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Clash of the Titans

Chinese and Indian growth compared

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Introduction

Both China and India emerged from World War II as shattered giants embroiled in civil conflict. By 1962 they were at war with each other over their shared Himalayan border. Upon these shaky foundations, both countries took different paths through the hostile Cold War environment—India with its market-based socialism and China with communism and collectivism.

The aim of this chapter is to ask what growth theory can tell us about the similarities and differences in India's and China's respective growth experiences and future prospects. This is important for several reasons. First, despite many popular explanations for China's success, or India's emergence, we simply do not have a good theory of all the necessary conditions for how a country can effect the transition from a developing to a developed economy. Understanding the process is likely to be important for understanding what bottlenecks or hurdles lie ahead, as well as for developing appropriate policies for other countries to follow.

Moreover, since China and India are, respectively, the world's largest and second-largest countries in terms of population, their continued economic growth will substantially change the world economic and geopolitical landscape in ways that have not been seen since the emergence of the United States at the end of the nineteenth century. The political dominance of the current Western world arguably, therefore, depends a lot on whether or not India, with its British colonial heritage and Westminster-style democracy, can match China in terms of economic might.

To think about past and future growth prospects, we need a framework for organising ideas. The benchmark model for thinking about both long-run growth and short-run transition is the neoclassical growth model. In what follows, a careful application of this model is used to shed substantial new insights on to the comparative performance of these two countries. In particular, the chapter demonstrates that: 1) increases in China's investment rate have had little impact on its growth, especially since the 1980s; 2) the difference in the investment rate between China and India does not explain their differing growth performances; and 3) there is some new evidence that human capital accumulation has been a critical source of growth in China, being not only a source of rising labour productivity but also through inducing capital accumulation.

The results are not inconsistent with existing growth accounting studies that tend to emphasise capital accumulation and the residual productivity growth. Rather, they offer a different way of thinking about causes and effects and hence also fresh insight into the way different policies have influenced the growth of these two titanic economies.

China’s and India’s stylised growth facts

Long-run growth of GDP per capita

The growth records of both countries are shown in Figure 14.1, which plots gross domestic product (GDP) per capita for China, India and, for reference, the United States, in dollars of purchasing power parity (PPP\$) since 1952. For China, two series are reported—both from the Penn World tables (Heston et al. 2011). The first series is based on China’s official price indices and the 2005 ICP benchmark. The second is an alternative series based on corrections to these official data following Madison and Wu (2008) and Wu (2010), among others.

Figure 14.1 GDP per capita (PPP\$)

Source: Heston et al. (2010).

The adjustment mainly concerns the growth rates of China prior to the 1980s. According to the official data, it can be seen that China’s GDP per capita in 1952 was only half that of India’s. From 1952 to 1978, China grew at 3 per cent per annum whereas India grew at 2 per cent per annum—the same as the United States. But from 1978 to 2010, China grew at 8.5 per cent per annum and caught up with India in 1986—less than a decade after the end of the Cultural Revolution.

The adjusted series, however, shows a remarkably different story. According to these data, China's GDP per capita in 1952 was the same as India's. This higher income level for China in 1952 implies a substantially lower growth rate from 1978 to 2010. Specifically, the revised series suggests that China's growth rate was 6.5 per cent per annum, instead of the official rate of 8.5 per cent per annum, for the post-reform era, 1978–2010.

Madison and Wu (2008) and Wang and Meng (2001) argue that their lower growth rates are much more reasonable than the official rates, since the lower level of GDP per capita in 1952 implies an income level of PPP\$282 per annum, which is far below subsistence. In comparison, India—itself a very poor country—had an income of PPP\$612 per annum. Heston (2008) also agrees that an implication of the official growth rates is that India was much wealthier than China in 1952, and that is implausible.² He supports this by citing earlier studies such as Kravis (1984) and Ruoen and Kai (1995), both of which found that China was wealthier than India in 1952. In particular, Kravis (1981) found that China has 12 per cent of the United States' GDP per capita and India only 6 per cent.³

Figure 14.2 provides some more evidence of this by comparing energy use in China and India. It shows the ratio of China's to India's per capita energy use. Although these data date back only to the 1970s, they show that China's demand for road transport energy was the same as India's in the 1970s when China was substantially poorer according to the official Chinese data. Moreover, at this time China's total consumption of energy was approximately double that of India. Taking these data at face value suggests that, at least by the 1970s, China was at least as industrialised as India was. Hence it seems plausible that the official data dramatically understate China's wealth and overstate its post-reform growth rate.

