and Output-per-worker growth rate estimates would have been higher than those of China if using Chinese deflator*. This is because India's GDP deflator inflation was way more than

[4]Consumer price index is available only for years 1985 onwards.

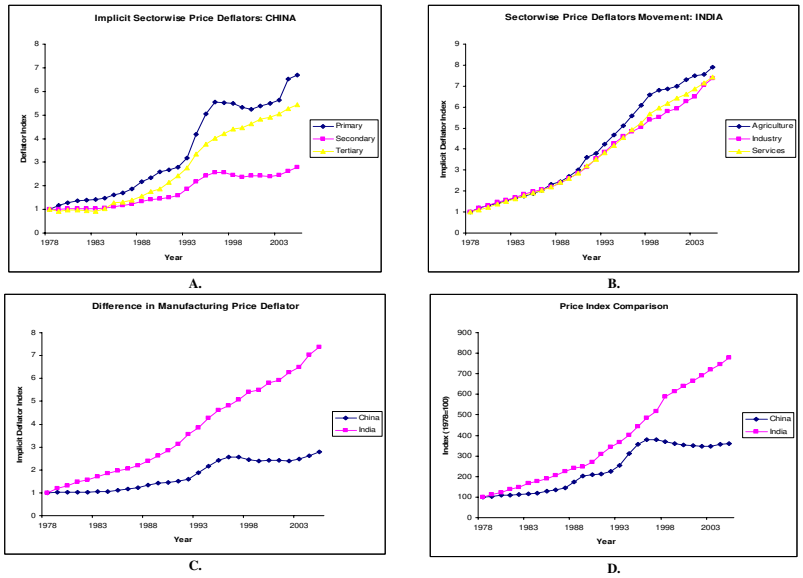

Figure 7: India & China: Sector-wise Deflator Indexes Comparison

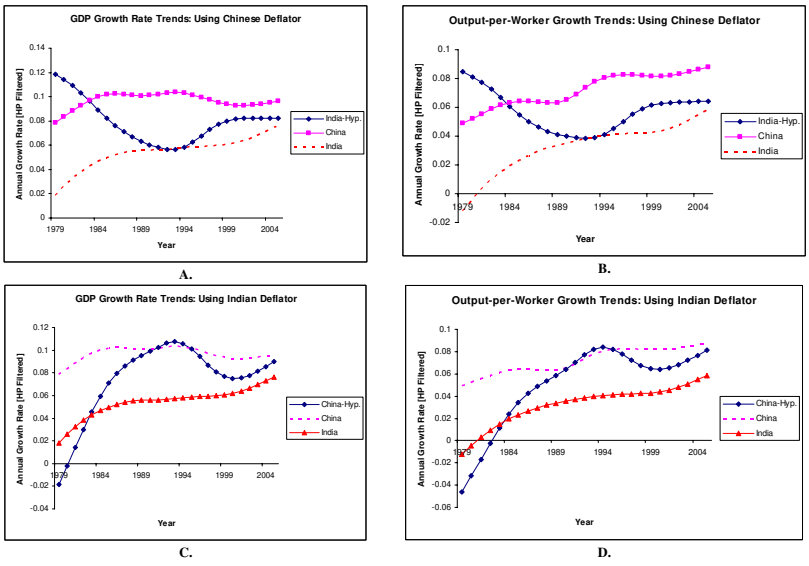

Figure 8: India & China: Hypothetical Series Growth Comparison

	GDP Growth			(GDP/Worker) Growth		
	$\frac{(CH-IN)}{IN}$	$\frac{(CH^*-IN)}{IN}$	$\frac{(CH-IN^*)}{IN^*}$	$\frac{(CH-IN)}{IN}$	$\frac{(CH^*-IN)}{IN}$	$\frac{(CH-IN^*)}{IN^*}$
79-85	1.61	-0.007	-0.026	5.97	-0.39	-0.084
86-92	0.74	0.34	0.24	0.65	-0.01	-0.03
93-99	0.50	0.38	0.25	0.82	0.64	0.43
00-05	0.44	0.33	0.30	0.79	0.63	0.55
79-05	0.78	0.36	0.22	1.22	0.54	0.27

Table 2: Hypothetical Series: Average Growth Rate Difference Reduces

China's during that time. For other periods the difference between Chinese and Indian growth rates would have been smaller. This is shown in table 2. China's average GDP growth rate exceeded that of India by 78%, but if the same deflator is used for both the countries then this difference reduces to 22% to 36%. For sub-period 1979-1985, the difference reverses sign i.e. Indian average growth rates for this period are higher than Chinese average growth rates when both are evaluated using same deflator series.

This analysis of hypothetical series and their growth rates should not be treated as indicative of economic growth potential i.e. it is wrong to conclude that India would have grown at much faster rate, had it managed its prices like China. This is about accuracy of price gathering and index calculation. If India overestimated its GDP inflation and its prices in fact moved more like Chinese prices, then Indian economy's growth rate was much faster than usually estimated. Similarly, if China underestimated its GDP inflation then its actual growth rates were lower.

4 With Human Capital

In this section I add human capital as one of the inputs and do the growth accounting using following production function.

$$Y = K^{\alpha}H^{\beta}(AL)^{1-\alpha-\beta} \equiv \frac{Y}{L} = A.(\frac{K}{Y})^{\frac{\alpha}{1-\alpha-\beta}}.(\frac{H}{Y})^{\frac{\beta}{1-\alpha-\beta}} \tag{3}$$

I use $\alpha = 0.3$ and $\beta = 0.28$. For generating the stock of Human capital, I follow Bosworth and Collins (2007) [**?**]. Using average year of schooling [5] for India and China from international database on educational attainment

[5]The data for missing years was generated using linear extrapolation.

