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Understanding China's Growth: Past, Present, and Future

Xiaodong Zhu

The pace and scale of China's economic transformation have no historical precedent. In 1978, China was one of the poorest countries in the world. The real per capita GDP in China was only one-fortieth of the U.S. level and one-tenth the Brazilian level. Since then, China's real per capita GDP has grown at an average rate exceeding 8 percent per year. As a result, China's real per capita GDP is now almost one-fifth the U.S. level and at the same level as Brazil. This rapid and sustained improvement in average living standard has occurred in a country with more than 20 percent of the world's population so that China is now the second-largest economy in the world.

To set the stage in this paper, I will begin by discussing briefly China's historical growth performance: that is, how China went from the world's leading economic power about 900 years ago to a situation in which it essentially missed the Industrial Revolution and had close-to-zero growth in per capita GDP from 1800 to 1950. I then present growth accounting results for the period from 1952 to 1978 and the period since 1978, using as my starting point a standard growth accounting exercise that decomposes the sources of growth into capital deepening, labor deepening, and productivity growth. For the period from 1952 to 1978, China's per capita GDP did rise by about 3 percent per year, but all of the growth was due to forced increases in government investment as well as a rise in education levels. Productivity actually regressed during this period, as China's economy went through the enormous disruptions of the famine in the late 1950s and the Cultural Revolution starting in the late 1960s. But the main focus of this paper will be to examine the sources of growth since 1978, the year when China started economic reform. Perhaps

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surprisingly, given China's well-documented sky-high rates of saving and investment, I will argue that China's rapid growth over the last three decades has been driven by productivity growth rather than by capital investment. The growth contributions made by human capital accumulation and an increase in labor participation are positive but modest. I will also examine the contributions of sector-level productivity growth, and of resource reallocation across sectors and across firms within a sector, to aggregate productivity growth. Overall, gradual and persistent institutional change and policy reforms that have reduced distortions and improved economic incentives are the main reasons for the productivity growth.

Despite the rapid growth of the last three decades, China's productivity is still only 13 percent of the U.S. level, which suggests that China still has plenty of room for productivity growth through further economic reforms. Even if China can replicate its extraordinary growth performance for another two decades, its productivity would still be only around 40 percent of the frontier productivity level.

Before delving into the analysis, let me first mention the three main data sources that I use for this paper. For examining China's historical performance, I use the data constructed by Madison (2007); for comparing China with other countries, I use the purchasing power parity data from Penn World Table (PWT7.0); and for detailed growth accounting exercises, I mainly use the data series my coauthor and I constructed for Brandt and Zhu (2010), in which we made adjustments to China's official statistics by using alternative deflators and information from household surveys.

China's Historical Economic Performance

China was a world economic and technological leader in the "premodern" era. Many historians think that China's premodern economic performance reached a peak in the Song Dynasty (circa 1200) when China is though to have had the most advanced technologies (Needham and Ronan 1978), the highest iron output (Hartwell 1962), the highest urbanization rate (Chao 1986), and the largest national economy (Madison 2007) in the world. However, sometime between 1500 and 1800, China lost its leadership position to Western Europe. Figure 1 plots Angus Madison's estimates of per capita GDP for China and Western Europe. According to his estimates, China's per capita GDP stagnated between 1500 and 1800 while Western Europe's per capita GDP increased steadily during the same period. These estimates suggest that, by the end of the fifteenth century, China had already started to fall behind Western Europe, well *before* the Industrial Revolution occurred in England. Some historians and economists attribute China's falling behind during this period to the more centralized and inward-looking political systems of the Ming (1368–1644) and Qing (1644–1911) dynasties that stifled innovation and commercial activities in China.

Not all economic historians agree with this explanation. Kenneth Pomeranz (2000) argues in *The Great Divergence* that in the eighteenth century, living standards and the degree of commercialization in China's Lower Yangzi region were comparable to those in the richest parts of Europe and that China only started

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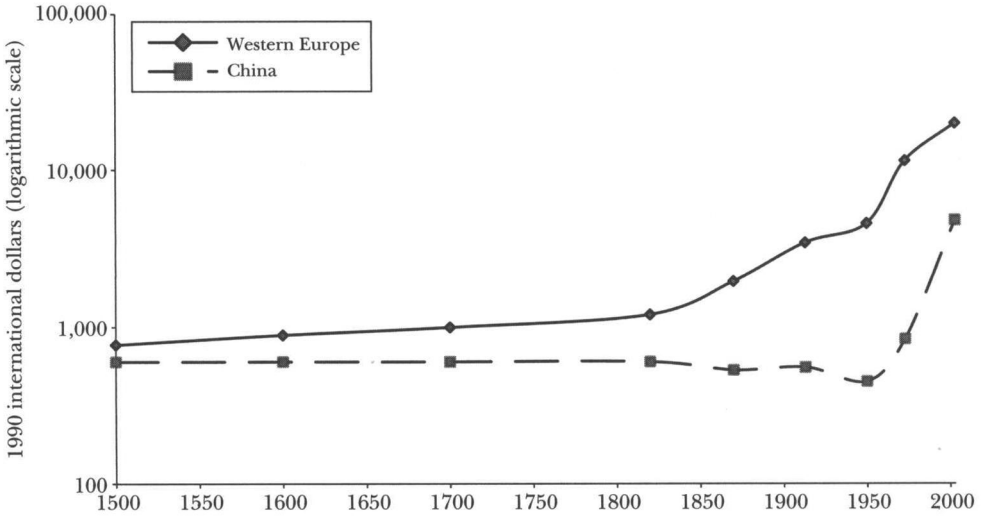
Figure 1
Per capita GDP of China and Western Europe



Source: Madison (2007).

to fall behind Western Europe *after* the Industrial Revolution in England. Shiue and Keller (2007) provide evidence that in the late eighteenth century, the degree of market integration was higher in the Lower Yangzi region than in continental Europe and only slightly lower than that in England. Instead of asking what went wrong in China, Pomeranz attributes the success of the Industrial Revolution to two lucky breaks for England: accesses to coal and colonies.

The questions of why China was not able to maintain its technological lead and the exact time when China started to fall behind Western Europe remain unresolved. There is no doubt, however, about the great divergence in economic performance between China and Western Europe in the nineteenth century and the first half of the twentieth century. Brandt, Ma, and Rawski (2012) review the debates over possible causes and the related literature. They argue that China's economic failure during this time period was due to an imperial political-institutional system that protected vested interests of elite groups—like imperial households, members of bureaucracy, and local gentry—who in turn were resistant to adoptions of new technologies. This imperial system was significantly weakened and eventually collapsed after two Opium Wars between China and Great Britain in the 1840s and 1850s and the Sino-Japanese War of 1894–95. The series of Chinese defeats was in effect a forced opening of China's borders, and it led to territories and treaty ports being conceded to the West and to Japan. These changes brought to China industrial technologies and factories, but continuous civil wars and World War II prevented the industrialization process from gaining much momentum in China until the 1950s. Indeed, industrialization had so little effect during this time that China's per capita GDP *declined* between 1800 and 1950.

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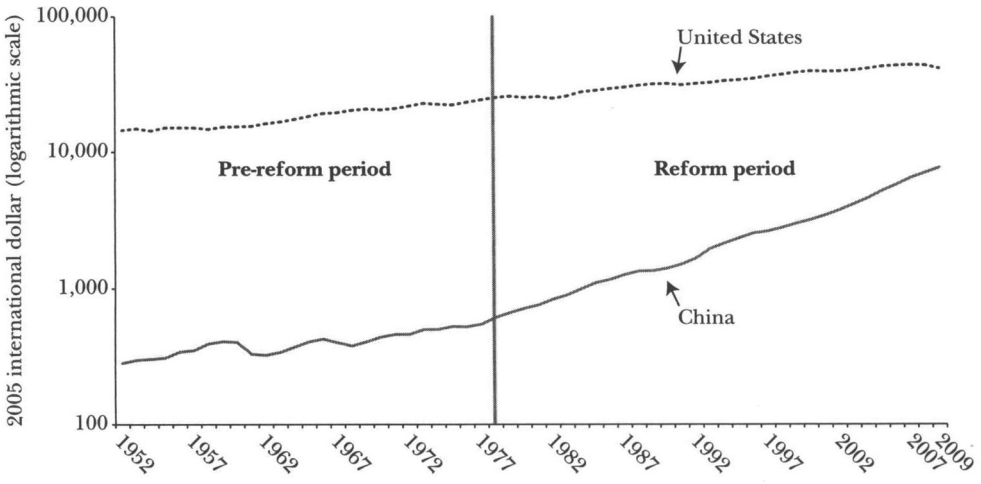
Figure 2
GDP per capita of China and US: 1952–2009



A Growth Accounting Decomposition for Modern China

After the establishment of the People's Republic in October 1949, China finally started its industrialization process in the early 1950s. However, growth performance before and after 1978 differs significantly. Prior to 1978, the average growth rate of real per capita GDP was a modest 3 percent a year, not much different from the growth rate in the United States though starting from a much lower base. Since 1978, China's growth in per capita GDP has accelerated to a rate in excess of 8 percent per year, and Figure 2 shows (on a log scale) how China's per capita GDP has begun to close the gap with U.S. per capita GDP.

Why did China's growth performance differ so much before and after 1978? To answer this question, I begin in this section by using the standard growth accounting method to take a look at the sources of China's growth in both periods, which shows that capital accumulation was the main source of economic growth in the 1952–1978 period while productivity growth has been the main source of growth since then. In the next two sections, I offer more details on these two periods, including why the capital-investment-led growth of the 1952–1978 period was unsustainable and came at such a high cost to the country, and what has been underlying the rapid productivity growth since 1978.

Let the relationship between production inputs (physical capital, human capital, and labor) and GDP be represented by a standard Cobb–Douglas production function:

$$Y = AK^{\alpha}(hL)^{1-\alpha}.$$

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Here Y is GDP, K is physical capital stock, L is labor (number of workers), h is the average level of human capital, A is total factor productivity (TFP), and α is the output elasticity of physical capital, which is usually measured by capital's share of national income. Hall and Jones (1999) show how to use this framework to calculate per capita GDP,[1] while Kehoe and Prescott (2002) note that in this framework the growth rate of per capita GDP can be decomposed as the sum of four terms:

$$\begin{aligned}\textit{Growth rate of per capita GDP} = {} & \textit{growth rate of labor participation rate} \\ & + \alpha/(1-\alpha)\ \textit{growth rate of the capital/output ratio} \\ & + \textit{growth rate of average human capital} \\ & + 1/(1-\alpha)\ \textit{growth rate of total factor productivity.}\end{aligned}$$

Note that in this decomposition the contribution of total factor productivity growth is weighted by $1/(1-\alpha)$, taking into account both the direct contribution of total factor productivity and the indirect contribution through its impact on capital accumulation.

For Table 1, I will set the value of α to 1/2 (as in Brandt, Hsieh, and Zhu 2008) to match China's average capital income share as reported in China's national accounts. With this assumption in place, Table 1 presents a decomposition of China's per capita GDP growth into contributions from growth of the labor participation rate, the capital/output ratio, average human capital, and total factor productivity.[2]

This decomposition reveals very different patterns of growth in the two periods. In the pre-1978 period, growth was mainly coming from increases in both physical and human capital rather than increases in productive efficiency. Total factor productivity actually deteriorated during this period, declining by 1.07 percent per year. Due to the increases in average schooling years, average human capital grew at 1.55 percent a year, partially offseting the reduction in total factor productivity.

[1] Specifically, Hall and Jones (1999) show that in this Cobb–Douglas framework one can express the GDP per capita in the following way:

$$\frac{Y}{Pop} = \frac{L}{Pop}\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} hA^{\frac{1}{1-\alpha}}.$$

In this formulation, *Pop* is the population. GDP per capita can thus be calculated as the product of four terms: the labor participation rate, the capital/output ratio raised to the power of $\alpha/(1-\alpha)$, the average level of human capital, and total factor productivity raised to the power of $1/(1-\alpha)$. The other variables are defined in the text.

[2] The data on GDP per capita, GDP per worker, and labor participation rate are taken from the Penn World Table (PWT7.0). The Penn World Table contains two versions of data for China. I use version 1 because it is more consistent with the series we constructed for Brandt and Zhu (2010) using China's national accounts data, with adjustments made to deflators in a way that is similar to what Alwyn Young (2003) did for the data over a shorter period of time. The physical capital stock data are constructed using the real investment data from the PWT7.0 and the perpetual inventory method with a depreciation rate of 0.06. The initial capital stock in 1952 was set to $I_{52}/(0.06 + \ln(I_{57}/I_{52})/5)$, where I_t is the real investment in year t. The average level of human capital is constructed using the average schooling years reported in the Barro and Lee (2010) dataset and the method of Hall and Jones (1999).

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Table 1
Decomposing China's Growth: 1952–2007

Period	*Average annual growth rates (%)*				
	GDP per capita	*Labor partication rate*	*Capital/output ratio*	*Average human capital*	*TFP*
1952–1978	2.97	0.11	3.45	1.55	–1.07
1978–2007	8.12	0.57	0.04	1.18	3.16
Period	*Contributions to per capita GDP growth*				
	GDP per capita	*Labor partication rate*	*Capital/output ratio*	*Average human capital*	*TFP*
1952–1978	100	3.63	116.15	52.25	–72.03
1978–2007	100	7.05	0.51	14.55	77.89

Source: Authors calculations. The data on GDP per capita, GDP per worker, and labor participation rate are taken from the Penn World Table (PWT7.0). The average level of human capital is constructed using the average schooling years reported in the Barro and Lee (2010) dataset. See footnote 2 for details.
Notes: Table 1 presents a decomposition of China's per capita GDP growth into contributions from growth of labor participation rate, capital/output ratio, average human capital, and total factor productivity. "TFP" is total factor productivity. See text for details.

The labor participation rate increased slightly, growing at 0.11 percent a year. The most important source of growth was increases in the physical capital/output ratio, which on average grew 3.45 percentage points a year and accounted for 116 percent of the per capita GDP growth.