Figure 14.2 China's energy use relative to India

Source: World Bank (Various years).

From the adjusted GDP series for China it can be seen that, initially, China's and India's growth performances were very similar, but China's was much more unstable, with booms and busts. The first severe economic downturns in China were associated with the Great Leap

Forward and the Three-Year Famine, which has been linked to about 15–20 million deaths. The second downturn was during the Cultural Revolution. In comparing India and China, considerable attention has been given to the costs of the failed collectivist experiments.⁴

Growth of GDP per worker

Another way to compare their growth rates is by looking at GDP per worker, rather than GDP per capita. This is more of a productivity measure and is also more closely tied to the concepts used in growth theory. Figure 14.3 reports the ratio of ‘working-age persons per capita’ in China and India from Heston et al. (2010). In India, approximately 41 per cent of the population in 1952 was working whereas in China, 50 per cent was working. But whereas China’s ratio of workers per person has risen—from 50 per cent in 1952 to 60 per cent now—India’s ratio of workers per person has remained relatively constant.

Figure 14.3 Working-age population per person

Source: Heston et al. (2010).

As discussed by Golley and Tyers (2011), the fall in dependency ratios in China is a result of China’s demographic transition, with falling fertility rates. This also has potential implications for China’s and India’s future prospects, with increasing age dependency in China in the future but falling youth dependency for India.

With respect to comparing past growth rates, however, it means that China’s growth of GDP per worker has not been as fast as its growth of GDP per capita. Nevertheless, even in terms of GDP per worker, with a faster growing denominator, China’s growth has still doubled India’s—with a tenfold increase in GDP per worker from 1952 to 2007—versus India’s fivefold increase.

Relative achievements

In comparing the two countries in the longer term, commentators also point to the role of poor economic management in contributing to China's mass famine, China's poor record on human rights and China's lack of democracy as significant costs of China's development policy. The reign of Mao has been estimated as contributing to the deaths of about 40 million people—double the human cost of Stalin's collectivist policies and one of the largest episodes of human life loss in modern history, second only to World War II as a whole. So the costs of these politically motivated policies cannot be understated.

Nevertheless, it remains the case that, since the Cultural Revolution, China's experience has been vastly superior to that of India's. Even when we adjust for systematic errors in China's national income reporting and look at GDP per worker, rather than GDP per capita, China's economic growth has been approximately double that of India's.⁵

Moreover, this superior economic growth has delivered equally superior reductions in mortality, malnutrition and poverty. For example, Ravillion (2009) finds that between 1981 and 2005 the poverty headcount index fell by a factor of five in China, compared with a factor of 1.4 in India over the same period.⁶ According to Ravillion (2009), this difference in poverty reduction is almost entirely explained by the difference in each country's growth rate.⁷

Sources growth

Growth accounting

Given the dramatic difference in growth performance, the next question is whether there are any notable differences in the characteristics of that growth that might point to key policy differences. The main tool for country growth studies is growth accounting. Bosworth and Collins' (2008) study is a useful starting point as they construct growth accounts for both countries over the period 1978–2004.

Specifically, they assume that real output per worker in both countries can be represented by a Cobb-Douglas production function (Equation 14.1).

Equation 14.1

$$y = k^a (Ah)^{1-a}$$

In Equation 14.1, k is physical capital per worker, y is output per worker, h is human capital per worker and A is a measure of productivity expressed in terms of equivalent units of labour. Taking the ratio of per capita GDP at two dates, and denoting these as y and y' respectively, we can compare the income level at these two dates as the product of the components (Equation 14.2).

Equation 14.2

$$y'/y = (k'/k)^a (h'/h)^{1-a} B'/B$$

In Equation 14.2, $B \equiv A^{1-\alpha}$ is total factor productivity (TFP), which is productivity expressed in equivalent units of output.⁸ Alternatively, log differentiation gives the usual growth accounting equation (Equation 14.3).

Equation 14.3

$$\hat{y} = \alpha \hat{k} + (1 - \alpha) \hat{h} + \hat{B}$$

In Equation 14.3, $\hat{B}$ is the ‘Solow Residual’.