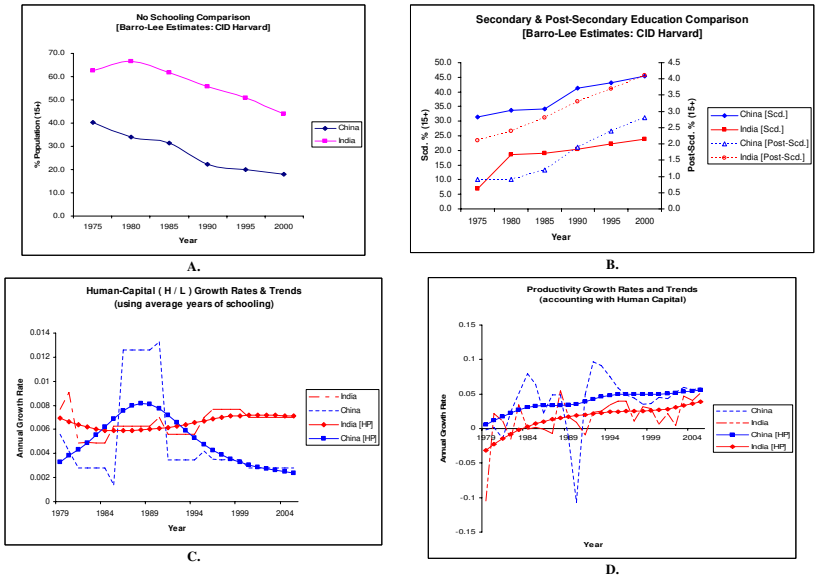

Figure 9: India & China: Human Capital and Productivity Growth Trends

by Barro-Lee (2000) [**?**], I use the same average return of 7% for each year of schooling for both countries.

$$\frac{H}{L} = e^{0.07*S} \tag{4}$$

The growth rate of Human-capital per worker is plotted in figure 9 along with comparison of trends in productivity growth rates for the two countries.

As shown in panel B, *India has a* ***higher*** *percentage of population with some post-secondary education than China throughout the entire time period.* But China's enrollment in secondary education is better than India's. But percentage of population (ages 15 and above) with No-Schooling is much higher in India (panel A). In China this percentage went from 40% in 1975 to 18% in 2000, a drop of more than 50%. But in India the reduction was only 30% during the same period, going down from 63% to 44%.

Panel C shows the rate of growth in $\frac{H}{L}$. China's human-capital per worker growth rate was below that of in India in early 80s, but it overtook Indian rate reaching a peak around 1990. But it has been going down since 1995, while India's human-capital per worker growth rate has been steady at around 0.7% per year. As a result the estimated difference in human-capital per worker

	$(\frac{H}{L})$		Productivity		No - Schooling[a]		Avg. Schooling[b]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
79-85	0.6%	0.3%	-0.7%	2.9%	-7.5%	-7.4%	11.3%	3.8%
86-92	0.6%	1.0%	1.2%	2.1%	-9.4%	-29.5%	12.6%	18.4%
93-99	0.7%	0.4%	3.0%	5.6%	-8.8%	-9.9%	10.2%	4.4%
00-05	0.7%	0.3%	2.9%	5.3%	-13.8%	-10%	11.9%	3.9%
79-05	0.7%	0.5%	2.0%	4.1%	-34.1%	-47.1%	54.7%	33.4%

[a]The time-periods for Productivity and Average Years of Schooling columns are 80-85, 85-90,90-95,95-00 and 80-00.

[b]The numbers in Productivity and Average Years of Schooling columns represent the overall percentage change during the period.

Table 3: Average Human Capital Growth Rates and Education Indicator Changes

between China and India reduces from 11.7% in 1978 to 7.2% in 2005.

The results of productivity growth rate calculations are shown in panel D. These trends are similar to previous ones. Chinese productivity growth being comparatively flatter in mid-80s and then increasing for a while in mid-90s, while Indian productivity growth is flatter for whole of the 90s but becoming quite steep after late 90s. The calculated values of these growth rates are shown in table 3

The reason for India's human-capital per worker growth being higher than China despite its poor performance in reducing illiteracy (No-Schooling percentage) is its better higher education (post-secondary) growth. As a result the estimates for average year of schooling in population over 15 years of age increased in India by 54.7% between 1980 and 2000 compared to 33.4% increase in China.[6]

5 Sector-wise Comparison

Different pattern in education growth is consistent with the observed pattern of Service sector growth in India and Manufacturing sector growth in China. Getting the estimates of Capital stock for each sector is problematic because of lack of reliable sector-wise Investment series. Thus I only discuss

[6]These are growth rates comparison. China's average year of schooling is higher than India for entire period, but that difference is shrinking.