After 1978, capital accumulation and total factor productivity growth reversed their roles. Between 1978 and 2007, the physical capital/output ratio remained roughly constant and the average human capital growth rate was lower than the growth rate in the pre-1978 period. The two sources combined contributed to around 15 percent of the growth in per capita GDP. Demographic factors played a very limited role. Partly due to the one child policy, the labor participation rate grew at 0.57 percent a year during this period, faster than in the pre-1978 period. But the contribution of the increases in labor participation rate was still modest, accounting for only about 7 percent of the growth. In contrast, total factor productivity grew rapidly at 3.16 percent a year. (Bosworth and Collins, 2008, in this journal, and Perkins and Rawski, 2008, report similar results in their growth accounting exercises.) Since the contribution of total factor productivity growth is weighted by $1/(1-\alpha)$ and α is 0.5, the growth contribution of total factor productivity growth is $2 \times 3.16 = 6.32$ percentage points, or 78 percent of the growth in GDP per capita.

The finding that aggregate productivity growth has been the most important source of China's growth since 1978 may seem surprising because it runs in the face of a popular view that China has followed an *investment-driven* growth model that relied heavily on capital-deepening for growth over the last three decades (for

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example, Wolf 2011). But, although the share of annual GDP that flows to real fixed capital investment in China increased from 33 percent to 39 percent between 1978 and 2007, China's capital-to-output ratio barely increased during this time. China's capital investment since 1978 has been keeping up with its rapid rate of output growth but not leading it. Examining the data between 1978 and 1998, Young (2003) also comes to the conclusion that capital deepening was *not* the source of China's growth. As Solow (1956) taught us: persistent economic growth can only come from growth in total factor productivity. More than three decades of rapid economic growth in China would not have been possible without significant growth in aggregate total factor productivity.

Government-led Industrialization between 1952 and 1978

After the People's Republic of China was established in 1949, the Chinese Communist Party government, like governments of many other countries at the time, thought the most effective way to speed up the industrialization process was by increasing investment in heavy industries such as steel, concrete, and heavy machinery. China's government mobilized the resources for investment by limiting household consumption and setting low prices for agricultural goods so that forced savings and surpluses extracted from the agricultural sector could be used for investment in such industries.

This strategy of extensive growth based so heavily on capital accumulation was not sustainable and had grave welfare consequences. The big push towards industrialization during the Great Leap Forward years (1958–1960) not only failed to raise the GDP growth rate, it also had such disruptive effects on agricultural production that a severe famine occurred when China was hit by adverse weather shocks in 1959 (Li and Yang 2005). The Great Leap Forward became the Great Leap Famine of 1959–1961, when the official statistics admit to 15 million deaths and unofficial estimates suggest double that number or more.

Despite these disastrous results, the Chinese government continued its unbalanced growth strategy with only minor adjustments after the famine. Unfavorable terms of trade were set on farm products, which effectively imposed heavy taxes on farmers. The *hukou* or household registration system was implemented to keep heavily taxed farmers from leaving rural areas. Furthermore, farmers were prohibited from engaging in any nonfarm activities. These policies initially helped to ensure that the government could extract surpluses from the agricultural sector to support the capital accumulation in the industrial sector. However, they also created incentive problems that significantly reduced the productivity of farmers. As a result, agricultural output grew slowly. In the late 1970s, the agricultural sector included more than 70 percent of China's labor force but was not even able to provide China's population with 2,300 calories per capita per day (near the UN-established minimum). Emergency grain imports were frequently needed to meet food deficits (Huang, Otsuka, and Rozelle 2008). China's nonagricultural sector was little better. It was dominated by the state-owned enterprises in which resource allocation and production activities

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were carried out according to government plan rather than market signals. Most of the state-owned enterprises at that time were inefficient, overflowing with redundant workers, and often producing output for which there was no market demand. At the same time, there were very few firms in the light industries like home appliances, furniture, and clothing, and there were constant shortages of consumer products.

Given this background, it may seem paradoxical that China's economy managed an average per capita GDP growth rate of even 3 percent from 1952 to 1978. The main reason for such a gain, as earlier emphasized earlier in Table 1, was the increases in physical and human capital, both of which were at very low levels in 1952. The capital/output ratio rose by about 140 percent during this time, from 0.91 in 1952 to 2.22 in 1978. In addition, average years of education rose from 0.74 in 1952 to 3.75 in 1978. Even with the substantial decline in aggregate productivity, these factors were sufficient to increase China's per capita GDP over this time.

In summary, the industrialization policies pursued by the Chinese government during this period from 1952 to 1978 created adverse incentives and gross misallocation of resources that resulted in declining aggregate productivity, recurring food crises, and relatively little improvement in living standards.

Sectoral Shifts and Productivity Growth Since 1978

When the Cultural Revolution ended after the death of the Communist Party chairman Mao Zedong in 1976, the Chinese government under the leadership of Deng Xiaoping sought to increase its legitimacy by improving aggregate economic performance and raising living standards. In December 1978, the government decided on a general policy of *Gaige Kaifang* or "reform and opening up." Xu (2011) reviews the institutional changes during the reform period in China. There was no grand design of systematic reform policies; instead, economic reforms have taken place in a gradual, experimental, and decentralized fashion. How did the reforms generate such impressive growth? Is the growth sustainable? As a starting point to answering this question, in this section, I look at productivity growth in different sectors and the reallocation of labor across sectors. In the following two sections, I then discuss the key economic reforms and institutional changes that were behind the sector-level productivity growth in agriculture and in the nonstate sector.

Table 2 presents total factor productivity growth rates of the aggregate economy, the agricultural sector, and the nonagricultural sector. Because of the importance of the state sector in the Chinese economy, the nonagricultural sector is divided into the state and the nonstate sectors. The "state sector" includes both state-owned enterprises and shareholding companies; and the "nonstate sector" includes domestic private firms, foreign-invested firms,[3] and collective

[3] In China, "foreign-invested" firm is a term used for any one of a number of legal entities with foreign stakeholders, including equity joint ventures, cooperative joint ventures, wholly-owned foreign enterprises, and foreign-invested companies limited by shares.

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Table 2

Employment Share, GDP Share, and Total Factor Productivity Growth by Sector

	Average annual total factor productivity growth (%)			
		Nonagricultural sector		
Period	*Agriculture*	*Nonstate*	*State*	*Aggregate*
1978–2007	**4.01**	**3.91**	**1.68**	**3.61**
1978–1988	2.79	5.87	−0.36	3.83
1988–1998	5.10	2.17	0.27	2.45
1998–2007	4.13	3.67	5.50	4.68
Year	*Employment share (%)*			
1978	69	15	16	100
2007	26	62	12	100
Year	*GDP share (%)*			
1978	28	27	45	100
2007	10	70	20	100

Source: Brandt and Zhu (2010).

Notes: Table 2 presents total factor productivity (TFP) growth rates of the aggregate economy, the agricultural sector, and the nonagricultural sector, with the nonagricultural sector divided into state and the nonstate sectors. See text for details on the categorization of firms and enterprises into sectors. Because the TFP growth rates reported in this table are based on China's national accounts data that use domestic prices, they are different from the TFP growth rates reported in Table 1, which are calculated from the Penn World Table data that use international prices.

firms in the nonagricultural sector. We include the shareholding companies in the state sector because many of them are former state-owned enterprises that were restructured into shareholding companies after the mid-1990s but are still controlled by the state. They continue to receive favorable treatment by the state, have easy access to bank credit, and are concentrated in protected industries such as energy and telecommunication. In contrast, the collective firms, including those that are controlled by lower-level governments, receive little support from the state and, like domestic private firms, have difficulties getting bank credit and entering into protected industries. Thus, we include them in the nonstate sector.

The growth rates are reported for the entire period of 1978–2007 and three subperiods. The productivity growth rates are calculated using China's official national accounts data on nominal output and fixed investment, the revised GDP and fixed investment deflators, the revised employment series that is consistent with

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China's census data, and the schooling year data of Barro and Lee (2010). In Brandt and Zhu (2010), we offer details on the construction of the data series.[4]

Total factor productivity grew rapidly in both the agricultural and the nonstate sectors. For the overall period from 1978 to 2007, the average annual growth rates of total factor productivity in these two sectors is 4.01 and 3.91 percent, respectively. In contrast, the average growth rate of total factor productivity in the state sector is only 1.68 percent per year. Prior to 1998, in particular, the state sector had very low productivity growth rates. After 1998, though, total factor productivity in the state sector grew rapidly, averaging 5.5 percent annually.

The similarity of productivity growth rates in agriculture and in the nonstate sector are associated with very different movements of these two sectors' employment shares. As reported in Table 2, agriculture's share of total employment declined from 69 percent in 1978 to 26 percent in 2007. The high rate of productivity growth in agriculture helped to push workers away from jobs in agriculture. Conversely, the nonstate sector's share of employment increased from 15 percent in 1978 to 62 percent by 2007. The extraordinary increase in the number of workers in this sector was not sufficient to drive down their productivity. Instead, the growth of the nonstate secotor represents the productivity benefits of a sectoral shift away from the agricultural sector to a sector of the economy that could absorb this labor and still generate rapid productivity growth.

The state sector's share of total employment remained remarkably constant at around 16–17 percent of the total labor force from 1978 until 1997. The restructuring of state enterprises circa 1998 led both to a rise in the rate of productivity growth for this sector and also to a decline in its share of China's labor to 12 percent in 2001—a level where it has remained since.

In the next section, I'll discuss the transformation in agriculture in more depth. In the following section, I'll delve more deeply into productivity growth for the nonstate and state producers in the nonagricultural sector.

Productivity Growth in Agriculture and Structural Transformation

Since China had experienced recurring food crises before 1978, it is not surprising that its economic reform started in the agricultural sector. There were two important reforms. First, the government increased prices for agricultural goods. Second, the previous "collective farming system" was shifted to the "household-responsibility system." Under the new system, each farm household was assigned a fixed quota of grains that the household had to sell to the government at

[4] Because the national accounts use domestic prices rather than international prices, these growth rates are not the same as the growth rates calculated from the Penn World Tables. However, the differences are small. For the entire period of 1978–2007, the annual growth rates of GDP per worker and total factor productivity calculated using the Penn World Tables are 7.55 and 3.16 percent, respectively. The corresponding growth rates calculated using China's national accounts data are 7.58 and 3.61 percent.

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official prices. However, any extra grain the household produced could be sold at market prices. The reforms were implemented gradually and completed in 1984. Between 1978 and 1984, total factor productivity in the agricultural sector grew 5.62 percent per year. Several studies argue that most of the productivity growth during this period can be attributed to the price and institutional reforms that generated strong positive incentive effects on farmers' efforts and input choices (for example, McMillan, Walley, and Zhu 1989; Lin 1992).

As a result of the productivity growth, China's agricultural output increased by 47 percent during this period. The increase in food availability alleviated China's subsistence food constraint and started a structural transformation that reallocated a large amount of labor from agriculture to industry. From 1978 to 1984, agriculture's share of total employment fell from 69 percent to 50 percent: that is, in just six years, 19 percent of China's labor force—more than 49 million workers—reallocated out of the agricultural sector. Most of the 49 million reallocated workers did not move to urban centers. Instead, they went to work in the rural industrial enterprises set up by township and village-level governments that are called "township and village enterprises" (TVEs).

For the first few years, the price and institutional reforms increased agricultural output mainly by improving incentives without much change in the production technologies being used. However, by about 1984 these static efficiency gains, from workers using the same technology with a much more rewarding set of incentives, were largely exhausted. Both agricultural productivity and structural transformation stagnated in the second half of the 1980s. Starting around 1990, markets for agricultural inputs and outputs were gradually liberalized and government interventions were significantly reduced. Huang, Otsuka, and Rozelle (2008) document extensive market liberalization in China's agricultural sector and state: "aside from restrictions on land ownership, China today may have one of the least distorted domestic agricultural economies in the World." As this market liberalization provided farmers with strong incentives to adopt new technologies, the average annual growth rate of total factor productivity in agriculture reached 5.10 percent between 1988 and 1998, and remained at 4.13 percent between 1998 and 2007. Most of agriculture's growth in total factor productivity after 1990 came from technological progress (Jin, Ma, Huang, Hu, and Rozelle 2010). Structural transformation also resumed after 1990. By 2007, agriculture's share of total employment had been reduced from 46 percent in 1991 to 26 percent in 2007.

How did productivity growth in agriculture contribute to the overall economic growth in China? Since T. W. Schultz (1953)'s pioneering work, economists have long emphasized the role of agriculture in economic development.[5] The standard argument is that productivity growth in agriculture not only contributes to aggregate productivity growth directly, but also indirectly through structural transformation. When agricultural productivity increases, food demand can be met with a smaller

[5] See, for example, Johnston and Mellor (1961), Jorgenson (1961), Schultz (1964), and Timmer (1988). See also Gollin, Parente, and Rogerson (2002), Restuccia, Yang, and Zhu (2008), and Yang and Zhu (2010) for some recent analyses.

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number of workers in the agricultural sector than before. As a result, some workers can be reallocated to the nonagricultural sector. Because average labor productivity is generally higher in the nonagricultural sector than in the agricultural sector, the reallocation of workers from agriculture contributes positively to aggregate productivity growth. Indeed, in 1978, the average labor productivity in China's nonagricultural sector was six times as high as in the agricultural sector, and therefore one would expect a significant contribution from the labor reallocation. For this reason, Young (2003) suggests that the reforms in the agricultural sector may have been the most important source of China's growth during the first two decades of economic reform.

In Brandt and Zhu (2010), my coauthor and I use a multisector model to quantify this contribution during the period of 1978–2007. We find that, out of the 43 percentage points of the reduction in agriculture's share of employment between 1978 and 2007, total factor productivity growth in agriculture accounts for 39 percentage points or 91 percent of the total reduction. Taking both the direct and indirect effects into account, we find that the contribution of total factor productivity growth in agriculture to aggregate productivity growth is 1.5 percentage points a year for the entire period of 1978 and 2007. However, we also find that the role of agriculture's productivity growth diminishes over time, from a contribution of 2.1 percentage points per year between 1978 and 1988, to a contribution of only 0.6 percentage points per year for the period between 1998 and 2007. There are two reasons for the decline. First, as the economy grew, agriculture's share of value-added decreased, and therefore its direct contribution also diminished. Second, the marginal contribution of reallocation is a decreasing function of the agricultural productivity level. After 20 years of productivity growth, the gain from reallocation naturally declined in the later years. As agriculture's share of employment and value-added continue to decline, the contribution of productivity growth in agriculture to aggregate productivity growth will be even smaller in the future.