Using Equation 14.3, Bosworth and Collins (2008) find that, in proportional terms, the contributions of growth of physical capital and other inputs in China and India are similar. For China, assuming $\alpha = 0.4$, the contribution of capital, $\alpha \hat{k}$, accounts for approximately 44 per cent of its growth. Human capital, $(1 - \alpha) \hat{h}$, accounts for 4 per cent of GDP per capita growth and the Solow Residual, $\hat{B}$, makes up the remaining 49 per cent. For India, the proportional contributions of capital, human capital and TFP are 39, 12 and 48 per cent, respectively.

Thus, human capital makes a slightly larger contribution for India, physical capital is moderately larger for China and in both countries the Solow Residual accounts for about half of their respective growth rates. Bosworth and Collins (2008) also note, however, that in absolute terms India’s record on capital accumulation is well below that of the East Asian economies during their rapid growth era whereas China’s capital accumulation experience has matched, and more recently exceeded, that of East Asia during the ‘East Asian Miracle’.

The emphasis on capital accumulation for China fits the perception that China has benefited from its high investment levels. Comparisons of India and China often point to the differences in investment rates across the two countries as evidence of why India has done relatively poorly compared with China (for example, Bardhan 2006; Basu 2009). Certainly, the results seem to suggest that capital accumulation has been vastly more important than human capital accumulation, and more so in China than in India.

Understanding the sources of capital accumulation

Recall that in the neoclassical growth model, capital accumulation is endogenous. The rate of capital accumulation is not something that is directly influenced by policy variables. In the simplest neoclassical model, the Solow–Swan model, the rate of capital accumulation is determined by changes in the rate of investment, the current value of capital per worker relative to the steady-state value, which determines the convergence rate, and all factors that affect productivity, including human capital. Thus, although growth accounting tells us that approximately 40 per cent of both India’s and China’s growth is due to physical capital accumulation, the neoclassical model says that this capital accumulation can in turn be attributed to (i) changes in the investment rate, s , changes in productivity, A , changes in human capital, h , and convergence to a steady state.

Note also that since some of the capital growth can be attributed to human capital accumulation, this means that the total contribution of human capital exceeds its growth accounting contribution.⁹ In this way, using the neoclassical growth model rearranges the

contribution of different factors and provides a different perspective on the growth process. As we shall see, this exercise will highlight the important role that human capital has played, not only in India but also in China.

The role of investment

Levels versus changes

To disentangle the effects of this rise in investment rates from other factors that have affected capital accumulation, we can again refer to the Solow–Swan model. In this model, the steady-state equilibrium condition is as shown in Equation 14.4.

Equation 14.4

$$sy/k = (1 + n)(1 + g) - (1 - \delta)$$

In Equation 14.4, s is the investment rate, and δ denotes the depreciation rate on capital, $1 + n = L_{t+1}/L_t$ is the annual increase in labour inputs, $1 + g = A_{t+1}/A_t$ denotes the annual increase in productivity.¹⁰ Given the Cobb–Douglas production function assumed above for the growth accounting exercise, $y = k^\alpha(Ah)^{1-\alpha}$, we can use these expressions to obtain Equation 14.5.

Equation 14.5

$$y = (s/\chi)^{\alpha/(1-\alpha)}Ah$$

In Equation 14.5, $\chi \equiv (1 + n)(1 + g) - (1 - \delta)$.¹¹ This shows a steady-state relationship between the investment rate, human capital, productivity and output. Thus, an economy that moves from an initial steady state to a new steady state due to a change in the investment rate from s to the new level of investment, s' , a new level of human capital, h' , and a new productivity level, A , will have an increase in per capita income as shown in Equation 14.6.

Equation 14.6

$$y'/y = (s'/s)^{\alpha/(1-\alpha)}(A'/A)(h'/h)$$

We can use this expression to compare the long-run changes in GDP in China and India across time.¹² First note that on a steady-state path, s is constant so the first term becomes $(s'/s)^{\alpha/(1-\alpha)} = 1$. Thus, on a steady-state growth path, per capita income growth depends only on the growth rate of productivity $y'/y = (A'/A)(h'/h)$. The long-run growth rate, though not the income level, is independent of the level of investment. This is a well-known result in this model. Thus, according to this standard model—and contrary to many informal discussions of China's high growth rates—China's higher level of investment relative to India's is not relevant for explaining its higher rate of growth.