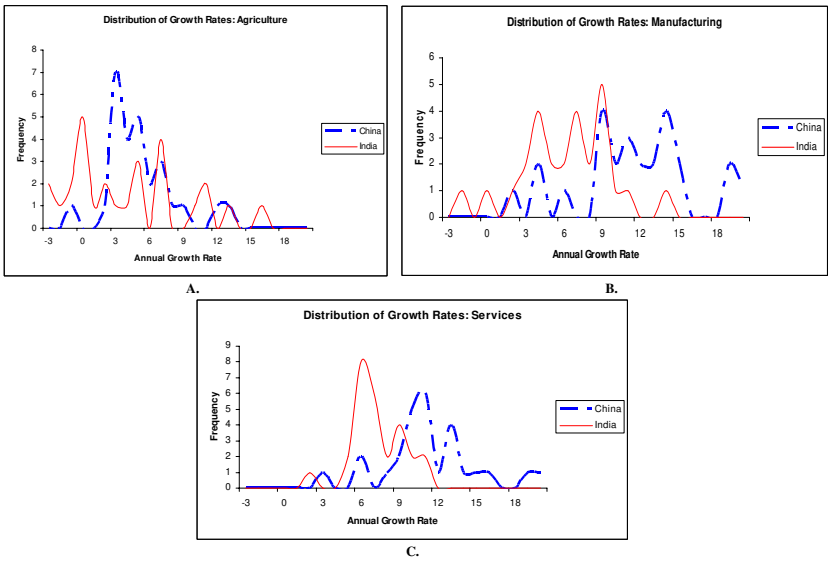

Figure 10: India & China: Distribution of Sector-wise Output Growth Rates

sector-wise output growth and compare the trends in the those growth rates. Like earlier I also analyze the differences in output deflator and generate hypothetical series (and their growth rates), in case one deflator series is more likely to be accurate than the other.

I start by calculating the output growth rates for each of the three sectors for India and China. The distribution of growth rates is plotted in figure 10.

In manufacturing and service sectors, growth rates in China are distributed towards right (higher mean) compared to India. In agriculture sector, Indian has experienced have varying growth rates. India's service sector has been quite consistent registering annual growth of 6% and 7% for 8 years and 6 years respectively.

Another interesting pattern to notice is that of growth of output growth-rates in India and China, as shown in panel A and B of figure 11. Chinese growth rates have went up and then came down for Manufacturing and Services sector. These are almost at the same level (or below) in 2005 as in 1978. But Indian growth rates show overall upward movements during this period.

The other difference between growth experience of these countries is the relative importance of Manufacturing and Services. For India, Service sector

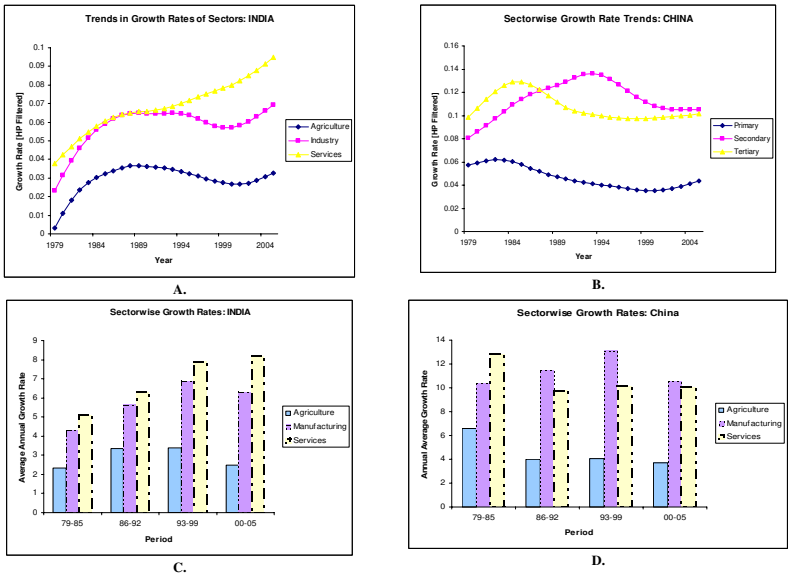

Figure 11: India & China: Sector-wise Growth Trends and Averages

has registered largest average growth in all of the sub-periods (panel C). Moreover Service sector's average growth rate in India has been increasing with time. For China, in first sub-period (1979-85) Service sector grew at fastest pace while Manufacturing sector takes lead in all sub-periods after that. The average growth rates have remained somewhat constant for China.

Table 4 shows these average sector-wise growth rates. For India, the average growth rate of Manufacturing sector has increased 40% between first and last sub-periods. This increase is for Service sector is 51%. For China these numbers are near zero and negative. As mentioned earlier, these numbers depend on choice of sub-periods. So the numbers should be taken just as an indication of increasing growth rates in India and constant growth rates in China.

5.1 Deflators

As shown in figure 7, the movement of sector-wise deflators is not similar for India and China. Given the concerns about measurement errors and lack of information (in case of China), I again compute hypothetical series for each sector by deflating sector outputs by *other country's deflator* for that sector.

	Agriculture		Manufacturing		Services	
	India	**China**	**India**	**China**	**India**	**China**
79-85	2.4%	6.6%	4.3%	10.4%	5.1%	12.9%
86-92	3.4%	4.0%	5.6%	11.5%	6.3%	9.8%
93-99	3.4%	4.1%	6.9%	13.1%	7.9%	10.1%
00-05	2.5%	3.7%	6.3%	10.5%	8.2%	10.1%
79-05	2.9%	4.6%	5.8%	11.4%	6.8%	10.7%

Table 4: Average period-wise Growth Rates Comparison for each Sector

	Agriculture		Manufacturing		Services	
	$India_{hyp}$ [a]	$China_{hyp}$ [b]	$India_{hyp}$	$China_{hyp}$	$India_{hyp}$	$China_{hyp}$
79-85	4.8%	4.1%	13.2%	2.0%	11.6%	7.4%
86-92	5.3%	2.2%	9.2%	7.9%	5.9%	10.3%
93-99	3.0%	5.4%	7.5%	12.9%	6.9%	11.6%
00-05	1.3%	5.3%	8.8%	8.1%	8.6%	9.7%
79-05	3.7%	4.2%	9.7%	7.7%	8.3%	9.7%

[a] $India_{hyp} = (\frac{CurrentOutput^{India}}{Deflator^{China}})$
[b] $China_{hyp} = (\frac{CurrentOutput^{China}}{Deflator^{India}})$

Table 5: Hypothetical Series: Average Growth Rates based on other deflator

Table 5 shows the period-wise average growth rates for these two hypothetical series. Trends in growth rates of these series are compared with actual sector-wise growth rate trends in figure 12.