Growth outside Agriculture: A Tale of Two Sectors

Before economic reform started in 1978, resource allocation was centrally determined by the government's plan rather than by the market. The state sector dominated nonagricultural activity, accounting for 80 percent of the total urban employment and more than three-quarters of industrial output. The nonstate sector at that time mainly consisted of collective firms. Urban collectives were confined to producing a small number of consumer goods and providing neighborhood services. Rural collectives were only allowed to manufacture producer goods for the agricultural sector.

1978–1988: Rise of the Nonstate Sector

In the early 1980s, encouraged by the success of the rural reforms, the Chinese government started two market reforms in the nonagricultural sector. First, a dual-track system was introduced. State-owned enterprises were still given quotas

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on both production inputs and output that transacted at official prices, but they were also allowed to buy inputs and sell output beyond quotas at market prices. Moreover, the non-state-owned enterprises, including collectives (as we discussed earlier), small-scale individual businesses, and foreign-invested firms in the special economic zones, were allowed to enter previously forbidden industries, buying and selling their inputs and outputs at market prices. Second, the central government also devolved economic decision-making powers to lower-level governments and provided them with fiscal incentives. Starting in 1980, a "fiscal contracting system" was implemented that effectively made local governments the "residual claimants" of the enterprises under their control (Qian 1999). As a result, provincial-, city-, and county-level governments controlled most of the state-owned enterprises while the township- and village-level governments controlled the group of rural collective enterprises that became known as the "township and village enterprises."

Under these reforms, the township and village enterprises based on the old rural collectives flourished and led the way to an expansion of the nonstate sector, while the state-owned enterprises did not. The number of township and village enterprises increased from 1,520,000 in 1978 to 18,880,000 in 1988 (National Bureau of Statistics of China 1999). The success of the agricultural reforms made available to these enterprises a large number of local workers, and the dual-track system allowed them to gain access to capital and raw materials from the markets. Between 1978 and 1988, the share of total employment in nonstate enterprises increased from 15 percent to 39 percent. The expansion of employment in the nonstate sector was also accompanied by total factor productivity growth averaging 5.87 percent a year during this period.

The reforms did less for state-owned enterprises. Local governments at county level and above sought to improve the economic performance of the state-owned enterprises under their control by implementing a "managerial responsibility system" that linked managers and workers' income to financial outcomes of the enterprises. The reforms did have some positive effect on productivity. Using a panel data set of 272 industrial state-owned enterprises collected by the Chinese Academy of Social Sciences, Li (1997) estimates that their total factor productivity on average grew at 4.68 percent per year between 1980 and 1989, and that most of the productivity growth could be attributed to stronger incentives, increased market competition, and better allocation of production inputs. Using the same data set, Groves, Naughton, Hong, and McMillan (1994) also report positive incentive effects of the managerial responsibility system on productivity.

While enterprise reforms made industrial state-owned enterprises more efficient, their productivity growth was slower than that of the nonstate enterprises and not fast enough to offset the rising real cost of material inputs. Using more aggregate data on industrial enterprises reported by China's National Statistical Bureau, Jefferson, Rawski, and Zheng (1996) estimate that between 1980 and 1988, the average annual growth rate of total factor productivity was 2.96 percent for state-owned enterprises and 3.66 percent for the nonstate collective enterprises. However, these estimated rates of productivity growth are based on a production function that uses gross output rather than value-added. If the costs of real material

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inputs are rising, using gross output rather than value-added may be misleading.[6] In the pre-reform period, prices of material inputs were kept artificially low, and so during the reform period, market prices of material inputs rose significantly faster than output prices. Using the information reported in Jefferson, Rawski, and Zheng, I calculated the growth of total factor productivity for the state and collective industrial enterprises between 1980 and 1988 using value-added, rather than gross output. By this metric, the state-owned firms had annual productivity growth of –1.33 percent, while the nonstate collective enterprises had a growth rate of positive 3.11 percent per year. (There has been no comparable study for the specific state and nonstate enterprises in services because data for such a study are not available.)

In short, the basic lesson is that productivity growth of the nonagricultural sector during this period was mainly due to the rise of the nonstate sector. As Table 2 showed earlier for the 1978–1988 period, the state sector had an average annual growth rate of total factor productivity during this time of –0.36 percent, while the nonstate sectors had annual productivity growth of 5.87 percent.

1988–1998: From Reform without Losers to Inevitable Tradeoffs

The drastic difference in economic performances between the township and village enterprises and the state-owned enterprises may seem implausible; after all, both are enterprises under the control of local governments, albeit at different levels. One reason for the difference is that state-owned enterprises remained under the constraints of government planning for a longer time, unable to sell their products at market prices, although these restrictions diminished over time (Naughton 1995).

But the more important difference is the commitment made by the central government to support employment in the state sector. Remember that employment in the state-owned sector remained essentially constant at about 16 percent of the workforce from 1978 up through 1997. This stability reflected the central government strategy of letting the nonstate sector grow without downsizing the state sector. The strategy had the political benefit of minimizing social instability and reducing resistance to reform. Lau, Qian, and Roland (2000) call it "reform without losers." To avoid laying off workers or shutting down factories, the government usually asked the state-owned banks to bail out loss-making state-owned enterprises. The possibility of bailout created a "soft budget constraint," to use a term common in the literature on centrally planned economies, that further reduced the economic incentives of the state-owned enterprises (Kornai 1980; Qian and Roland 1998; Brandt and Zhu 2001). The lack of exit also eliminated market selection as an important mechanism for improving aggregate productivity in the state sector. In contrast, the central government had no commitment to support employment in the township and village enterprises. While the local governments that ran the township and village enterprises did have political incentives to minimize unemployment and maintain social stability in their communities, these local governments had only weak influence on

[6] Specifically, let s_m be the share of material inputs in gross output, then $\Delta\ln(TFP_{\text{value-added}}) = [\Delta\ln(TFP_{\text{gross output}}) - s_m\,\Delta\ln(\text{real material input cost})]/(1 - s_m)$.

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banks. For example, millions of township and village enterprises went bankrupt when there was a general tightening of credit in 1989 (Qian and Xu 1993). Thus, township and village enterprises faced a much tighter budget constraint and stronger market discipline than did the state-owned enterprises.

Unsurprisingly, at least to economists, a "reform without losers" strategy still poses tradeoffs. In the absence of hard budget constraints and market discipline, the state-owned enterprises continued to be outperformed by the nonstate sector. Between 1988 and 1998, the average annual growth rate of total factor productivity in the state sector was only 0.27 percent, while the comparable growth rate of the nonstate sector was 2.17 percent (as shown earlier in Table 2). Faced with increasing competition from the more efficient nonstate firms and without significant productivity growth, the financial condition of the state-owned firms deteriorated. The resources needed to support the state-owned enterprises increased steadily between 1986 and 1993. Nonperforming loans in the state banking system increased rapidly, and the creation of money to make these loans was leading to chronic high inflation (Brandt and Zhu 2000).

By 1994, it had become clear that the strategy of "reform without losers" could no longer be sustained. In 1995, the Chinese government reduced its commitment to stable employment in the state sector. Many small-scale state-owned enterprises were allowed to go bankrupt or be privatized through management buyouts. Between 1995 and 2001, the state sector's share of total employment declined from 17 percent to 12 percent.[7] More diversified ownership forms were also introduced within the state sector. Some of the large-scale state-owned enterprises were converted into shareholding companies, with a majority of shares controlled by the state.

1998–2007: Privatization and Trade Liberalization

The 15th Congress of the Chinese Communist Party held in 1997 was a milestone in China's economic policies. The Congress formally sanctioned ownership reforms of the state-owned firms and also legalized the development of private enterprises. With the reduction of legal barriers, private enterprises grew rapidly. Collective enterprises such as township and village enterprises lost their edge, some were closed and many of them were privatized, also in the form of management buyouts. As part of the lead-up to China's joining the World Trade Organization in 2001, China's government also started to cut tariffs, broadened trade rights, and liberalized its regime for foreign direct investment (Branstetter and Lardy 2008). Between 1998 and 2007, the share of total urban employment in domestic private enterprises and foreign-invested enterprises increased from 8 to 24 percent. The increase in the manufacturing sector was even more pronounced. By 2007, domestic private enterprises alone accounted for 51 percent of total urban employment in the manufacturing sector (National Bureau of Statistics of China, 2008, tables 4–2,

[7] China's official employment statistics did not record a reduction in the employment of state-owned enterprises until 1998. The state-owned sector actually started to downsize and lay off workers a few years earlier in 1995.

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4–6, 4–13). Song, Storesletten, and Ziliboti (2011) present a model that describes the transformation during this period.

The combination of privatization and trade liberalization had strong effects on productivity growth in both the state and nonstate sectors. Between 1998 and 2007, the average annual total factor productivity growth rates of the state and nonstate sectors were 5.50 percent and 3.67 percent, respectively (as shown in Table 2). After stagnating for much of the first two decades of reform, the state sector finally experienced productivity growth in the last decade.

In the manufacturing sector, productivity growth during this period is even higher. Using data of the China Annual Survey of Industries,[8] Brandt, Van Biesebroeck, and Zhang (2012) estimate that, for the manufacturing sector, the total factor productivity growth rate is 13.4 percent a year. Because even state-owned enterprises were allowed to go bankrupt and exit during this period, reallocation through the process of entry and exit contributed significantly to productivity growth, accounting for 72 percent of the aggregate growth of total factor productivity in the manufacturing sector. Jefferson, Rawski, and Zhang (2008) report similar results. Using the same data, Hsieh and Klenow (2009) examine the contribution of capital and labor reallocation among existing firms to the aggregate total factor productivity growth in the manufacturing sector. They find that between 1998 and 2005, a more efficient allocation within four-digit-level manufacturing industries contributed 2 percentage points per year to aggregate total factor productivity growth in the manufacturing sector, with a significant portion of it coming from the reallocation from state-owned to nonstate enterprises. In short, privatization and trade liberalization reduced barriers to entry and exit, and increased competition, which in turn led to rapid productivity growth in the manufacturing sector by raising within-firm productivity and through reallocation along both the extensive and intensive margins.

However, China's nontradable sectors—primarily construction and services—have faced much less international competition. There have also been significant barriers to entry of private and foreign-invested firms into service industries, and significant barriers to exit of state-owned enterprises in services. In 2007, the state sector still accounted for 77 percent of total urban employment in services, in contrast to 15 percent in manufacturing. It is perhaps not surprising, then, that researchers have found that productivity growth in the nontradable sector lagged behind growth in the tradable sector (for example, He, Zhang, Han, and Wu 2012).

Sources of Aggregate Productivity Growth in China: A Summary

From 1978 to 2007, China's annual growth rate of total factor productivity was 3.61 percent per year. We can summarize the sources of aggregate productivity growth in China during the reform period as follows. In the agricultural sector, productivity

[8] This firm-level survey has been conducted annually by China's National Bureau of Statistics. It covers all Chinese industrial firms (manufacturing, mining, and construction) with sales over 5 million renminbi yuan.

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growth contributed 1.5 percentage points a year to aggregate productivity growth over the 1978–2007 period, both directly and indirectly through structural transformation. However, this source of growth diminished over time as agriculture's share of GDP diminished, and its contribution to China's future growth will be small. In the nonstate sector, productivity growth contributed 2.27 percentage points per year to aggregate productivity growth over the 1978–2007 period.[9] This source of growth will continue to drive China's future growth as the nonstate sector's share of total nonagricultural employment has risen from 48 percent in 1978 to 84 percent in 2007 (more than 60 percent of total employment). Productivity stagnated in the state sector until the late 1990s, and for the 1978–2007 period as a whole this sector contributed essentially zero to aggregate growth in total factor productivity. However, since 1998, the state sector also experienced rapid productivity growth as a result of restructuring.

The proximate sources of productivity growth have shifted over time. For example, productivity growth in agriculture under the dual-track system led the way from 1978 up to about 1984; starting in the mid-1980s, the nonstate sector in the form of township and village enterprises under its own dual-track system led the way through much of the 1980s and 1990s; and from the late 1990s and into the 2000s, the nonstate sector in the form of privately-owned firms and a restructured state-owned sector led the way in an economic climate much friendlier to the private sector and with lots of entry, exit, and competitive pressures. Whenever the effect of one set of reforms on productivity seemed to be exhausted, the Chinese government found a way to initiate new reforms that reignite growth.

The Future of China's Economic Growth

Experiences from other economies, especially the East Asian economies such as Japan, Korea, and Taiwan, suggest that periods of extremely rapid growth eventually slow down and China's more than 8 percent a year per capita GDP growth rate will not last. China's per capita GDP is now around 20 percent of the U.S. level. Will China's per capita GDP level out at 40 percent of the U.S. level, or 80 percent, or 120 percent? Of course, any answer to this question will contain a large dose of speculation. But I will attempt to address this question by discussing what would be the key sources of China's growth in the future based on what we know about the sources of China's growth in the last three decades.

Following the earlier decomposition of the sources of economic growth, we can decompose China's GDP per capita relative to that of the United States into

[9] In Brandt and Zhu (2010), we estimate that, if there were no total factor productivity growth in the nonstate sector, the producutvitiy growth rate for the nonagricultural sector would have been close to zero for the entire period between 1978 and 2007 and during each of the three sub-periods. I should also note that productivity growth in different sectors may interact so that one cannot infer the contribution of productivity growth in the state sector by simply substracting the contributions of agriculture and nonstate sector from the aggregate productivity growth.