What might explain China's higher growth rate is the change in the investment rate. The neoclassical growth model shows that if a country is experiencing an increase in its investment rate, other things being equal, the rate of capital accumulation will exceed the growth rate. As shown in Figure 14.4, which illustrates the basic Solow–Swan diagram,

a higher investment rate, s , increases the steady-state ratio of capital per effective worker. Since sy/k is constant, the shift from s to s' must imply that y/k falls, so that y does not grow as fast as k . Thus, an increase in the investment rate, s —other factors held constant—increases capital accumulation and raises the growth accounting capital contribution. The question remains, to what extent were rising investment rates in China and India responsible for the large capital contributions found by Bosworth and Collins (2008)?

Figure 14.4 GDP per worker (PPP\$)

Source: Heston et al. (2010).

Investment data

To look at the relative role of capital accumulation in each country more carefully, Figure 14.5 compares Chinese and Indian investment rates, or, more specifically, gross fixed capital formation as a fraction of GDP, both measured in real PPP\$. Figure 14.5 shows that using the official statistics, China’s investment rate rose from 17 per cent of GDP in 1952 to 33 per cent of GDP in 1978. The investment rate remained at this level until the 1990s, but then stepped up again—by another 10 percentage points, eventually rising to more than 40 per cent of GDP.

Figure 14.5 Capital accumulation in the Solow–Swan model

In contrast, India's investment rate was only 10 per cent of GDP in 1952, despite its higher income level, and by 2003 it doubled to 20 per cent of GDP. The significant rise in India's investment rate occurs only after 2003, with the investment rate then reaching 32 per cent of GDP. Thus, a simple comparison shows the much higher investment levels in China, although India has caught up considerably in recent years. Overall, the Indian investment rate has increased approximately 3.2-fold whereas China's has increased 2.7-fold. Viewed in these terms, India appears to have outperformed China in terms of investment rate increases.

The comparison is even more dramatic if we use the unofficial Chinese data where adjustments have been made to the price of consumption goods. As shown in Figure 14.6, the adjusted data show that the real quantity of investment as a fraction of output has been about 40 per cent since 1952—much higher than India's level but with very little increase over time.

Figure 14.6 Gross fixed investment as a fraction of GDP (per cent)

Source: Heston et al. (2010).

Quantifying the impact of investment

So how much growth can be explained by the rising investment rate in each country? Suppose we assume that $\alpha = 1/3$, which is a widely used value in the cross-country growth accounting literature. The total growth from one steady state to the next comparative steady state with productivity and human capital is constant and is $y'/y = (s'/s)^{1/2}$. As we have seen above, the investment rate in China since 1952, using the official data, is $s'/s = 2.7$. This accounts, at best, for a $\sqrt{2.7} = 1.64$ -fold increase in per capita GDP between 1952 and 2009. This confirms that the increase in the investment rate has made only a very small contribution to China's growth, given that GDP has increased at least twelvefold.¹³ In India, the slightly more substantial increase in the investment rate of 3.2-fold would increase GDP per capita by a factor of 1.8. Relative to India's 5.3-fold increase in per capita income, this is a more substantial contribution to India's overall growth. Thus, the contribution of increases in the investment rate to growth has been greater in India than in China, both in absolute and in proportional terms. This suggests that, for example, policies that have encouraged investment and perhaps savings, such as bank reforms in India, have contributed to growth in India to a greater extent than in China.

So we can conclude that the different increases in investment rates do not help much in explaining the different growth experiences of the two countries. In proportional and absolute terms, investment rate increases have been more important to India than China. In addition, if capital income shares are close to $\alpha = 1/3$, we can also conclude that the increases in the investment rate have in fact been a relatively minor contributing factor to growth, especially in China.

Human capital

Since increases in the investment rate do not appear to explain much of China's or India's growth, we now consider human capital. Human capital incorporates the skills and attributes of workers that have been accumulated through schooling, as well as health, experience and training. It is thus an asset and is valued as the present value of the higher income stream that an individual attains from undertaking such investments, above what they would have otherwise earned.

Figure 14.7 shows primary and secondary schooling attainment rates for China and India. It shows that even in 1950 China had higher schooling rates than India and the gap has tended to widen, with China's population reaching 85 per cent who had 'completed primary school' and 93 per cent with 'some schooling' by 2010. In comparison, India achieved 65 per cent who had 'completed primary school' and 67 per cent with 'some schooling'.