As with the GDP, trends in sector-wise growth rates also differ a lot because of differences in deflator inflation over time. All three sectors follow the same pattern over different periods. In early periods the growth rate of sector-output for *Manufacturing* and *Services* in India is higher than that in China when evaluated using Indian deflator or using Chinese deflator for both countries. This is because Indian deflator inflation is much higher compared to China in these periods. In 1979 the deflator inflation for agriculture, manufacturing and services for India is 18.6%, 18.2% and 9.9% respectively, while for China these values are 16.5%, 1.3% and -6.6%. After mid-80s China has higher growth rates in each of the sector than India even when using the same deflators for both countries.

For Agriculture sector, even when using same deflators Chinese growth

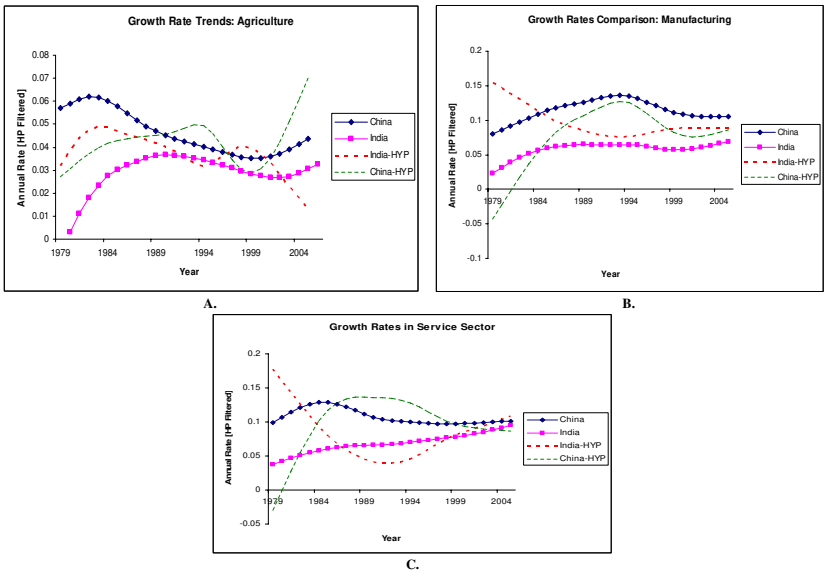

Figure 12: India & China: Sector-wise Growth Rates Comparison

rates are always higher than Indian growth rates. This is because deflator for Agriculture move similarly in both the countries. The reason for the stark divergence of hypothetical series in Agriculture sector towards the end is due to very high inflation (15.8%) of Agriculture-Output deflator in China between 2003 and 2004.

Comparing results in tables 5 and 4, we see that the difference in average Agriculture growth rates over the entire period reduces from 1.7% annually to 0.9% (when using Chinese deflator) and 1.3% (Indian deflator). For manufacturing the average growth rate difference goes down from 5.6% to 1.7% and 1.9%, which is a reduction of 66% to 70%. But even when using the same deflators for both countries in Service sector, 60% of average growth rate differences remain.

6 Correlation Comparison

In this section, I look for differences and similarities in relationships between economic time-series for India and China. I check for correlation between *probable-cause* of economic growth series and *indicator* of economic growth series. I use following series for later: Output, Output-per-Worker, Produc-

tivity, Agriculture-output, Manufacturing-output and Services-output along with their growth rates, trends in these growth rates and deviation from trends. Three of the most discussed causes are Trade, Governance and Production Technology.

I generate growth rate of cause-series, trend in growth rates and deviation from that trend and then find the correlations with all of these. Hence I end up getting a 4x4 matrix for each X, Y pair for each country. This setup gives more detailed look at the relationships between these variables. X can be linearly related to Y (as represented by the correlation coefficient) in levels, or in growth rates or any of the 16 combinations possible.

Detailed results are shown in appendix B. I discuss main highlights of results considering only value of greater than 0.5 as indication of somewhat strong relationship. I have included those results in table 6.

Even though correlation is not sufficient to establish causality, it is necessary. Hence we can definitely find out which of the relationships do not exist in Indian and Chinese data.

6.1 Trade

I use series on import and export to proxy for trade. Imports include the machinery and that represent the technology improvement[7], hence finding the separate correlations gives more insight than using combined trade volume series.

- Export level and trend in growth rates of export both are positively correlated with trend in GDP growth rates for India, but not for China.
- Export level is positively correlated with trend in growth rates of Output-per-worker and productivity for both China and India. But trends in growth rates of export is positively correlated with output-per-worker and productivity growth rate trend for India, but negatively for China (weakly for productivity).
- Level of export is negatively correlated with Agricultural output in China. This might be because of migration of worker from agriculture to export oriented manufacturing sector. But trend in export growth rates is positively related to trends in growth rate of agriculture output for *both* India and China. This correlation is stronger for India pointing towards presence of a long term relationship between export growth and agriculture output-growth.

[7]The data on Foreign Direct Investment is only available for last few years

- Surprisingly the correlation between trends in growth rates of export and growth rates of manufacturing output is very weak in China (0.1) and 0.9 in India.

- For service sector, both India and China have positive correlation in trends of export growth rates and trends in output growth rates.

- Import is positively correlated with output-per-worker and productivity for both the countries, which agrees with the idea of imported capital embodying the developed technology.

- This correlation of import with output growth rate trend is very strong for Indian service sector.

- There is a sharp contrast in correlation of trend in import growth rate for India and China. For China the trend is *negatively* related to output-per-worker and productivity growth rate trends. For India the correlation becomes weak. So positive trend in growth of import does not have significant positive effect on productivity growth rate trend.