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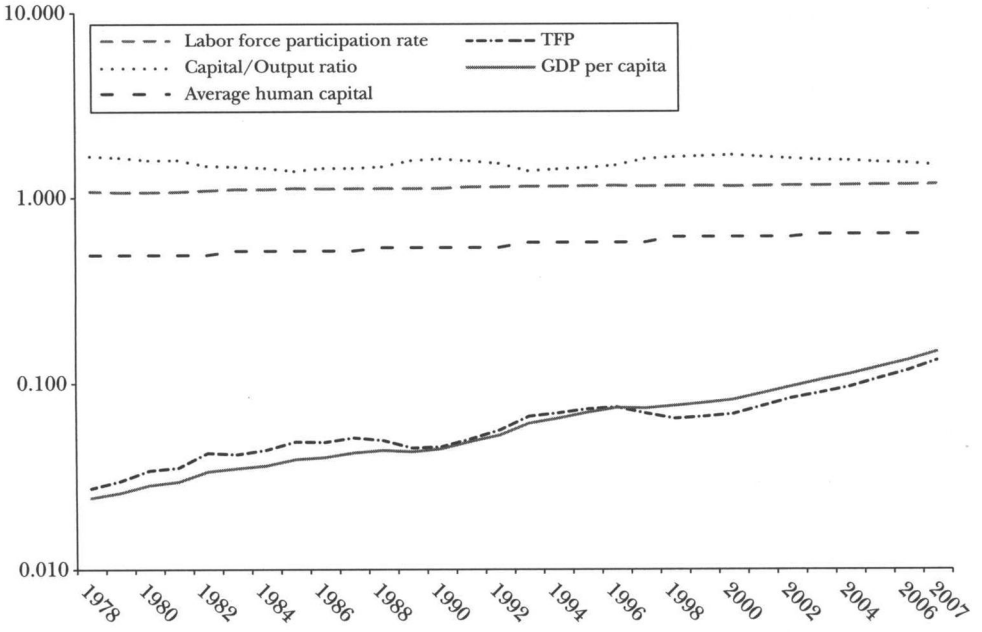
Figure 3
China Relative to the Uniteed States



Note: "TFP" is total factor productivity.

four ingredients: relative labor participation rate, relative average human capital, relative capital/output ratio, and relative total factor productivity.[10] Figure 3 plots these ratios for the period between 1978 and 2007. China's labor force participation and capital/output ratios are above U.S. levels, while China's relative level of human capital has risen somewhat over time (notice that Figure 3 is on a log scale). But clearly, the growth of China's relative GDP per capita is mainly driven by the growth of China's relative total factor productivity. To answer the question about China's future growth, then, one has to assess the future of China's relative productivity growth.

Although economic reforms have been crucial in generating productivity growth in China over the last three decades, many other economies in Eastern Europe and Latin America also had economic reforms, but their growth performances are nowhere near the performance achieved by China. What is special about China? One potential explanation is simply China's backwardness at the start of economic reform in 1978, which increased China's potential for catch-up growth.

[10] To be precise, the last two ratios should be the relative capital/output ratio raised to the power of $\alpha/(1-\alpha)$, and relative total factor productivity raised to the power of $1/(1-\alpha)$. For simplicity, however, I will simply refer them as "relative capital/output ratio" and "relative total factor productivity."

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When China started economic reform in 1978, its aggregate total factor productivity was less than 3 percent of the U.S. level, much lower than Mexico and the economies in Eastern Europe and South America. Because China was far away from the frontier, the impact of reforms in closing the productivity gap has been particularly large. Parente and Prescott (1994) present a model along these lines, and Kehoe and Ruhl (2010) suggest that this argument may explain why economic reforms have produced rapid growth in China, but less growth in Mexico.

Has China's productivity gap now been narrowed enough so that China will find it difficult to generate further productivity growth? Compare China's growth experience with three other East Asian economies that also had rapid and sustained reductions in their productivity gaps with the U.S. economy but eventually experienced significant slowdown in relative productivity growth: Japan, Korea, and Taiwan. In 1950, Japan's total factor productivity was 56 percent of the U.S. level; by 1975, Japan's was at 83 percent of the U.S. level. But since then, Japan's relative total factor productivity has somewhat fallen back. In 1965, Korea's total factor productivity was 43 percent of the U.S. level; by 1990, it had reached 63 percent of the U.S. level. After 1990, Korea's relative productivity has continued to converge with the U.S. level, but at a much slower rate of about 0.24 percent per year. In 1965, Taiwan's total factor productivity was 50 percent of the U.S. level; by 1990, it had reached 80 percent of that in the United States. Since then, Taiwan's relative total factor productivity has continued to converge, but (like Korea) at a much slower rate.

Back in 1978, China was starting at a far lower level of productivity than these comparison countries: indeed, from 1978 to 2007, after three decades of rapid productivity growth, China's total factor productivity had risen from 3 percent to 13 percent of the U.S. level. Even if China can replicate this extraordinary growth performance for another two decades, its productivity level would still be only 40 percent of the frontier U.S. level—still below the level of Japan in the 1950s or South Korea and Taiwan in the 1960s. In Japan, South Korea, and Taiwan, relative total factor productivity grew rapidly for a sustained period of time and did not slow down until after the relative productivity had reached 60 percent or higher.

China's economy still has large opportunities for raising productivity growth through reducing the still-existing distortions and inefficiencies in its production. For example, Hsieh and Klenow (2009) use firm-level data to estimate within-industry misallocation of capital and labor across existing firms in China's manufacturing industries. They find a reduction in distortions between 1998 and 2005, but they still estimate a potential total factor productivity gain of 30 percent for China's manufacturing sector if the distortions are reduced to the U.S. level. Song and Wu (2011) find a very similar gain using a different dataset and method. In Brandt, Tombe, and Zhu (2012), my coauthors and I take sector-level total factor productivity in each province as given and measure the potential productivity gain from eliminating factor market distortions across provinces and between the state and the nonstate sectors in China. We find the potential total factor productivity gain in China's nonagricultural economy to be

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at least 20 percent in our estimates, in which half the gain comes from eliminating cross-province dispersion in returns to labor and the other half comes from eliminating within-province difference in returns to capital between the state and the nonstate sectors.

While these potential efficiency gains are substantial, many obstacles exist that may prevent these gains from being realized. Despite many years of financial sector reforms, China's banking sector is still dominated by the state-controlled banks that lend disproportionately to local government projects and to firms in the state sector. Protected by barriers to entry of private and foreign firms, state-controlled firms continue to enjoy substantial monoploy rights and profits in industries ranging from energy, transportation, and telecomunication to banking, entertainment, education, and health care. Further institutional change and policy reforms will be needed if China is to maintain its productivity growth by reducing these distortions.

In the last three and half decades, China's leaders have chosen to carry out economic reform without political reform or the establishment of rule of law. Instead, they have implemented institutional changes and policy reforms in a piecemeal fashion that usually provided benefits to key interest groups within the state sector. Giving monopoly rights to state-controlled or politically connected firms is one example. While this approach has helped to reduce political resistence to economic reform, it has also resulted in corruption and income inequality in addition to economic distortions. If reducing the state sector's monopoly rights in various industries is important for reducing distortions and solving associated social-political problems of corruption and income inequality, it remains to be seen if China's leadership will be flexible enough and strong enough to do so.

Finally, I conclude by noting that I have only considered the direct contributions of human capital accumulation and demographic factors on GDP growth. It is possible that the increases in average years of education and the decreases in the dependence ratio due to the one-child policy have also reduced the cost of migration, facilitated the reallocation of labor away from agriculture, and therefore contributed positively to aggregate total factor productivity growth. If that is the case, I may have underestimated the growth contribution of the demographic factors and human capital accumulation. However, given that the marginal gains from labor reallocation have been decreasing over time, the contributions of these factors to productivity growth should also decline in the future.

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Korea's Economic Growth and Catch-up: Implications for China*

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Abstract

This study investigates the main factors that explain Korea's economic growth and catch-up over the past half century. The gap of output per worker between Korea and the US has decreased rapidly as Korea's lower per capita income, relative to its potential level, led to higher growth over the period, confirming the prediction of "conditional convergence" theory. Cross-country regression suggests that Korea's strong catch-up to the US is also attributable to strong investment, lower fertility, greater trade openness, and improvements in human resources and rule of law, while improvement in democracy tends to slow the pace of the catch-up. As Korea catches up to the US or its steady-state level in per worker output, it is subject to growth slowdown, unless it improves institutions and policy factors. While manufacturing- and export-oriented development served Korea's success well, poor productivity performance in the services sector has hampered overall productivity growth. Korea's experience implies that China's potential growth rates are likely to slow in coming decades due to the convergence effect and with the rebalancing towards a domestic consumption and services-based economy. China needs to upgrade institutional quality and improve productivity, particularly in its services sector, to sustain strong growth.

JEL Classification: O11, O14, O19, O47, O53, O57

Keywords: Economic Growth, Catch-up, Convergence, Productivity, Structural Change, Korea, China

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1. Introduction

The Republic of Korea (henceforth, Korea) has delivered a remarkable economic performance since the early 1960s, achieving per capita income of US$ 27,000[1] to become the world's eighth largest trading nation. However, the economy's recent growth performance has been rather disappointing compared with its historical record. Gross domestic product (GDP) growth was 4.1% on average in 2000–2010, marking a significant drop from the average 7.9% achieved between 1960 and 2000 (Table 1). From 2011 to 2015, Korea's GDP growth averaged only 3%. The Organisation for Economic Co-operation and Development (OECD) projects a further decline in Korea's growth rate to the 2% range in the coming decade.[2]

(TABLE 1 HERE)

The startling long-term performance of the Korean economy raises a challenging question as to what the fundamental factors that explain Korea's growth performance are. Some researchers argue that Korea's strong economic performance is an outcome of factor accumulation rather than efficiency improvement (Krugman, 1994). Others attribute Korea's growth largely to "good fundamentals," including a high savings rate, strong human capital, maintenance of good institutions, high trade openness, and prudent fiscal and monetary management (Radelet, Sachs, and Lee, 2001; De Gregorio and Lee, 2004). In particular, trade openness, driven by outward-looking development-strategy, is often emphasized as a key growth factor, as it has provided access to inexpensive imported intermediate goods, larger markets, and advanced technologies, and thereby contributed to rapid productivity growth of Korea's manufacturing industries. The Korean government has played an important role in promoting export-oriented industrialization. Export-oriented policies

[1] Gross national income per capita in 2014 from the World Bank's *World Development Indicators.*

[2] OECD, Economic Outlook No 95 - May 2014 - Long-term Baseline Projections.

designed to offer performance-based incentives for exporters have facilitated continuous upgrading of Korean firms' comparative advantage in global markets. [3]

A hot debate is whether Korea's current slowdown is an indication of a permanent drop in its growth potential. Some scholars argue that Korea's economic downturn will be exacerbated further, eventually leading to a situation comparable to Japan's "lost decades" (Cho, 2014). Others consider that the dynamic forces that have enabled Korea's fast growth, in particular manufacturing exports, remain vibrant, and thus, Korea can continue strong growth with the appropriate policies (Sharma, 2012).

The purpose of this study is to investigate the main factors that explain Korea's growth performance and assess its growth prospects. The change in Korea's per capita income and growth rates over the past 5 decades are discussed and compared with Japan in particular over a comparable period. This study assesses changes in the gap of per worker output between Korea and the US over time, and analyzes the extent to which the gap is explained by differences in factor inputs and total factor productivity (TFP) between the two economies. In addition, the study adopts a general framework of cross-country analysis, putting the Korean experience in a global context, and identifies and discusses the major factors that enabled Korea to achieve strong growth over a half century and that caused the recent growth slow-down. Furthermore, the study adopts more detailed industry-level data of the Korean economy to assess the imbalance between the manufacturing and services sectors, and compares Korea's sectoral performance with those of the US and Japan.

Thereafter, the study assesses the implications of the empirical findings from the Korean experience for the growth performance and prospects for the next decades of the Chinese economy. China's economic performance since the 1980s—its economy has grown more than 9.5% annually—has been astonishing. However, China's economy is now slowing. It

[3] It remains controversial to what extent industrial policy that targets specific industries has contributed to overall economic growth. The developmental state view, such as that of Amsden (1992), argues that selective government policies attempted to "pick winners". By contrast, the World Bank (1993) asserts that Korean government intervention conformed to the market, rather than replaced the market, using a pragmatic and flexible approach. Lee (1996) shows that targeting specific industries was often harmful to productivity growth of the overall economy.

grew 7.4% in 2014, the lowest since 1990, and is predicted to grow more slowly in the coming years. Considering China's influence on the world economy, the future of China's growth is of concern to all and has generated debate with diverse views. This study contributes to this issue by analyzing Chinese economic growth in the context of global standards as well as the Korean experience. It discusses the changes in the gap of per worker output between China and the US over time and compares performance of China with that of Korea for an equivalent period. It suggests possible policy measures that China could adopt to sustain strong growth. Although significant differences exist between two economies, such as country size and economic and political institutions, there are common factors that contribute to their economic growth and catch up processes. In this regard, Korean experiences can provide useful lessons for China.[4]

The remainder of this paper is organized as follows. Section 2 describes the economic performance of the Korean economy and examines Korea's catch-up process to the US in per worker output over time, in comparison with the relative performances of Japan and China. Section 3 uses cross-country panel datasets to examine the determinants of per worker output growth. Using the results, the critical factors behind Korea's growth performance relative to other countries are explained. Section 4 analyzes the patterns in structural change and growth of per worker output at the sectoral level. It discusses the role of services sector productivity growth in overall economic growth. Section 5 draws implications from the empirical findings for the growth performance and prospects over the next few decades of the Chinese economy. Section 6 provides concluding observations.

2. Korea's Economic Growth and Catch-up

2.1 The Korean Experience versus Others

[4] Japan's experiences, in particular asset bubble burst and long-term stagnation since the early 1990s, can be also useful for China's policymaking. However, China's per capita output as well as economic structure lag over 40 years behind Japan, which makes difficult to compare two economies and draw useful policy implications for China.