Figure 14.7a School completion rates in India

Source: Barro and Lee (2010)

Figure 14.7b School completion rates in China

Source: Barro and Lee (2010).

The figures also show the proportion of the population that commenced secondary education in each country and the percentage that completed secondary education or higher. This shows an enormous difference, with China's secondary completion rate reaching 55 per cent of the population, compared with India at only 6.7 per cent.

Although India has lower levels of education attainment, it experienced slightly larger increases than China in the fraction of its population with primary schooling—increasing 7.2-fold versus China's 6.2-fold. So in terms of increases in primary attainment, India has experienced higher growth than China.

There are, however, far more dramatic differences in the growth of secondary schooling rates in the two countries. For India, the secondary schooling rate increase was quite large—from 0.7 per cent of the workforce to 6.7 per cent of the workforce—which is a 9.6-fold increase. Nevertheless this is dwarfed by China's increase from 2 per cent of the labour force to 55 per cent—a 28-fold increase!

Attainment rates, however, are a flow variable, which gives us an idea about the rate of investment in education in each country, but not the total stock of the accumulated education. To obtain a measure of human capital stocks, Barro and Lee (2010) convert these attainment rates into a measure of average years of schooling in the labour force. These are shown in Figure 14.8. Over the period 1950–2005, India's average years of schooling increased from 0.98 to 4.7—a 4.8-fold increase. In comparison, China's average years of schooling in the labour force increased from 1.5 to 7.6—a fivefold increase. In these terms, then, the rate of increase in the human capital stock appears to be fairly similar for the two countries over this period.

Figure 14.8 Human capital indicators

Source: Barro and Lee (2010).

For these measures to be meaningful, however, we need to convert years of schooling into a quantity of human capital that is proportional to labour productivity. We follow previous studies such as Bosworth and Collins (2008) and Klenow and Rodriguez-Clare (1997), who employ evidence from Mincerian earnings regressions. These studies establish a relationship between human capital stock, h , and years of schooling, t , given by $h = e^{\theta t}$, where θ is estimated to be approximately 0.15.¹⁴

Figure 14.8 shows the implied level of human capital, h , for China and India based on this simple transformation. By this measure, India's human capital rate increased 1.7-fold and China's increased 2.5-fold.¹⁵ China's figure here is larger because, with this method, additional years of higher schooling are recognised as adding more to the human capital stock than additional years of lower schooling levels.

The long-run impact of human capital

Although these values are relatively modest, recall that according to the Solow–Swan growth model, an increase in human capital not only has a direct impact on output through the production function but also has an indirect effect on capital accumulation. As shown by Equation 14.6, across steady states this total contribution is linear in the increase in human capital. That is, holding productivity, A , and the investment rate, s , constant, from Equation 14.6, we have Equation 14.7.

Equation 14.7

$$y'/y = h'/h$$

Thus, the doubling of human capital per person will double steady-state income per capita in the long run.

India's GDP per capita over the 55-year period 1950–2005 increased 4.3-fold, which implies a growth rate of approximately $4.2^{1/55} - 1 = 2.7$ per cent per annum. We have a total contribution of human capital to growth of $1.7^{1/55} - 1 = 1$ per cent per annum. So the maximum impact of human capital on growth, allowing for full realisation of transitional growth to the new steady state, is 1 per cent relative to 2.7 per cent. This represents 38 per cent of India's growth. Similar calculations for China give a total human capital contribution of 41 per cent of its adjusted growth rate.

It is therefore possible that human capital can explain a very large fraction of growth in both India and China. Again, this overturns the received view from growth accounting studies. The difference is simply due to: 1) adjusting China's GDP growth according to the Heston et al. (2010) and Madison and Wu (2008) figures; and 2) allowing for the indirect effects of human capital on physical capital accumulation.

The analysis here is only exploratory, but these back-of-the-envelope calculations suggest that the role of human capital in China's growth might have been understated by conventional growth accounting studies. Even so, based on the years of schooling data, a concern is that there does not appear to be any acceleration in the rate of growth of human capital between China's first phase, 1950–80, and the post-reform phase from 1980 onwards. A natural question, then, is whether any other studies of human capital have suggested a faster rate of growth in the post-reform era?