- Trends in growth rate of imports seem to be positively related to trends in growth rate of output of service and manufacturing sectors of China. For India these correlations are weak, except for the service sector.

Significant correlations of both import and export with trends in growth rate of output-per-worker and productivity for India and China support the conventional **trade-growth** link.

6.2 Governance

I use government deficit series; government spending on development series for India & government spending on capital creation series for China.

- Government deficit (and development spending) is strongly and positively related to growth trends in GDP, output-per-worker, productivity and service-sector output for India. This may point towards service sector responding very positively to government initiatives, while manufacturing and agriculture do not. The alternative explanation of spending bias towards service sector does not have merit, because most of the budgets have higher portion of government spending going towards Agriculture or Manufacturing compared to Services.

	$\mathbf{Y}$ [a]	$(\frac{Y}{L})$	$\mathbf{A}$	Y_A	Y_M	Y_S
Export						
Level-Trend	0.7364	0.7223	0.7030	0.1380	0.4008	0.8665
	-0.0836	0.7814	0.6959	-0.5451	-0.1050	-0.4971
Trend-Trend	0.7348	0.7534	0.7600	0.9086	0.9064	0.5712
	0.3116	-0.6004	-0.4614	0.6431	0.1060	0.6386
Import						
Level-Trend	0.7113	0.6904	0.6700	0.1309	0.3891	0.8379
	-0.0766	0.7760	0.6933	-0.5378	-0.1026	-0.4875
Trend-Trend	0.2921	0.3117	0.2822	-0.2669	-0.0222	0.4571
	0.1917	-0.6254	-0.5151	0.7731	-0.1211	0.8090
Govt. Deficit						
Level-Trend	0.7953	0.7828	0.7713	0.0257	0.3586	0.9157
	-0.2094	0.7640	0.6819	-0.6548	-0.1714	-0.5513
Trend-Trend	-0.7131	-0.6438	-0.6193	0.1473	-0.3015	-0.7974
	-0.3964	0.9083	0.8431	-0.8556	0.0094	-0.9452
Govt. Spending						
Level-Trend	0.8308	0.8117	0.7964	0.0828	0.4277	0.9370
	-0.1616	0.7621	0.6821	-0.5709	-0.1839	-0.4793
Trend-Trend	-0.8752	-0.9382	-0.9461	-0.5069	-0.7515	-0.8095
	-0.2310	0.9395	0.9309	-0.9181	0.0930	-0.8238
Infrastructure/ Energy						
Level-Trend	0.8873	0.8884	0.8781	0.1859	0.5120	0.9715
	-0.6451	0.8706	0.8853	-0.5734	-0.5678	-0.6373
Trend-Trend	-0.8822	-0.9135	-0.9231	0.8432	0.2736	-0.9497
	-0.3850	0.2689	0.2871	0.1964	-0.6846	0.1291

[a] Values are for India in first row followed by China in the next row.

Table 6: Summary of Correlation Results from Appendix **??**

- For China, government expenditure on capital creation is positively related to $(\frac{Y}{L})$ growth and productivity growth trends.

- For India, trend in growth of government deficit and development spending strong and negative effect on growth rate trends of everything. This makes sense if increase in growth rate of government deficit harms the economy by creating problems in financial markets.

- But for China, the effect of growth trend in government spending on capital creation is strongly positive on $(\frac{Y}{L})$ and productivity growth trends. This can be explained by increased growth rate of capital-per-worker ratio.

- For China relationship with growth trends in agriculture sector and service sector output is strongly negative both with levels and trends in growth of spending.

One striking result is that the effect of early 1990's financial crisis in India can be seen in the opposite correlations of government deficit growth trends on growth trends of output-per-worker and productivity. While increased growth of spending on capital creation are accompanied by increase the growth rate of productivity in China, in India increased growth of development expenditure happens with decreased growth rate of productivity.

6.3 Production Technology

- Infrastructure industry index is strongly and positively related to trends in growth rates of GDP, output-per-worker, productivity and service sector output for India. The correlation is weak for agriculture, implying that infrastructure industry output does not effect the growth rate trends of agriculture output. These values also indicate that infrastructure affects the growth rates in service sector more than growth rates in manufacturing.

- Energy consumption is positively correlated with output-per-worker and productivity growth trends in China. This becomes intuitive if we assume that more power consumption means better technology (i.e. more capital intensive) or more use of existing machines leading to productivity growth.

7 Conclusion

Chinese economy has grown at much faster rate than Indian, but India seems to be catching up. The average estimated productivity growth rate of China (5.9%) is more than double that of India (2.4%). The difference between *same-deflator* average growth rates of India and China reduces significantly (by as much as 70%) for manufacturing sector. Both import and export are significant correlated of with trends in growth rate of output-per-worker and productivity for India and China pointing towards presence of conventional Trade-Growth link. While increased growth of spending are accompanied by increase the growth rate of productivity in China, in India the correlation is negative. For India, service sector growth trend is more strongly correlated with government spending and infrastructure.

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A National Accounts

The output data is published in Current values along with the GDP indices (with 1978=100). Using these two, I derive GDP Deflator as

$$Deflator \quad = \quad 100 * \frac{GDP^{Current}}{GDP_{1978}} * GDP^{Index}$$

Since I do not have capital prices series, I use this deflator to convert GFCF and Change-in-Stock series from current to constant values.

I derive sector-wise output deflator series in similar manner.

The GDP growth rate PWT series is generated using Penn-World Tables data. I obtain the Real GDP series by multiplying Real-GDP-Per-Capita series by Population series and then calculate its growth rate.