During the past half century, the Korean economy has shown impressive growth, with average annual GDP growth rate surpassing 7.1%, raising the level of real per capita GDP almost 18 times (Table 1). Average GDP growth rates accelerated to 7.5% in the 1960s, 8.6% in the 1970s, and 9.3% in the 1980s, but the impressive performance was interrupted by the 1997–1998 Asian financial crisis. The sudden crisis had a devastating effect on the Korean economy, and real GDP fell by almost 7% in 1998. The direct cause of the Korean crisis was a huge, sudden reversal of short-term capital flows triggered by international investors' panic (Radelet, Sachs, and Lee, 2002). However, structural problems underlying the economy, including under-supervised financial systems and an over-leveraged corporate sector, led to the accumulation of vulnerabilities that set the stage for the crisis and amplified its shock to the economy.

Korea managed to recover rapidly from the shock from 1999 faster than anyone had expected. However, there seems to have been a permanent decline in growth potential, as the average GDP growth rate remained at 4.1% over 2000–2010.

The global financial crisis in 2008–2009, which evolved from the US subprime crisis, seriously affected Korean economy through spillovers from global trade and financial markets. Korea's GDP growth rate dropped to 0.3% in 2009. While Korea managed the global economic crisis relatively well, showing the fastest recovery among OECD members, its economy has not yet resumed precrisis growth rates.

(FIGURE 1 HERE)

Over the past half century, due to Korea's strong growth performance, its economy has experienced fast catch-up to advanced economies in per capita output and income. Figure 1 shows annual per capita GDP from 1960 to 2011, compared to the US, Japan, and China.[5] Korea has managed to achieve a high income level in half a century with per capita income

[5] For an international and intertemporal comparison, this study uses data on per capita GDP at chained purchasing power parity (PPP) international dollars from the Penn-World Tables 8.1 (see Feenstra, Inklaar, and Timmer, 2013).

of $ 29,122 PPP in 2010, from being a lower-middle income country in 1960 with per capita GDP of $ 1,633 PPP. Korea has rapidly caught up to the US and Japan in per capita output.

Japan has experienced a significant growth slow-down since early 1990s. The burst of asset bubbles in the 1990s left Japan's financial system and private sector saddled with a huge debt overhang. During its so-called "lost decades," Japan suffered from deflation and economic stagnation due to its dysfunctional financial system and lack of private demand. Consequently, the gap in per capita GDP gap between Japan and Korea has narrowed rapidly, and has been close to zero in recent years (Figure 1).

In the last 35 years, since former Chinese leader Deng Xiaoping embarked on economic opening and reforms, China has shown astounding output growth of an average 9.5%-plus annually. China has rapidly narrowed its per capita output gap with advanced economies. Despite this stellar performance, China's per capita output continues to lag that of advanced economies. China's GDP per capita in 2011 was $ 10,538 PPP, which is comparable to Korea's 1989 level ($ 10,666 PPP), and Japan's 1968 level ($ 11,070 PPP). Based on per capita GDP, China is more than 20 years behind Korea and more than 40 years behind Japan.

(FIGURE 2 HERE)

Figure 2 shows the evolution of per capita GDP levels of the three Asian economies relative to the US over time. The values are 5-year averages, matched with average GDP growth rates in the corresponding period.[6] Korea's sustained growth contributed to narrowing the gap in its per capita GDP with the US. Korea experienced a very rapid catch-up to the US in per capita output over time. The value of per capita output increased from approximately 10% of the US value in 1960 to more than 60% in the late 2000s.

Figure 2 shows that the pace of the catch-up slowed as the Korean economy narrowed its per capita income gap compared to that of the US. While income per capita in Korea was

[6] The underlying data are the adjusted PPP values from the Penn-World Table 8.1. For 2012, 2013, and 2014, the values were estimated from information on real GDP growth rates from the IMF, World Economic Outlook Database.

less than 30% of the US average in the 1970s and 80s, annual per capita GDP growth reached 7–8%. By the time Korea had reached 50% of US per capita income in 2000, its annual growth rate had slowed to 3–4%.

This Korean experience resembles the case of Japan. Japan's annual per capita GDP growth dropped from 8.6% in the 1960s to 0.7% in the 2000s as its per capita income jumped from less than 25% to about 80% of the US level over the period (Figure 2).

The evolution of per capita income and its growth rates over time can be explained by the "conditional convergence" theory. Conditional convergence of per capita (or per worker) output is predicted by an extended version of the neoclassical growth model, as described by Barro and Sala-i-Martin (2004), as follows: A country with a low initial per capita output relative to its own long-run (or steady-state) potential level of per capita output grows faster than a country with a higher level of per capita output. The basic concept is that the farther a country is located from its steady-state output or income level, the greater is the gap of reproducible physical and human capital stock and productivity (technology) from its long-run levels. The gap of existing physical and human capital from steady-state levels offers the chance for a rapid catch-up via high rates of physical and human capital accumulation, which are encouraged by higher rates of return on investment. In addition, the greater technology gap stimulates faster productivity improvement via the diffusion or imitation of technology from more technologically advanced economies. Therefore, the lower is the initial level of per capita output relative to the steady state, the higher the subsequent growth tends to be.

2.2 Catch-Up and Convergence in Output and Productivity

This subsection assesses the role of factor accumulation and productivity increase in the evolutionary process of the gap in income between two countries. The aggregate production function is used and the level of per worker output is decomposed into productive inputs,

including physical and human capital, and TFP based on the "development accounting" approach (Hall and Jones, 1999).[7]

A simple Cobb–Douglas production function is assumed,

$$Y = AK^{(1-\alpha)}(hL)^{\alpha}, \quad (1)$$

where *Y* is value-added output (GDP), *K* is physical capital, *L* is the number of workers, *h* is human capital per worker, and *A* is TFP. The labor share of output is given by *α*, which varies across countries and over time.

At the per worker level, the production function can be written as

$$y = Ak^{(1-\alpha)}h^{\alpha}, \quad (2)$$

In order to assess how much of the gap in *y* is explained by differences in the two productive inputs, *k* and *h*, and in the TFP, the ratio of per worker output between two countries, *i* and *j*, is expressed as

$$\mathrm{y_i}/\mathrm{y_j} = (\bar{\mathrm{k}}_{\mathrm{i}}/\bar{\mathrm{k}}_{\mathrm{j}})(\bar{\mathrm{h}}_{\mathrm{i}}/\bar{\mathrm{h}}_{\mathrm{j}})(\mathrm{A_i}/\mathrm{A_j}), \quad (3)$$

where $\bar{k} = k^{(1-\alpha)}$, $\bar{h} = h^{\alpha}$.

Equation (3) enables us to decompose the differences in per worker GDP between two countries into the differences in the physical capital–labor ratio, human capital per unit of labor, and TFP. Note that this framework relies on several simplifying assumptions. The estimate of TFP, which is an unobservable "residual," may incorporate many elements other than productivity, such as natural resources and business cycle factors. The distinction between factor accumulation and technology (productivity) increase is often ambiguous because *A*, *k*, and *h* are not independent of each other.

The US is considered a reference country (*j*) in equation (3). Thus, the value of each term in equation (3) indicates the level of per worker output, physical capital per worker, human capital per worker, and TFP of Korea (*i*) relative to that of the US.

[7] Lee (2005) adopts the same methodology to analyze Korea's catch-up process over 1970–2000.

To conduct the decomposition of output, data on GDP and physical capital stock are collected from the Penn-World Tables (PWT) 8.1. Labor shares, which vary across countries and over time, are also available from the PWT 8.1. The working-age population sourced from the United Nations is used as a measure for the number of workers. The available cross-country sources of labor force or employees are less reliable than those of the working-age population.

Human capital per worker is measured by the sum of the shares of workers across all education categories weighted by their relevant productivity, measured by relative wage rates (Barro and Lee, 2015, Chapter 4). The relative wage rate of a worker with schooling is calculated by assuming a constant marginal return rate to an additional year of schooling of 10%, which is the world average (Psacharopoulos, 1994).

(TABLE 2 HERE)

Table 2 summarizes the results of the development accounting exercise for Korea, Japan, and China. It shows the ratio of per worker output in each country to that in the US for the years 1960 to 2010 at 10-year intervals. In addition, it shows the levels of physical capital per worker, human capital per worker, and TFP relative to those of the US.

Table 2 presents the evolution of the gap in per worker output between Korea and the US over time, while assessing the sources of Korea's catch-up to the US. Korea experienced a very rapid catch-up in per worker output over time. The value of per worker output increased from 10% of the US value in 1960 to 61% in 2010. The output catch-up process was associated with strong catch up in physical and human capital accumulation and total factor productivity. Physical capital showed the fastest expansion: the level of physical capital stock per worker in Korea relative to that of the US increased tremendously from 9% in 1960 to 79% in 2010. This contrasts with the increase in the relative levels of human capital per worker from 46% to 98%, and productivity (TFP) from 22% to 64% over the same period.

In addition, Table 2 shows that for the most part, the pace of Korea's catch-up slowed after 2000. This is attributed mainly to negligible gains in productivity catch-up during 2000–

2010. Indeed, the relative level of productivity decreased, although marginally, from 68% to 64% during this period. Note that this could have been caused by not just the slow-down of Korea's productivity growth, but also the relatively high growth rates of productivity of the US economy in the early 2000s.

Furthermore, Table 2 explains the sources of Japan's catch-up in per worker output over time. For example, in 1960, the value of per worker output in Japan was only 23% of that value in the US, but rose to 72% in 2000. Like in the case of Korea, in Japan, physical capital accumulation showed the fastest growth in this catch-up process. The level of physical capital stock per worker in Japan relative to that of the US increased tremendously from 14% in 1970 to 100% in 2000. This contrasts with a moderate increase in the level of productivity from 34% to 86% of the US over the same period. The level of per worker output in Japan relative to the US dropped to 69% in 2010. This decline has been attributed to the decline in productivity. The relative level of productivity in Japan deteriorated from 86% in 1990 to 79% in 2000 and further to 72% in 2010.

In addition, Table 2 shows that there is a significant difference in the levels of per worker output between China and the three advanced economies in the study. In 2010, the value of per worker output in China was only 15% of that value in the US, which is comparable to Korea's level in the 1970s.[8] China's physical capital stock per worker (18%) and productivity (37%) levels in 2010 relative to the US levels are comparable to Korea's 1980 levels. China's' relative human capital level (60%) is comparable to that of Korea in 1970.

Equation (3) can be transformed by taking logs in order to express the log difference in per worker output of Korea with the US as an additive sum of three components:

$$\ln\left(\frac{y_{US}}{y_K}\right) = \ln\left(\frac{\overline{k_{US}}}{\overline{k_K}}\right) + \ln\left(\frac{\overline{h_{US}}}{\overline{h_K}}\right) + \ln\left(\frac{A_{US}}{A_K}\right) \quad (4)$$

[8] Considering that China has grown much faster that the US over the past five years, the value of per worker output in China in 2015is estimated to be approximately 20% of that value in the US. Note that the gap in per worker output of China with the US is much larger than that in per capita output because China has a larger share of workers in total population than the US.

Figure 3 depicts the results. It shows the gap of per worker output and its sources at 10-year intervals from 1960 to 2010. In 1960, US per worker output was about 10 times Korean per worker output, which are decomposed into differences in per worker capital, human capital, and TFP.

The income gap between Korea and the US continued to decrease in the past half century. Over time, the gaps in physical capital and human capital per worker have decreased rapidly. By contrast productivity gap decreased until 2000 and then increased.. Currently, the productivity gap is the principal source of the income gap. If Korea's productivity level were upgraded from the current 64% to 80% of that of the US, Korea's per worker output would jump to 76% of that of the US, with gaps in the relative levels of physical capital and human capital per worker in 2010.

(FIGURE 3 HERE)

The results of development accounting explain that Korea requires productivity improvement for further catch-up to the US. During Korea's fast catch-up phase of development, factor accumulation played an important role. Consequently, Korea now faces a much smaller gap in physical and human capital stock from both its long-run potential and US levels. Thus, according to the prediction of conditional convergence, the Korean economy will experience slower factor accumulation than it did in previous decades.

In terms of physical capital accumulation, Korea has maintained very high investment rates throughout its catch-up process. The ratio of real investment to real GDP continued to increase over time, from approximately 10% of GDP in the early 1960s to close to 40% during the 1990s prior to the financial crisis (Figure 4). The ratio dropped significantly during the crisis, recovered gradually to 35%, and then declined again.

(FIGURE 4 HERE)

The low investment rates relative to the precrisis level may suggest that a permanent negative occurrence.[9] The rate of return of capital has declined as indicated by Korea's low real interest rate. The permanent depression of investment would have negative consequences for the Korean economy's catch-up pace.

In addition, Figure 4 depicts investment rates for Japan and China. Japan's investment rates increased to 40% in 1973 prior to the oil shock that began in the same year and in recent years, has slowed gradually to 20%. China's investment rates continued to increase gradually over the 1960s, 1970s, and 1980s, and more rapidly from the early 1990s. China currently invests almost 50% of GDP, which is disproportionate compared to the historical experience of Japan and Korea.

(FIGURE 5 HERE)

Concerning the accumulation of human capital, Korea's performance has been quite remarkable. Figure 5 shows that education expanded significantly over the past half century. The number of average years of schooling increased from 4.1 years in 1960 to 12 years in 2010. As a result, the gap in the average educational attainment between Korea and the US narrowed substantially. Korea's dramatic catch-up reflects the rapid increase in Korean school enrollment rates for all education levels. Considering that enrollment ratios at secondary and tertiary levels will not increase much beyond current levels, which are among the highest in the world, the speed of Korea's human capital accumulation will eventually decelerate.[10]

3. Determinants of Economic Growth and Korea's Catch-up

3.1 Cross-country Analyses of Economic Growth

[9] Barro and Lee (2003) suggest that, based on broad international evidence, a financial crisis typically has a persistent adverse effect on investment. In addition, they find that the financial crisis of 1997–1998 has had a long-term negative impact on investment in the Korean economy.

[10] The number of average years of schooling does not take into account differences in quality of schooling and the measurement of skills obtained on the job. Thus, Korea could continue to improve the quality of its human resources to catch up to the US. See the discussion of educational quality and adult skills in Barro and Lee (2015).

The general approach in this section is to apply the framework of cross-country analyses of economic growth in order to investigate the major factors that can explain Korea's growth and catch-up experience over the past half century.