Re-examining China's growth and human capital post-1980

Several recent studies have suggested that the impact of human capital in China might be even larger than the rates implied by the increase in average years of schooling. In particular, Li et al. (2009) estimate that the rate of return to schooling in China has increased dramatically from just 1 per cent in 1985 to 11 per cent in 2007.¹⁶ As a result, they find that human capital levels in China increased by a factor of 3.8 over the period 1985–2007 compared with the estimates used above of just 1.5 over a similar period.

Using the adjusted Penn World tables data, the increase in China's GDP per worker over this period is $y'/y = 3.8$. Li et al.'s (2009) measured increase in human capital is also $h'/h = 3.8$. Thus, Li et al.'s measured increase in human capital is potentially capable of accounting for 100 per cent of China's adjusted growth of GDP per worker.

Human capital transitional dynamics

Of course these back-of-the-envelope calculations assume, unrealistically, that a full transition to a steady state has already occurred. Much of the increase in human capital is very recent and hence might in fact take many years to be realised in terms of its effects on capital accumulation.

Fortunately, it is straightforward to quantify these impacts while also allowing for only partial convergence in the transitional dynamics, using simple simulation methods. Specifically, I simulate the Solow–Swan model using the method described in Robertson (2000), and using the

Penn World tables' (adjusted) data for Chinese GDP, labour and investment and Li et al.'s (2009) human capital data. Given these data, and assuming an initial steady-state capital stock in 1952, a capital stock series can be calculated. The residual productivity level for each year, A , can then also be calculated so that the calibrated model exactly reproduces the actual GDP data for each year, consistent with observed investment rates and human capital levels for each year.

Given this benchmark calibration, we can then consider counterfactual simulations holding human capital growth constant at its 1985 value, letting the other exogenous variables, s and A , take their actual values, and letting capital update using the standard Solow–Swan equation. This quantifies the contribution of the increase in human capital, h , given the Solow–Swan dynamics and holding other factors constant.

Figure 14.9 shows the actual GDP growth, which provides the benchmark and also the counterfactual path of growth of GDP per worker that would have occurred if human capital levels were held constant at their 1985 values, given the Solow–Swan model. For the benchmark, GDP per worker in 1985 is indexed to unity and it rises to a value of 3.8, which represents an average growth rate of 6.25 per cent per annum. The counterfactual, with h held constant at the 1985 level, implies that the economy grows very slowly. Gross domestic product per worker increases only to a value of 1.35, which represents a growth rate of 1.3 per cent per annum.

Figure 14.9 Simulation results

Thus, Li et al.'s (2009) measure of human capital can account for 4.9 percentage points out of 6.25 percentage points of growth per annum, or 78 per cent of China's growth since 1985! Thus, even after allowing for transitional dynamics, the impact of allowing human capital to grow at the rate suggested by Li et al. (2009) is enormous.

Caveats

Li et al. (2009) suggest that their finding of a high growth rate of human capital is due primarily to the rising rate of return to education in China. Taken at face value, their estimates imply that a year of schooling in later years in China generates more units of human capital, or skills, than the same years of schooling in earlier years. Thus, their results imply that the relationship between schooling and human capital investment has changed over time, which is a type of technical change in education. This is an interesting conclusion as recent cross-studies, such as Manuelli and Seshadri (2007), have suggested that differences in the quality of schooling across countries can explain a large fraction of the variance in income across countries.

But there are alternative explanations for Li et al.'s (2009) results. One might be that skills were undervalued by the Chinese command economy in earlier years, relative to later years, as emphasised by Liu et al. (2010) and Zhang et al. (2005). In this case, the market return to human capital might have increased even though the marginal product of human capital might not have changed very much at all. So changes in the organisation of labour markets might affect the effectiveness of human capital employment, and it might be difficult to disentangle this effect, which represents a technical change, from an increase in human capital *per se*. Second, the estimated increasing return to schooling might in fact reflect technical change or complementary factors of production that might have been omitted from the earnings regression estimates.

Thus, the argument would appear to rest on whether we can obtain independent evidence of increases in the quality of schooling in China. If the quality of schooling accelerated in China, but not in India, at a rate suggested by Li et al. (2009), the preceding results suggest that this would provide a simple and elegant proximate explanation for China's remarkable success and also its performance relative to India.

If evidence of increases in schooling quality cannot be found, the results nevertheless point to the reorganisation of labour markets as part of China's reforms, and subsequent improved allocation of human capital, as a major source of productivity growth that affects the effective units of human capital. This is perhaps an alternative interpretation of the Li et al. (2009) results and the preceding simulations.