B Correlation Results

- Export and Import series for India and China are in local currencies, so that units are same as GDP and output series.
- For Government Deficit, the growth rate is calculated using $\frac{(Deficit^T - Deficit^0)}{Deficit^0}$ rather than $\Delta log(Deficit)$ because of possible negative values.
- Government Spending is taken from "government spending on capital creation" series for China and from "government expenditure on development" series for India.
- Infrastructure industry index for India and Energy consumption for China is used in Infrastructure/ Energy set of correlations.

	Y		$\Delta logY$		**Trend** $\Delta logY$		**Fluctuation**[a]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
Export								
Level	0.9657	0.9486	0.3593	0.0217	0.7364	-0.0836	0.0254	0.0425
Growth Rate	0.1324	-0.0868	0.0676	0.1530	0.3080	0.1444	-0.0867	0.1327
Trend	0.3371	-0.4823	0.3600	0.1544	0.7348	0.3116	0.0269	0.0960
Fluctuation	0.0001	0.0089	-0.0869	0.1303	0.0231	0.0882	-0.1149	0.1209
Import								
Level	0.9408	0.9464	0.3678	0.0356	0.7113	-0.0766	0.0489	0.0560
Growth Rate	0.2202	-0.0760	0.1564	0.4938	0.0451	0.1505	0.1598	0.5002
Trend	0.6773	-0.4649	0.0695	0.1885	0.2921	0.1917	-0.0759	0.1603
Fluctuation	0.0220	0.0023	0.1594	0.4833	-0.0491	0.1237	0.2143	0.4949
Govt. Deficit								
Level	0.9717	0.9087	0.2636	-0.0781	0.7953	-0.2094	-0.1880	-0.0368
Growth Rate	-0.2540	0.1818	0.0955	0.0733	-0.1918	-0.1097	0.2005	0.1044
Trend	-0.8669	0.8107	-0.3613	-0.1170	-0.7131	-0.3964	-0.0139	-0.0643
Fluctuation	0.0004	-0.0042	0.2188	0.1046	0.0190	-0.1076	0.2222	0.1274
Govt. Spending								
Level	0.9931	0.9520	0.3320	-0.0385	0.8308	-0.1616	-0.1417	-0.0048
Growth Rate	-0.2432	0.3567	0.0781	0.2082	-0.3260	0.2717	0.2516	0.1634
Trend	-0.7101	0.8132	-0.2293	-0.0214	-0.8752	-0.2310	0.2099	0.0122
Fluctuation	0.0209	-0.0094	0.1776	0.1808	-0.0029	0.1081	0.1899	0.1757
Infrastructure/ Energy								
Level	0.9951	0.9657	0.3042	-0.0097	0.8873	-0.6451	-0.2000	0.0812
Growth Rate	-0.3996	0.3693	-0.0176	0.3154	-0.5302	0.0122	0.2559	0.3267
Trend	-0.9615	0.6575	-0.2346	-0.0049	-0.8822	-0.3850	0.0356	0.0509
Fluctuation	0.0063	0.0444	0.1914	0.4369	0.0335	0.2879	0.1971	0.4132

[a]HP Non-smoothed part

Table 7: Correlation with GDP (Level, Growth Rate, Trend and Noise)

	$\frac{Y}{L}$		$\Delta log(\frac{Y}{L})$		**Trend** $\Delta log(\frac{Y}{L})$		**Fluctuation**[a]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
Export								
Level	0.9644	0.9485	0.4470	0.2137	0.7223	0.7814	0.0332	0.0237
Growth Rate	0.1166	-0.0942	0.1562	-0.1034	0.3206	-0.1157	-0.0399	-0.0801
Trend	0.3187	-0.4803	0.4765	-0.1436	0.7534	-0.6004	0.0480	0.0037
Fluctuation	-0.0100	0.0006	-0.0364	-0.0798	0.0295	0.0030	-0.0693	-0.0859
Import								
Level	0.9392	0.9465	0.4489	0.2225	0.6904	0.7760	0.0597	0.0345
Growth Rate	0.2165	-0.0775	0.1748	0.2972	0.0755	-0.0683	0.1691	0.3348
Trend	0.6740	-0.4556	0.1480	-0.0995	0.3117	-0.6254	-0.0438	0.0573
Fluctuation	0.0187	-0.0009	0.1536	0.3284	-0.0203	0.0386	0.2139	0.3401
Govt. Deficit								
Level	0.9711	0.9093	0.3993	0.1673	0.7828	0.7640	-0.2170	-0.0211
Growth Rate	-0.2415	0.1717	-0.0240	0.0630	-0.1830	0.1841	0.1139	0.0190
Trend	-0.8537	0.7945	-0.4553	0.1826	-0.6438	0.9083	-0.0318	-0.0138
Fluctuation	0.0097	-0.0114	0.1191	0.0218	0.0064	-0.0137	0.1339	0.0261
Govt. Spending								
Level	0.9904	0.9540	0.4865	0.1738	0.8117	0.7621	-0.1496	-0.0138
Growth Rate	-0.2353	0.3563	-0.0236	0.1558	-0.3541	0.5050	0.2470	0.0342
Trend	-0.7082	0.8099	-0.4424	0.2455	-0.9382	0.9395	0.2114	0.0456
Fluctuation	0.0287	-0.0094	0.1526	0.0282	-0.0082	0.0933	0.1842	0.0085
Infrastructure/ Energy								
Level	0.9951	0.9608	0.4873	0.2165	0.8884	0.8706	-0.2107	0.0582
Growth Rate	-0.3927	0.3744	-0.0870	0.2839	-0.5334	0.1618	0.3120	0.2711
Trend	-0.9653	0.6670	-0.3314	0.0458	-0.9135	0.2689	0.0357	-0.0022
Fluctuation	0.0102	0.0448	0.2409	0.3579	0.0348	0.0330	0.2641	0.3741