The "conditional convergence" theory implies that each country has its own steady-state levels of per worker output to which it is converging.

The basic framework is expressed as

$$Dy_{it} = \mathrm{f}(y_{it},\ y_i^*) \tag{5}$$

where Dy_{it} is country i's per worker GDP growth rate in period t, y_{it} is the country's per worker output, and y_i^* its own long-run (or steady-state) level of y. Dy_{it} is inversely related to y, indicating conditional convergence of per worker output to its own steady-state level over time. In the cross-country context, countries with higher per worker output would grow slower than those with lower per worker output when controlling for the variables influencing the steady-state level. Consistent with the production function, the dependent variable is expressed as the growth in per worker output rather than per capita output. Note that the per capita output growth rate is calculated by the per worker output growth rate added to the growth rate of the share of the working-age population to the total population.

The long-term level of per worker output depends on various external environmental and policy variables. In the extended neoclassical growth model, the steady-state level of per worker output is determined by investment rate, population growth, and human capital (Mankiw, Romer, and Weil, 1992). Previous theoretical and empirical studies consider institutions and policy factors as other important determinants of long-run per worker output. These factors include government consumption, institutional quality, macroeconomic stability, trade openness to the world economy, and democracy (Barro and Lee, 1994; Barro and Sala-i-Martin, 2004, Chapter 12).

The empirical framework can be represented by a reduced form, such as[11]

[11] Our specification and data follow those of Barro and Lee (2015, Chapter 4), with the updated national accounts data from the Penn World Tables 8.1.

$$Dy_{i,t} = \beta_0 + \beta_1 \log(y_{i,t}) + \beta_2 X_{i,t} + \varepsilon_{i,t,} \quad (6)$$

where *Xi* denotes an array of the variables that influence country *i*'s steady-state level of per worker output. The regression of specification (6) applies to a panel set of cross-country data for 75 countries over 10 5-year periods from 1960 to 2010, corresponding to the periods 1960–1965, 1965–1970, 1970–1975, 1975–1980, 1980–1985, 1985–1990, 1990–1995, 1995–2000, 2000–2005, and 2005–2010. The panel is unbalanced with 713 observations in total. This system of 10 equations is estimated by adopting instrumental variable (IV) estimation techniques to control for the endogeneity of explanatory variables. Instruments are mostly lagged values of the explanatory variables. The estimation results from the IV panel estimation with and without country fixed effects are presented. The exclusion of country fixed effects can cause bias of the estimates. However, the fixed-effects technique eliminates information from cross-section variations and could exacerbate measurement errors, especially if the timing of relationships is not known precisely (Barro and Lee, 2015).

The representative set of the explanatory variables, *Xi*, include investment, fertility, and human capital as fundamental growth factors. The stock of human capital is measured by the average years of schooling for the population aged 15 years and over. In addition, the regression includes the reciprocal of life expectancy at birth as a measure of the health of workers in an economy. Five other variables are included to control for institution and policy variables: government consumption, overall maintenance of the rule of law, inflation rate, trade openness, and democracy. A measure for changes in the terms of trade is included as an exogenous factor.[12] In addition, the regressions include period dummies to control for common shocks to per worker GDP growth in all countries.

(TABLE 3 HERE)

Summary statistics of the variables for 1970–1975 and 2000–2005 for Korea, Japan, China, the US, and the world are presented in the Appendix Table.

[12] We have also considered a measure of financial crisis as an independent variable, but it is statistically insignificant. As discussed in footnote 9, the impact of financial crisis on growth can occur through its adverse effect on investment.

Column 1 of Table 3 presents the regression results of the basic specification (6) without country fixed effects. The negative estimate of the coefficient on the first explanatory variable, the log of per worker GDP at the start of each period, reveals a strong “conditional convergence” effect. The estimated speed of conditional convergence is about 1.7% per year. This implies that a country at half the per worker output level of another country tends to grow by 1.2 percentage points (= 1.7 x ln(2)) faster than the richer country, assuming the same level of long-term per worker output.

The investment rate has a positive and statistically significant effect on growth. The log of the total fertility rate is significantly negative. The estimated coefficient on the reciprocal of life expectancy at birth is negative and highly significant, indicating that better health is associated with higher economic growth.

The regression result shows the nonlinear relationship between human capital stock and growth, as discussed in Barro and Lee (2015). The coefficients on average years of schooling and its square term are negative and positive, respectively, although only the square term is marginally statistically significant. The pattern of the coefficients demonstrates that the growth rate increases with the level of educational attainment only when the society has attained 6.9 average years of schooling. Hence, only countries that have accumulated human capital above a certain threshold are able to experience higher GDP growth induced by an increase in educational attainment for given values of the other explanatory variables.

The regression results show that government policies and institutions play a significant role in determining economic growth. A subjective measure of the extent of maintenance of the rule of law is significantly positive. Increased openness to international trade is a positive determinant for growth, although the estimated coefficient is marginally significant.

The level of democracy has a nonlinear relationship with growth, as found by Barro (1996). The coefficients on the indicator of democracy and its square term are positive and negative, respectively, and both coefficients are jointly statistically significant. The pattern of

the coefficients on the indicator of democracy and its square term indicates that GDP growth rate increases with political freedom at low levels of democracy but decreases with democracy once the society has attained a certain level of political freedom. The threshold level is 0.5. The nonlinear relation suggests that autocracy can have negative effects on growth if a dictator uses his power to steal the nation's wealth but more democracy above the threshold level can also retard growth if it promotes income-redistributive policies, rather than pro-growth ones, in systems of majority voting.

Inflation, an indicator of macroeconomic instability, has a negative effect on growth, but the estimated coefficient is not statistically significant. The ratio of government consumption to GDP is statistically insignificant. A higher growth rate of the terms of trade (export prices relative to import prices) has a strong, positive effect on economic growth.

In summary, the regression results in column 1 show that per capita GDP growth has strong relationships with the initial per capita GDP level, investment, fertility, the quality of human resources, rule-of-law maintenance, trade openness, and democracy.

Column 2 of Table 3 adds country fixed effects. The results are quite similar to those of column 1. The estimated coefficient on the log of per worker GDP remains statistically significant. The estimated speed of conditional convergence increases to about 3.4% per year. Since the unobserved country-specific factors that influence the steady-state value of per worker output are likely to have positive relationships with current per worker GDP, the omitted variables tend to bias upward the estimated effect of lagged per worker GDP on growth. Consequently, the inclusion of the country fixed effects tends to lower the convergence rate below zero.

The results with country fixed effects show that some economic policy and institutional factors, such as rule of law and trade openness, become statistically insignificant. By contrast, the estimated coefficient on inflation becomes statistically significant.

3.2 Korea's Economic Growth in Comparative Perspective

The growth regressions imply that Korea has grown faster than high-income countries by many factors, including convergence, due to the low level of per worker output relative to its long-term level as well as favorable environmental and policy factors influencing the long-term potential level of per worker output, y_i^*, to which Korea has been converging.

Korea's relatively favorable environment and policy factors have facilitated faster catch-up to the advanced economies than other developing countries with the same level of per worker output over the transition to a higher steady-state level of per worker output. Note that these factors could affect both the rate of factor accumulation and the rate of productivity growth.

The cross-country regression results allow us to analyze the growth performance of Korea relative to the performance of the US. The point estimates of the parameters in the regressions of Table 3 are used for simple accounting that breaks down the fitted values of growth rates for each country into the contributions from each of the explanatory variables. Although the residual errors in individual country growth rates are substantial, it is worthwhile to examine the differences in the explanatory variables that generate the differences in the fitted growth rates. The accounting results can be used to explore the sources of the differences in the fitted growth rates between Korea and the US.[13]

(TABLE 4 HERE)

Table 4 presents the results of the accounting exercise in this study. The basic regression can account for a substantial part of the growth differences between Korea and the US over time. The predicted growth rates of Korea are higher than those of the US over the period. Growth rate differentials are shown by the averages over three subperiods,

[13] Using the same technique, De Gregorio and Lee (2004) compare the economic performance of East Asian economies relative to Latin America, and show that better growth performance of East Asia relative to Latin America is largely attributable to "fundamental growth factors," including high savings rates, strong human capital, high trade openness, maintenance of good institutions, and prudent fiscal and monetary management.

1960–1980, 1980–2000, and 2000–2010. The results in panel A of Table 4 are based on the estimates in column (1) of Table 3; the estimated growth rate differentials are 1.2, 2.3, and 2.7 percentage points for each subperiod, while the actual differences are 4, 3.9, and 2.9 percentage points. Therefore, the model underestimates Korea's relative growth performance over the periods, especially in the earlier subperiods. The cross-country regressions represent the "average" relationships applied to all countries across time. Some individual countries undoubtedly differ in terms of the magnitude of the relationships, and in terms of the list of the most important variables affecting growth. The accounting result indicates that while the basic set of explanatory variables explain most of the differences in growth rates between Korea and the US, there are other unexplained factors that made Korea growth faster than other countries in the sample, in particular, in the 1970s and 1980s.

(TABLE 5 HERE)

The accounting exercise in Table 5 breaks down the predicted differences separately into the contributions from the 11 explanatory variables. The result shows that the lower income level of Korea compared to that of the US led to higher growth over the whole period because of the convergence effect. However, the magnitude of the convergence effect became smaller over time as Korea caught up to the US in per capita income: this effect declined from 3.1 percentage points a year over 1970–1990 to 2 percentage points a year in 1980–2000, and then 1.1 percentage points a year in 2000–2010.

While the convergence effect was an important factor explaining Korea's growth performance, the rest of the explanatory variables also influenced a significant part of the growth difference. For example, during 2000–2010, the model predicts an average growth rate for Korea that is 2.7 percentage points per year higher than that of the US. The convergence effect explains a difference of 1.1 percentage points while the rest of the factors influencing growth explain the remainder (1.6 percentage points).

The exercise shows that higher investment rates in Korea explain about 0.3−0.5 percentage points and trade openness accounts for about 0.1−0.2 percentage points in

growth differentials over the whole period. The gap between Korea and the US in terms of human resources (schooling and life expectancy) contributed to lowering growth of Korea relative to the US by 0.9 percentage points over 1960–1980. However, as Korea has experienced improvements in human resources, the human resources variables explain a smaller difference, of 0.2 percentage points, in 2000–2010.

In addition, Korea has improved institutional quality, which contributed positively to growth. The relatively low level of the rule-of-law variable accounted for about 0.8−0.9 percentage points of slower growth of Korea relative to the US over 1960–2000. However, this dropped to only 0.2 percentage points in 2000–2010. The Appendix Table shows the values of the variables in 1970–1975 and 2005–2010 for Korea and the US. Korea has caught up rapidly to the US in human resources, policy, and institutional variables over the period from 1970 to 2010.

Korea had higher fertility rates in the earlier periods, but now has lower fertility rates than the US. The change in the fertility gap between Korea and the US is predicted to contribute positively to the higher growth of Korea with a net effect of 1.3 percentage points over 2000–2010. Note that the estimated positive effect of fertility applied to per worker GDP growth rates rather than per capita GDP growth rates. While the decrease in fertility has a positive effect on per worker (or per capita) output growth by lowering population growth and raising the steady-state per worker output, it eventually has a negative effect on per capita output growth when it leads to a decline in the working-age population.

For Korea, the ratio of the working-age population to total population is expected to decline from 73.1% in 2010 to 70.6% in 2020, and further to 62.3% in 2030. The decline in the working-age population ratio will have additional negative effects on per capita GDP growth of −0.3% in 2010–2020 and −1.3% in 2020–2030 (see Table 5).

An interesting prediction is that the improvement in democracy contributed negatively to the catch-up in the recent decades in Korea. Korea's level of democracy indicator is slightly lower than the critical level of 0.5 in the 1970s and then, increased above the critical level of

0.5 in 1989 (0.533). Thereafter, the nonlinear relationship between democracy and growth worked unfavorably for Korea's catch-up to the US in per capita income.

Panel B of the Table 4 presents the predicted growth rates that are based on the estimates in column (2) of Table 3. The estimated growth rate differentials are 5.2, 4.8, and 4.1 percentage points for each subperiod. Therefore, the model overestimates Korea's actual growth rate differentials by approximately 1.2 percentage points in each subperiod. The effect of the difference of per worker output levels between the two countries on subsequent growth differentials becomes much larger in Panel B than in Panel A due to the larger convergence estimate. The predicted effects of the differences in other environment and policy variables—human resources, investment, fertility, rule of law, inflation, democracy, and trade openness—on growth differentials between Korea and the US are broadly similar to those in Panel A.

Overall, Korea's historical experience of economic growth and catch-up to the US is largely attributed to Korea's favorable "growth factors." Relatively low per worker output level, high investment rate, strong human capital, high trade openness, maintenance of good institutions, and low inflation have contributed to strong growth. Since Korea's rapidly growing economy has continued to narrow the gap with the US in per capita income and levels of environmental and institutional variables, it has inevitably encountered a slow-down in growth potential.

4. Sectoral Productivity and Economic Growth in Korea

Korea's remarkable economic transformation since the early 1960s has been characterized by fast industrialization and strong economic growth, with the manufacturing sector being a key growth driver.

In the early 1960s, Korea shifted its economic policy focus from import substitution to export orientation to support industrialization and economic growth. Export-oriented policies, designed to provide incentives to exporting firms based on their performance, were effective

in pushing the pace of change in comparative advantage. The exposure to international export markets and performance-based government support stimulated efficiency improvement and faster productivity growth in Korean manufacturing industries, which successfully underwent diversification stages. The numbers of goods produced expanded along with quality upgrades of existing products. Korean exporters were able to build up their comparative advantage in labor-intensive manufacturing and then, to move to more capital-intensive and technology-intensive industries, including electronics, machinery, automobiles, ships, chemicals, and information and communication technology products (Table 6).

(TABLE 6 HERE)

Overall, Korea's export-oriented growth strategy worked in its favor, enabling the country to sustain strong growth and transform into a more technologically advanced economy. However, the strategy made the country very vulnerable to external shocks. The Korean economy came to rely increasingly on external demand to drive growth. Exports accounted for about 56% of GDP in 2014 from 15% in 1970 and 34% in 2002. As occurred during the 2008 global financial crisis, over-reliance on external demand made Korea susceptible to the economic recession in industrial countries and drop in global demand.