One aspect of this conclusion suggests that China's current strategy of heavy investment in tertiary education and liberalisation of the education sector is appropriate. It likewise indicates that for India there might be severe institutional or structural barriers to growth due to the barrier in educational attainment. Basu (2009) and Yao (2008), for example, emphasise the role of the Chinese state prior to 1978 in providing 'social priming' for rapid economic growth. This priming most notably includes a high degree of social and economic equality including literacy.

In contrast, as noted by Bardhan (2010), India is the largest single-country contributor to world illiteracy, and also has a very high degree of education inequality. Clearly such unequal access to education makes it much more difficult to increase the average skill level of the labour force. Moreover given India's relatively younger population, investment in

education is imperative, since failure to do so could mean a lost opportunity to rapidly increase the average years of schooling as an extremely large cohort of children enter their schooling and hence formative years.

These final remarks are of course speculative. But if human capital accumulation has been as important as the results in this chapter suggest, it does have important implications for investments in access to education in both countries, but particularly in India with its younger population, lower levels of urbanisation and higher levels of inequality.

Conclusions

This chapter aimed to explain China's and India's economic growth in the context of the neoclassical growth model, which has long provided the theoretical benchmark for understanding of the growth process. The neoclassical model places strict discipline on the way we understand and interpret the data. It reminds us, for example, that we cannot simply point to China's high levels of investment and conclude that this explains China's growth, since growth in that model depends on the changes in the investment rate, not the level.

Thus, as we have seen, in the context of this model, changes in the Chinese and Indian investment rates during the past three decades or so do not adequately explain the differences in their growth rates. India has had larger increases in investment, and yet experienced only a fraction of China's growth. Moreover, it was shown that increases in the investment rate contributed to only a very small fraction of the observed growth in the capital stock in both countries. Of course, an analyst might simply take this as a rejection of the model. It is, however, no small task to replace the neoclassical model. It is easy to speculate, for example, as to how institutions, externalities and various exotic theories can explain China's growth. But such theories are necessarily complex, and have not been particularly successful in systematic empirical tests. Occam's razor suggests that we should not reject the neoclassical model in favour of more exotic models as long as the former can explain the facts.

To this end, the neoclassical model shows clearly that an increase in labour productivity— as might arise from an increase in human capital per worker—can have a magnified impact on growth. This is because it increases output directly and also induces capital accumulation by raising the average product of capital. Hence some of the large share of growth that is usually attributed to capital accumulation for China and India can be seen to be associated with increases in human capital instead. Indeed, according to our estimates of these direct and indirect effects, human capital accumulation might in fact explain a very large fraction of growth in India and an even higher fraction of growth in China since 1950.

Finally, although conventional estimates of human capital based on average years of schooling do not show an acceleration of average years of schooling after the Chinese reforms, Li et al.'s (2009) estimates suggest a very rapid growth rate for China's human capital after 1985. A simple numerical simulation, moreover, showed that the direct and indirect effects of human capital accumulation might account for as much as 78 per cent of China's growth in GDP per worker between 1985 and 2007.

These results raise the possibility that human capital accumulation in China and India might have been a very significant part of both their growth success and also the differences in their respective growth performances. It points, moreover, to human capital investments and improvements in the quality of education as critical ingredients of China's recent success.

The emphasis on human capital also points to potential barriers for both China's and India's future growth ambitions. Commentators have emphasised that India's 'ace card' is its democracy and ability to manage conflict (Bardhan 2010; Basu 2009). But India's investment in democratic institutions might be wasted unless it is backed up with greater and more equitable investment in education. Conversely, for China, a lack of democracy is argued to be its greatest hurdle to future growth. But China's past and ongoing investment in human capital must surely also smooth its path to a more inclusive form of government. Fundamentally, for both China and India to realise their full potential on the world geopolitical and economic stage, the citizens of these countries must also realise their full potential as educated and informed citizens participating and sharing in the gains from economic growth. This can be achieved only with access to education and labour markets that will deliver returns to people's human capital investments.