[a]HP Non-smoothed part

Table 8: Correlation with Output-per-worker (Level, Growth Rate, Trend and Noise)

	log A		$\Delta logA$		Trend $\Delta logA$		Fluctuation[a]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
Export								
Level	0.9494	0.8770	0.4255	0.2501	0.7030	0.6959	0.0242	0.0146
Growth Rate	0.0979	-0.1139	0.1253	-0.0967	0.3177	-0.0821	-0.0754	-0.0760
Trend	0.3063	-0.5407	0.4684	-0.1416	0.7600	-0.4614	0.0369	0.0171
Fluctuation	-0.0263	-0.0077	-0.0691	-0.0731	0.0229	0.0095	-0.1062	-0.0844
Import								
Level	0.9216	0.8746	0.4240	0.2598	0.6700	0.6933	0.0468	0.0263
Growth Rate	0.2143	-0.0792	0.1549	0.3190	0.0566	-0.0469	0.1575	0.3703
Trend	0.6555	-0.5451	0.1101	-0.0948	0.2822	-0.5151	-0.0686	0.0891
Fluctuation	0.0227	0.0131	0.1435	0.3503	-0.0321	0.0417	0.2090	0.3716
Govt. Deficit								
Level	0.9676	0.8716	0.3960	0.2208	0.7713	0.6819	-0.2147	-0.0126
Growth Rate	-0.2144	0.1641	0.0167	0.1096	-0.1688	0.1425	0.1470	0.0675
Trend	-0.8227	0.8281	-0.4267	0.1968	-0.6193	0.8431	-0.0157	-0.0340
Fluctuation	0.0293	-0.0242	0.1541	0.0667	0.0140	-0.0313	0.1647	0.0799
Govt. Spending								
Level	0.9803	0.8856	0.4701	0.2219	0.7964	0.6821	-0.1593	-0.0115
Growth Rate	-0.2260	0.4117	-0.0335	0.2498	-0.3572	0.5130	0.2328	0.0831
Trend	-0.7168	0.8942	-0.4282	0.2693	-0.9461	0.9309	0.2306	0.0178
Fluctuation	0.0424	0.0040	0.1360	0.0820	-0.0083	0.0866	0.1610	0.0622
Infrastructure/ Energy								
Level	0.9930	0.9362	0.4747	0.2300	0.8781	0.8853	-0.2201	0.0579
Growth Rate	-0.3853	0.2957	-0.0770	0.2861	-0.5410	0.1827	0.3227	0.2694
Trend	-0.9713	0.5421	-0.3353	0.0553	-0.9231	0.2871	0.0156	0.0019
Fluctuation	0.0176	0.0246	0.2458	0.3543	0.0340	0.0489	0.2674	0.3689

[a]HP Non-smoothed part

Table 9: Correlation with Productivity (Level, Growth Rate, Trend and Noise)

	Y_A		$\Delta logY_A$		**Trend** $\Delta logY_A$		**Fluctuation**[a]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
Export								
Level	0.8899	0.8612	0.0239	-0.1171	0.1380	-0.5451	0.0036	0.0568
Growth Rate	0.1288	-0.1034	-0.1303	0.0036	0.4120	0.1485	-0.1964	-0.0464
Trend	0.4408	-0.5156	0.1556	0.2335	0.9086	0.6431	0.0215	0.0372
Fluctuation	-0.0522	-0.0018	-0.2260	-0.0452	0.0654	0.0230	-0.2418	-0.0572
Import								
Level	0.8556	0.8573	0.0394	-0.1171	0.1309	-0.5378	0.0205	0.0544
Growth Rate	0.1579	-0.0867	0.0533	-0.1307	-0.1467	0.1680	0.0771	-0.1999
Trend	0.5576	-0.5386	-0.0731	0.3096	-0.2669	0.7731	-0.0344	0.0763
Fluctuation	-0.0094	0.0041	0.0882	-0.1912	-0.0790	0.0396	0.1025	-0.2225
Govt. Deficit								
Level	0.9407	0.8449	-0.1249	-0.2714	0.0257	-0.6548	-0.1240	-0.0746
Growth Rate	-0.1795	0.1812	0.1702	0.0757	0.0740	-0.2075	0.1624	0.1532
Trend	-0.7546	0.8513	-0.0045	-0.3048	0.1473	-0.8556	-0.0199	-0.0349
Fluctuation	0.0455	-0.0052	0.1863	0.1901	0.0335	-0.0183	0.1827	0.2317
Govt. Spending								
Level	0.9467	0.8611	-0.0910	-0.1973	0.0828	-0.5709	-0.0985	-0.0221
Growth Rate	-0.2500	0.4488	0.1859	0.1724	-0.2091	-0.3759	0.2077	0.3161
Trend	-0.8026	0.8972	0.0260	-0.4840	-0.5069	-0.9181	0.0790	-0.2230
Fluctuation	0.0508	0.0335	0.1923	0.2091	-0.0238	0.0482	0.1948	0.2289
Infrastructure/ Energy								
Level	0.9847	0.9520	-0.1352	0.2539	0.1859	-0.5734	-0.1543	0.4562
Growth Rate	-0.4482	0.2592	-0.0713	0.1849	-0.3547	0.2560	-0.0342	0.0850
Trend	-0.9689	0.5284	0.0422	0.1375	0.8432	0.1964	-0.0171	0.0609
Fluctuation	-0.0186	-0.0159	-0.1209	0.1572	0.0465	0.2135	-0.1252	0.0739