(TABLE 7 HERE)

An imbalance between Korea's manufacturing and services sectors is another outcome of its export-promotion strategy that has encouraged more investment in manufacturing than in services. Despite the size of Korea's services sector, which employs 76% of the country's workers, its contribution to overall economic growth is small owing to its low productivity. Value added per worker in the services sector remains just 48% of that in the manufacturing sector. Table 7 shows value added per worker for nine sectors, including four services industries for Korea, Japan, China, and the US in 2010. Within the services sector, the levels of labor productivity across services industries are quite diverse. In general, labor productivity is relatively high in the transport, storage, and communications industry and the finance, insurance, real estate, and business services industry (see Table 7). By contrast,

the wholesale and retail trade, hotels, and restaurants industry has shown a lower productivity level relative to the manufacturing sector. It is notable that the finance, real estate, and business services industry had higher labor productivity than the manufacturing sector in Japan, the US, and China, but it had lower productivity in Korea in 2010.

(TABLE 8 HERE)

Table 8 presents the average annual growth rates of per worker value added by sector in three decades—the 1980s, 1990s, and 2000s—and overall during 1980–2010. The annual labor productivity growth in the services sector was only 1.6%, which is significantly lower than that in the manufacturing sector of 7.7%, for 1980–2010. The average annual growth in per worker value added dropped from 2.5% during 1980–1990 to an annual average 1.2% during 1990–2000 and 1.1% during 2000–2010. Korean services industries, including finance, real estate, and business services as well as community and government services, have shown negative or zero growth of per worker value added over all subperiods.

The lower productivity growth of the stagnant services sector relative to the manufacturing sector has been well known since the seminal study of Baumol (1967). Hence, the fact that the Korean services sector has had relatively lower productivity growth than the country's manufacturing sector is not extraordinary. However, the differentials in labor productivity (i.e., per worker value added) and the growth rates in labor productivity between the two sectors have been much larger in Korea compared to other industrialized economies. Table 8 shows that the gap in average growth rates of per worker value added between the manufacturing and services sectors are much smaller in the other countries.

Figure 6 confirms the stylized pattern of structural change in the literature.[14] An increase in GDP per capita is associated with a decrease in agricultural employment and an increase in employment in the services sector. The manufacturing employment share shows hump-shaped changes. China has been following the stylized pattern although it has a larger share

[14] See Chenery (1960), Herrendorf, Rogerson, and Valentinyi (2013), and Lee and McKibbin (2014).

of employment in the agricultural sector and a smaller share in the manufacturing sector in 2010, compared to Korea and Japan in the 1980s.

It is clear that there have been major employment shifts toward the services sector in selected Asian economies over 1980–2010. In Korea, the share of employment in the services sector increased dramatically from 37% in 1980 to 67.5% over 1980–2010. This share increased in Japan from 53.1% to 70.2% over the same period. In China, the employment share of the services sector increased fast over the period from 16.4% to 39.3%.

(FIGURE 6 HERE)

The low labor productivity of the services sector relative to the manufacturing sector tends to hamper overall productivity growth. Lee and McKibbin (2014) show a negative relationship between the overall labor productivity growth rate of an economy and the employment share of its services sector.

A key to Korea's further growth is to rebalance its economy through diversification of growth sources. A new growth strategy should entail productivity increases in services industries. Structural reforms to stimulate productivity growth in the services sector are essential for sustained long-term growth. One of the effective ways to raise productivity is developing modern services industries, including healthcare, education, telecommunications, business processing, and legal and financial services (Eichengreen and Gupta, 2013). Lowering product regulations and barriers to foreign direct investment would promote more competition and boost new technology innovation. Enhancing services sector productivity is important for Korea to obtain a second growth driver that could propel strong and sustainable growth in the future.

5. Implications for China's Sustained Growth

Sections 2–5 explain that the Korean economy, like other developing countries, started its conditional convergence and catch-up process with low initial per worker output relative to its

own long-run (or steady-state) potential, which provided the opportunity for faster capital accumulation and technology diffusion. Good environmental and policy factors, such as a high investment rate, strong human capital, high trade openness, and improved institutions, guided the economy toward a higher level of long-run steady state compared to other economies, enabling Korea to realize its strong potential for catching up. For this successful catch-up, Korea's manufacturing- and export-oriented growth strategy played a critical role. International trade provided large external markets for Korean products and facilitated imitation and adoption of advanced technologies. Continuous product diversification and technology upgrading in the manufacturing sector characterized Korea's economic development.

China's economy has also grown fast over the last 35 years, as it transformed successfully from a controlled socialist economy to a market-oriented economy. In this period, China has shown strong output growth, which averaged more than 9.5% annually, and rapidly narrowed its per capita income gap with Korea, Japan, and the US (see Figure 1). China's unprecedented economic growth since the 1980s reflects a strong convergence effect fueled by economic reform and opening. In addition, abundant human resources, high savings and investment rates, and prudent macroeconomic management have contributed to strong growth. China's economic power continues to rise, making it the largest economy in the world. China's share of world GDP in PPP terms is expected to increase to about 17% in 2015, exceeding that of the US and EU.[15] Advancing from upper middle-income to high-income status, China now strives to develop more technologically sophisticated industries.

Although its economy has grown rapidly and its per capita income gap has diminished, China showed increasing average growth rates until recent years. This acceleration of economic growth in the take-off stage of development also occurred in Korea until 1990 and in Japan until 1970 (Figure 2). China caught up fast to the US in terms of per worker output

[15] IMF, World Economic Outlook Database, October 2015.

and per capita income. In 1980, the value of per worker output in China remained only 5% that of the US, which then rose to 15% in 2010.

Although China has caught up to advanced economies very fast, a significant development gap still exists between China and advanced economies. China's per worker output relative to the US in 2010 is comparable to Korea's 1970 value (13%). China's average per capita income level relative to the US in 2010–2014 is still lower than Korea's level in 1990 and Japan's level in 1970 (Figure 2).

As shown in Table 2, physical capital accumulation contributed most significantly to China's catch-up process, as it did for Korea. The level of physical capital stock per worker in China relative to that of the US increased significantly from 3% in 1970 to 18% in 2010. By contrast, the relative level of productivity increased at a modest rate from 20% to 37% of the US over the same period. Because the current levels of physical capital accumulation, human capital stock, and TFP relative to the US are comparable to Korea's levels in 1970, China must have significant room to catch up to the US in per worker output by increasing factor accumulation and productivity growth. Economic growth can remain strong. However, it would decelerate to lower rates.

The Chinese economy is currently experiencing a slowdown. China recorded a 7.4% GDP growth rate in 2014, the slowest since 1990, and it is expected to continue slowing. The International Monetary Fund (IMF), in its latest World Economic Outlook, forecasts a growth rate of 6.8 percent in 2015 and 6.3 percent in 2016. The reduced return on investment has lowered physical capital accumulation. China cannot continue to maintain the unprecedented level of investment ratio over 50%. In addition, labor inputs have dropped due to fertility decline and population ageing. With limited institutional and innovative capability, China is struggling to maintain strong technological progress.

For China to continue catching up and to achieve a level of development comparable with that in Korea, Japan, or the US, a faster growth rate is required in the coming decades, which is why it is important for China to study and learn from the early development

experiences of Korea and to develop its catch-up strategy. In particular, China's growth strategy over the next two decades should be designed by analyzing the experiences of the Korean economy and learning from Korea's successes and failures. Specifically, understanding the role of convergence, technology, institutions, and the manufacturing and services sectors in driving sustained economic growth could help guide China's economic policies.

Forecasting China's mid- and long-term growth is a hot topic among scholars and policymakers.[16] The discussion focuses mostly on interpreting China's growth experience in a global and historical context. For instance, Pritchett and Summers (2014) argue that China's growth could slow to 2–4% over the next 2 decades as China will probably succumb to the historically prevalent growth pattern of "regression to the mean." One critical assumption of this view is that China will follow the average pattern of historical experiences across all the world's economies. On the other hand, Lin (2015) suggests that China has the potential to grow 8% for another 20 years. He assumes China can continue to grow by rapidly narrowing its technology and per capita income gap with that of the US through technological imitation and adaptation through leveraging "latecomer advantage."

Based on the experience of Korea as well as a broad sample of countries over time, a decline of China's growth potential seems inevitable due to the diminishing pace of convergence. If the estimated convergence effect from the cross-country regression prevails, China's per worker GDP growth is expected to decline by 1.2 to 2.5 percentage points when its per worker GDP doubles. China's per worker GDP growth rate was 8.5 percent over 2000–2010, raising per worker GDP from $ 5,462 in 2000 to $ 12,786 (2005 PPP international prices) in 2010. Hence, the convergence effect implies that a smaller per worker GDP gap would lower the per worker GDP growth rate to between 5.5% and 7.0% in 2010–2015, assuming other environmental and policy variables remain unchanged. Since the working-age population growth rate is estimated to be approximately 0.2% in 2010–2015,

[16] The discussion in this paragraph is from Lee (2015).

the GDP growth rate would also decline to 5.7–7.2%. China's per capita GDP growth rate would decline further to 4.8-6.3% by considering its total population growth of 0.9% during the period 2010-2015.

China's actual per worker GDP growth rate is estimated to be approximately 7.3% between 2010 and 2015, increasing the per worker GDP level by 44% over the period. Due to convergence effect, this is estimated to lower per worker GDP growth further to 5~6.7% in the coming period. Table 5 shows that while the change in the working-age population ratio had an additional positive effect of 0.9 percentage points on per capita GDP growth relative to that on per worker GDP growth in 2000–2010, it would have a negative effect of −0.7 percentage points in 2010–2020 and −0.4 percentage points in 2020–2030. Both the convergence effect and working-age population decline would cause a slowdown of GDP growth in the coming decades. It would be very difficult that China maintains 6% for GDP growth over the coming decade, without significant improvements in institutions and policy factors.

These forecasts are broadly consistent with views that predict a "soft landing" of the Chinese economy, such as Lee and Hong (2012), the World Bank (2012), Cai and Lu (2013), and Perkins (2015). For example, Lee and Hong (2012) predict that China's average potential per worker GDP growth would decline to approximately 6.1% over 2011–2020 and 5% over 2021–2030 under the baseline scenario, which assumes a steady improvement in human capital but no serious policy and institutional reform. This prediction is based on the conditional convergence framework using cross-country growth regression analysis, in which physical capital accumulation, human capital accumulation, and TFP growth are estimated separately and then, combined to produce long-run GDP forecasts. In addition, this study shows considerable growth gains of policy reforms in the alternative scenario: when China significantly improves education, R&D stock growth, and maintenance of rule of law, China would achieve average potential per worker GDP growth of approximately 7% over 2011–2020 and 6.2% over 2021–2030.

There are significant gaps in human capital and quality of institutions between China and advanced economies (see the Appendix Table), indicating that China could stimulate economic growth by more educational investment and institutional reform. The Chinese government has been carrying out structural reforms aimed at labor market flexibility and human capital development, privatization of state owned enterprises, and liberalization of the financial sector. The success of these reforms will improve environmental and policy variables and support productivity growth, thereby offsetting the convergence effect.

In addition, the future of China's growth hinges critically on policies to promote continuous technological innovation and industrial upgrading, which could contribute to productivity increases in both the manufacturing and services sectors. Increased research and development (R&D) investment and its more efficient allocation could stimulate productivity growth.[17] Policies aimed at strengthening the research capacity of domestic firms and the protection of intellectual property rights could stimulate innovative activities.

Chinese authorities are pushing on with rebalancing from an investment and export-driven economy to a domestic consumption and services-based economy. Effective rebalancing is critical to move the economy to a sustainable growth path, especially under great uncertainties in the global economy. Due to its bigger size, China will have more challenges maintaining its export-led growth than Korea did. However, premature switching from exports to the domestic sector may hamper overall productivity growth. Reallocating resources from a productive export-oriented industry to a highly unproductive services industry could cause a permanent decline in the economy's productivity (Kim, Lee and McKibbin, 2014; Lee, 2015). There are significant gaps in the labor productivity level and growth between the manufacturing and services sectors in China (Tables 6 and 7). The average annual growth in per worker value added in the services sector was only 1.1% per year for 1980–2010, which is significantly lower than the manufacturing sector's 14.8%. The

[17] According to the *OECD Science, Technology and Industry Outlook 2014*, gross domestic expenditure on R&D in 2012 was US$ 257 billion in China. It predicts China will be the world's top R&D spender by around 2019.

annual growth rates in per worker value added increased to 5.8% during 2000-2010 from an annual average of -0.7% during 1981–1990 and -1.3% during 1990-2000. Chinese services industries, in particular the wholesale and retail trade, hotels, and restaurants industry and the transport, storage, and communications services industry, showed strong, positive growth of per worker value added in the recent decade. However, the finance, real estate, and business services industry showed negative growth. The sectoral data are subject to measurement errors because of data constraint at industry level. As discussed by Maddison (2007) and Wu (2014), the official GDP estimates for the “nonmaterial services” are highly likely to be exaggerated.

Hence, China should pursue successful rebalancing along with improved productivity growth. Rebalancing policies alone are unlikely to increase average output growth substantially in China. Enhancing productivity is critical for achieving higher economic growth over the long run (Kim, Lee, and McKibbin, 2014). China’s growth strategy over the next 2 decades still necessitates continuous upgrading in manufacturing and export industries while improving domestic services industries. Improving productivity and achieving more balanced growth will require careful long-term strategies.

The Chinese government has implemented structural change and growth-enhancing polices in gradual and pragmatic ways (Naughton, 2007). It has started with rural reform using a dual-track strategy. Markets were opened first in some selected coastal areas and then expanded to other areas. In addition, the Chinese government has adopted incremental managerial reform instead of rapid privatization of state-owned enterprises. At a later stage, the Chinese government ended its dual-track strategy and adopted more rapid restructuring and downsizing of state-owned enterprises. The Chinese economy has made a successful transition from a command economy to a market economy while achieving rapid economic growth. In addition, China has maintained macroeconomic stability as well as political and social stability.