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Endnotes

1. I am grateful for comments from and insightful discussions with Rod Tyers and Jane Golley.
2. Heston (2008) notes that the GDP growth figures for India are much more reliable than those for China due to the more detailed price-survey data available.
3. Garnaut and Ma (1993) argued that whereas China's GDP in US dollars, as reported by the World Bank, was similar to India's in 1990, food consumption patterns suggest it should be approximately three times higher in real terms. See also Clements and Chen (2010), who argue that food consumption share data also suggest that official data understate China's current per capita GDP.
4. Gilley (2005) and Swamey (2005), for example, argue for many downward adjustments to China's growth rate and emphasise the social costs of China's economic policies, which provide a basis for more favourable evaluations for India relative to China.
5. In terms of the official data, China's GDP has increased 27-fold—more than five times that of India.
6. Ravillion (2009) has the poverty headcount in China in 1981 at about 80 per cent versus approximately 60 per cent for India in 1980. This appears to be based on the World Bank's International Comparison Program (ICP) data, which in turn are based on the official Chinese GDP growth estimates, rather than the adjusted data. Hence in 1981, Ravillion (2009) estimates China's GDP at PPP\$543, compared with a figure for India of PPP\$901, so that India's income is 60 per cent higher than China's. The adjusted data from the Penn World Table v.7, however, have China 17 per cent wealthier than India in 1981. If poverty rates are based on the official GDP per capita series for China and the implied PPP price levels then Ravillion's estimates potentially overstate the level of poverty in China and therefore the reduction in poverty.
7. Specifically, he finds elasticities of poverty reduction with respect to per capita income growth of approximately -0.7 in India and up to -0.8 in China.
8. This comparison of income levels when y and y' represent outputs across countries is known as the 'development accounting equation' (Hsieh and Klenow 2010).
9. For example, in the neoclassical model, the contribution of human capital to growth can be characterised as a direct effect, $(1-\alpha)\dot{h}$, and an indirect effect that measures its impact on capital accumulation. This is because an increase in h raises the average product of capital and induces capital. Thus, a fraction of the term $\dot{y}$ will be attributed to human capital.

10. Note that productivity here is measured in Harrod-neutral units, A , as opposed to Hicks-neutral units, B , where $B = A^{1-\alpha}$. I switch between the two because the use of Harrod-neutral units is more common, and useful, in growth theory whereas the use of Hicks-neutral units is the convention in growth accounting. Since we have assumed a Cobb-Douglas production function, however, it makes no difference as to whether productivity is in fact Hicks or Harrod-neutral or indeed some combination of both.
11. To obtain this expression, divide both sides of the production function by y^α , solve for y and then substitute for the steady-state value of $k/y = s/\chi$.
12. A similar steady-state decomposition has also been used by Hall and Jones (1999) in a cross-country context. They do not explicitly use the Solow–Swan relationship to analyse changes in s , but rather just look at changes in Y/K .
13. Though most studies assume a capital income share between 0.3 and 0.4, occasionally studies have suggested that the capital share of income is much larger. For example, if we assumed $\alpha = 0.5$, the Solow–Swan model says that a 3.2-fold increase in the investment rate—to use the example of India—would cause a 3.2-fold increase in the level of per capita GDP. This would make the increase in the investment rate very important for India explaining the bulk of its fivefold increase in GDP per capita. The 2.7-fold increase in China’s investment rate would, however, still be a relatively minor factor in China’s twelvefold increase in GDP per capita.
14. The Mincer model is $w = \beta e^{\phi t}$ in which t is the years of schooling and w is the wage rate. The empirical literature based on wage regressions suggests that the return to an additional year of education is approximately $\phi = 10$ per cent (Barro and Lee 2010). Using the preceding Cobb-Douglas production function, the wage rate in a market economy is $w = k^{1-\alpha} h^{1-\alpha}$ in which k and h are physical and human capital per worker, respectively. These equations suggest that $h = e^{\phi t/(1-\alpha)}$, so if $\alpha = 1/3$ then $\phi/(1-\alpha) = 0.15$ and so $h = e^{0.15t}$. As we shall see below, however, there is reason to believe that China’s returns to schooling have increased over time.
15. These values are not too dissimilar from Bosworth and Collins’ (2008) estimates. Using the traditional growth accounting approach, convert these changes to annual growth rates and then, as in Equation 14.3, weigh the growth rate of human capital by the labour share $(1 - \alpha)$. As noted above, this gives a relatively modest contribution to growth, especially for China.
16. Also see Whalley and Zhao (2010).