[a]HP Non-smoothed part

Table 10: Correlation with Agriculture Output (Level, Growth Rate, Trend and Noise)

	Y_M		$\Delta logY_M$		**Trend** $\Delta logY_M$		**Fluctuation**[a]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
Export								
Level	0.9516	0.9566	0.1708	-0.0004	0.4008	-0.1050	0.0467	0.0355
Growth Rate	0.1431	-0.0880	0.3768	0.2101	0.4129	0.0987	0.2725	0.1978
Trend	0.3579	-0.4864	0.3387	0.1555	0.9064	0.1060	0.0524	0.1351
Fluctuation	0.0031	0.0084	0.2880	0.1908	0.0675	0.0827	0.2975	0.1820
Import								
Level	0.9234	0.9541	0.1709	0.0149	0.3891	-0.1026	0.0510	0.0516
Growth Rate	0.2173	-0.0771	0.1111	0.5473	-0.0355	0.0486	0.1369	0.5868
Trend	0.6565	-0.4620	-0.0384	0.0896	-0.0222	-0.1211	-0.0349	0.1403
Fluctuation	0.0258	0.0007	0.1439	0.5567	-0.0339	0.0721	0.1730	0.5890
Govt. Deficit								
Level	0.9613	0.9104	-0.0161	-0.0847	0.3586	-0.1714	-0.1215	-0.0347
Growth Rate	-0.2443	0.1826	-0.0080	0.0623	-0.0882	0.0041	0.0116	0.0673
Trend	-0.8347	0.8080	-0.0898	-0.0106	-0.3015	0.0094	-0.0222	-0.0145
Fluctuation	0.0006	-0.0039	0.0200	0.0579	0.0003	-0.0136	0.0197	0.0687
Govt. Spending								
Level	0.9822	0.9581	0.0568	-0.0599	0.4277	-0.1839	-0.0669	-0.0031
Growth Rate	-0.2544	0.3464	0.1431	0.0787	-0.3020	0.2250	0.2090	0.0097
Trend	-0.7397	0.8037	0.0726	0.1052	-0.7515	0.0930	0.2388	0.0915
Fluctuation	0.0206	-0.0091	0.1268	0.0845	-0.0266	-0.0271	0.1318	0.1022
Infrastructure/ Energy								
Level	0.9978	0.9667	0.0662	-0.1251	0.5120	-0.5678	-0.0819	0.0052
Growth Rate	-0.4056	0.3721	0.3986	0.2691	-0.4549	-0.2468	0.4966	0.3572
Trend	-0.9628	0.6591	0.1425	-0.1169	0.2736	-0.6846	0.1187	0.0509
Fluctuation	0.0166	0.0471	0.4862	0.4521	0.1612	0.1429	0.4887	0.4550

[a]HP Non-smoothed part

Table 11: Correlation with Manufacturing Output (Level, Growth Rate, Trend and Noise)

	Y_S		$\Delta logY_S$		**Trend** $\Delta logY_S$		**Fluctuation**[a]	
	India	**China**	**India**	**China**	**India**	**China**	**India**	**China**
Export								
Level	0.9784	0.9502	0.6439	-0.1403	0.8665	-0.4971	0.0393	0.0128
Growth Rate	0.1287	-0.0770	0.0803	0.0184	0.2224	0.1218	-0.1203	-0.0220
Trend	0.3045	-0.4553	0.4043	0.1878	0.5712	0.6386	-0.0050	-0.0075
Fluctuation	0.0108	0.0136	-0.0926	-0.0199	-0.0021	-0.0044	-0.1398	-0.0218
Import								
Level	0.9570	0.9491	0.6512	-0.1324	0.8379	-0.4875	0.0817	0.0187
Growth Rate	0.2328	-0.0677	0.2171	0.3972	0.1036	0.2095	0.2197	0.3935
Trend	0.7039	-0.4387	0.2484	0.3784	0.4571	0.8090	-0.1194	0.1563
Fluctuation	0.0275	0.0065	0.1682	0.3488	-0.0381	0.0767	0.2998	0.3840
Govt. Deficit								
Level	0.9734	0.9115	0.6176	-0.1660	0.9157	-0.5513	-0.1328	0.0019
Growth Rate	-0.2707	0.1770	-0.0027	-0.0604	-0.2158	-0.3284	0.2110	0.0465
Trend	-0.8933	0.7944	-0.5456	-0.4565	-0.7974	-0.9452	0.0363	-0.1870
Fluctuation	-0.0093	-0.0051	0.1709	0.0465	0.0197	-0.1280	0.2176	0.1036
Govt. Spending								
Level	0.9981	0.9568	0.6701	-0.1347	0.9370	-0.4793	-0.0834	0.0130
Growth Rate	-0.2363	0.3475	-0.0657	0.2004	-0.2920	-0.1054	0.1994	0.2743
Trend	-0.6753	0.7979	-0.4646	-0.3237	-0.8095	-0.8238	0.1606	-0.0746
Fluctuation	0.0144	-0.0184	0.1156	0.2145	0.0077	0.1535	0.1527	0.1974
Infrastructure/ Energy								
Level	0.9880	0.9638	0.6833	-0.1809	0.9715	-0.6373	-0.1022	0.0159
Growth Rate	-0.3840	0.3919	-0.1080	0.2158	-0.4828	0.1303	0.3305	0.1802
Trend	-0.9504	0.6864	-0.4920	0.0847	-0.9497	0.1291	0.0600	0.0461
Fluctuation	0.0080	0.0552	0.2926	0.2369	0.0123	0.0882	0.3617	0.2152

[a]HP Non-smoothed part

Table 12: Correlation with Services Output (Level, Growth Rate, Trend and Noise)