Currently, China faces difficult challenges to continue its reforms. It needs to continue reforms in the factor markets of labor, finance, and land. Furthermore, it must continue to restructure state-owned enterprises and increase domestic competition, especially in the services sector, by overcoming pressures from vested interest groups. Yao (2013) asserts that China's authoritarian government was able to adopt the right growth-enhancing polices at critical points because it was not unduly swayed by any interest group. It is unclear whether the authoritarian Chinese regime can continue to maintain its neutrality and perform better than other regimes. Since the economy has become bigger and more unpredictable, government interventions would probably not work as they did before. Furthermore, the rise of the middle class would likely promote political development, particularly democracy, which could lead the population to push for government focus on social welfare policies, which are important but do not necessarily enhance growth.

6. Concluding Remarks

The recent growth slowdown of the Korean economy reflects its diminishing mid-term and long-term growth potential due to convergence and structural factors. As argued by "convergence theory," a fast-growing country would eventually grow slower, encountering difficulties in maintaining the same fast rates of human and physical capital accumulation and technological progress.

Korea's recent growth slowdown is also attributable to its unbalanced economic structure. Export-oriented policies have caused Korea to depend overly on manufacturing exports for growth. Increased imbalance between Korea's manufacturing and services sectors hampers the productivity growth of the overall economy. Due to its low productivity growth, the contribution of Korea's services sector to overall economic growth is small, despite its increasing size. Due to over-dependence on external demand, the Korean economy has become prone to risk from global economic cycles, as demonstrated by its experience during

the recent global financial crisis of 2008–2009. External demand may not assure Korea of a continued market for its exports in the post-crisis global environment, in which the recovery of advanced economies remains sluggish and the Chinese economy—Korea's largest trading partner—begins to slow rapidly. Korea needs structural reforms and productivity growth, particularly in its services sector, for more balanced and sustained growth.

Like Korea, China's economic slowdown is an inevitable trend. The recent growth slowdown is partly an outcome of its earlier success. China has narrowed its income gap continuously from its long-run potential over time. Thus, according to the prediction of conditional convergence, economies with higher initial income can expect slower growth. China's average potential GDP growth will decline to approximately 5~6% over the coming decades, unless it significantly improves institutions and policy factors. The slowdown could be accelerated further if Chinese policymakers were to make major mistakes in handling domestic weaknesses and political transformation.

The data indicate that Korea and China have had more favorable conditions for rapid growth than the other developing countries by maintaining strong investment, high trade openness, and macroeconomic stability, and by improving the quality of human resources and institutions continuously.

The future of economic growth in China and Korea is not preordained and hinges critically on reforms and policies that could contribute to increasing productivity, thereby at least partially offsetting the growth deceleration due to convergence in the coming decades.

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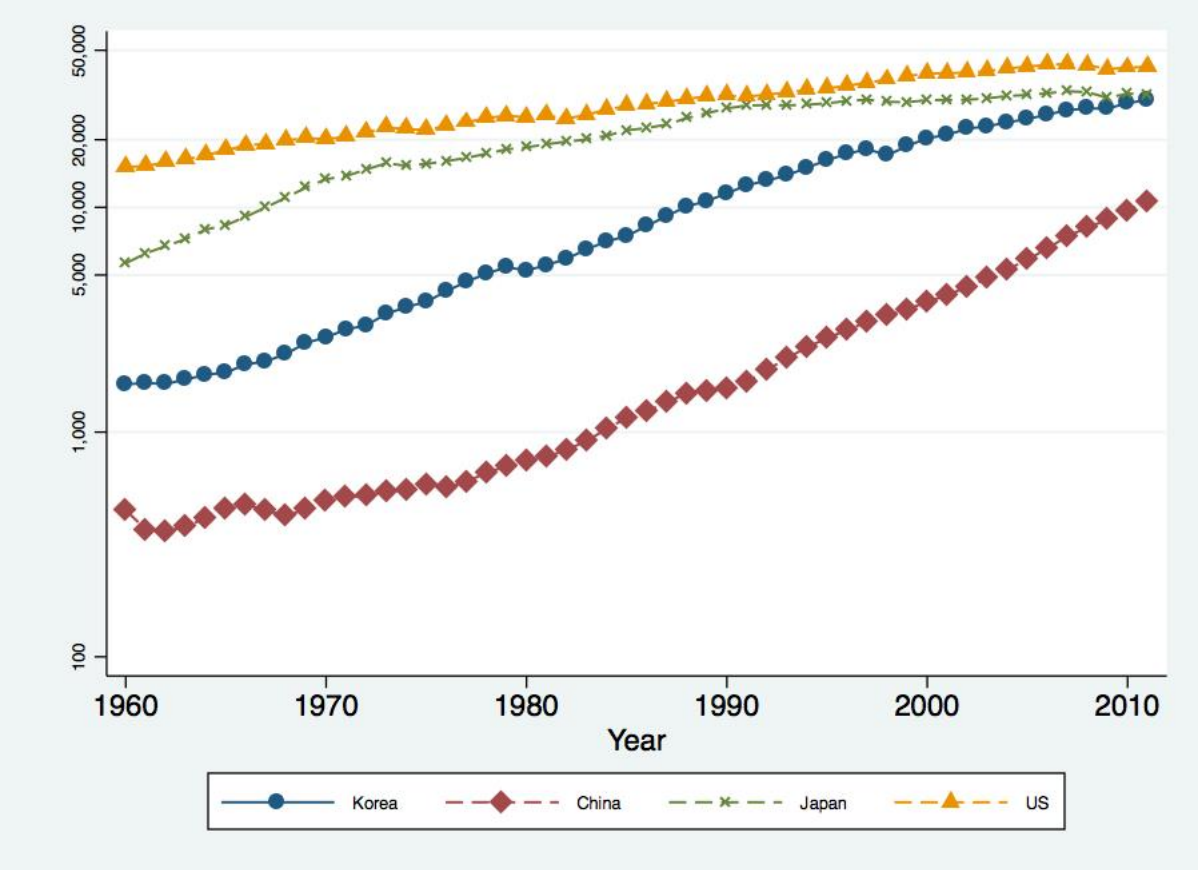

Figure 1. Trends in Per Capita Gross Domestic Product in Selected Economies(in purchasing power parity International dollar, 2005 constant prices)

Source: Penn World Table 8.1 (Feenstra, Inklaar,and Timmer 2013).

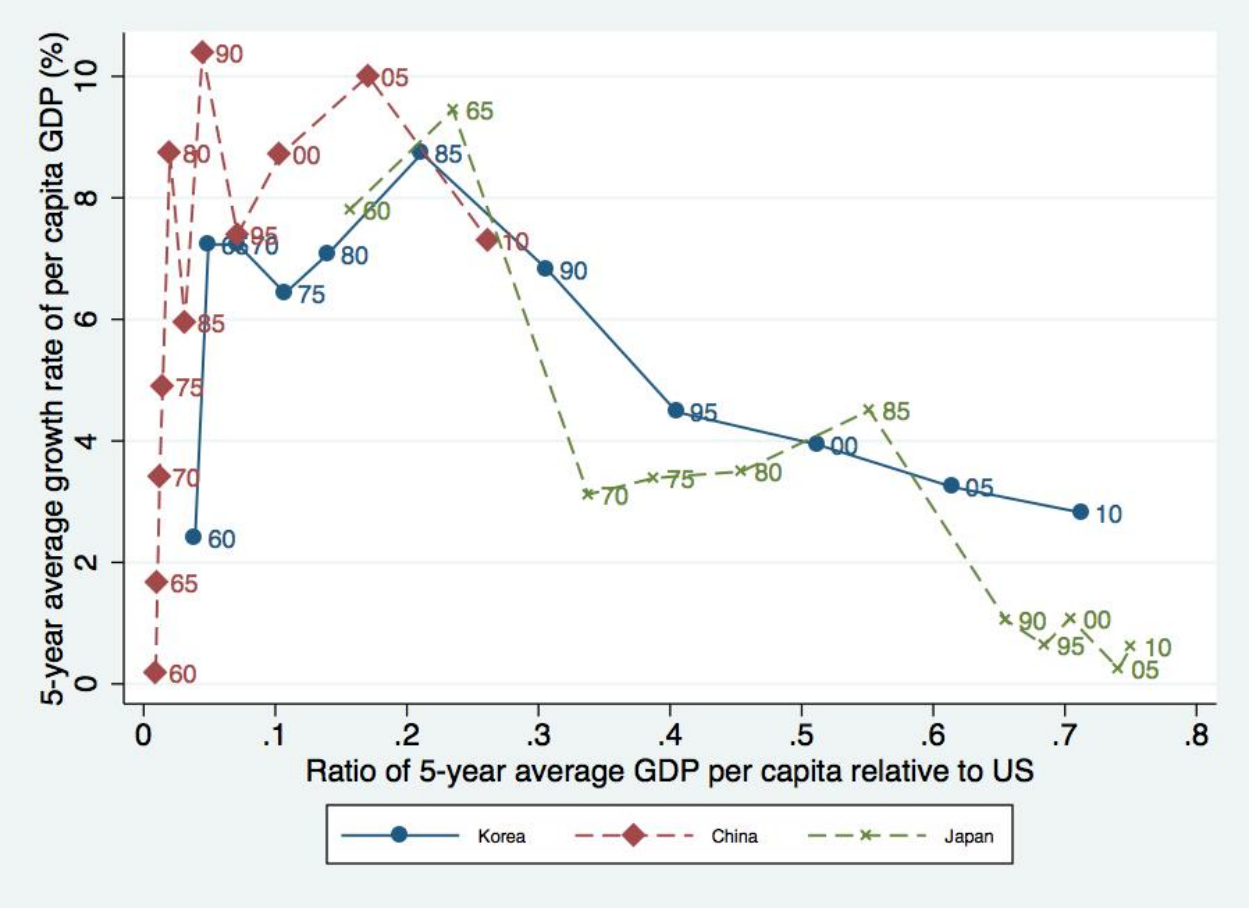

Figure 2. Per Capita Income Level and Growth Rates of Korea, Japan, and China Relative to the US

Note: The figure shows the period average of relative per capita income and its growth rates over the corresponding 5 years. For decades, 60 indicates 1960–1964,…, and 10 indicates 2010–2014. The data from 2012 to 2014 are from the IMF, World Economic Outlook Database, October 2015.

Source: Author's calculation based on data from Penn World Table 8.1 (Feenstra, Inklaar,and Timmer, 2013) and the IMF, World Economic Outlook Database, October 2015 for 2012–2014.

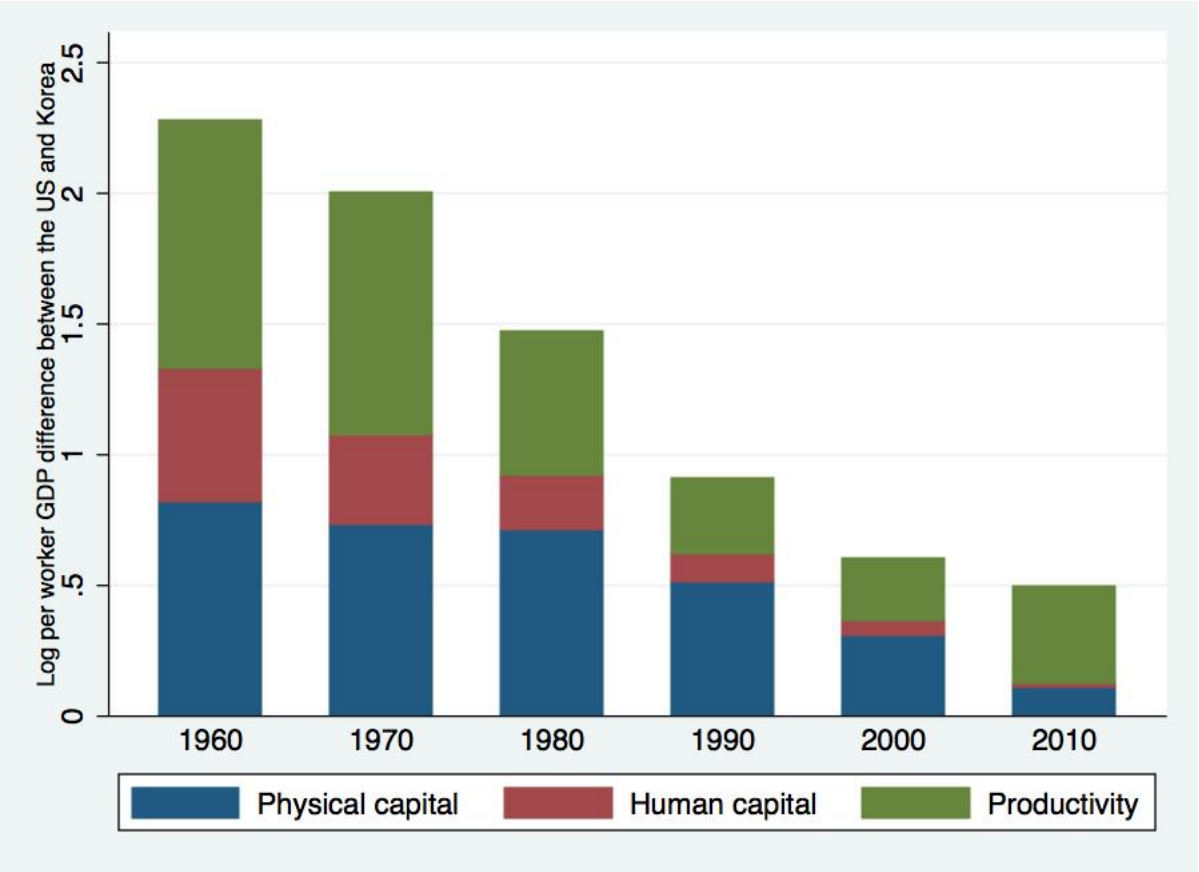

Figure 3. Change in the Gap of Per Worker Output and its Components between Korea and the US, 1960–2010

Note: The gap is expressed as the log difference in the value of each term between the US and Korea.
Source: Author's calculation based on equation (4).

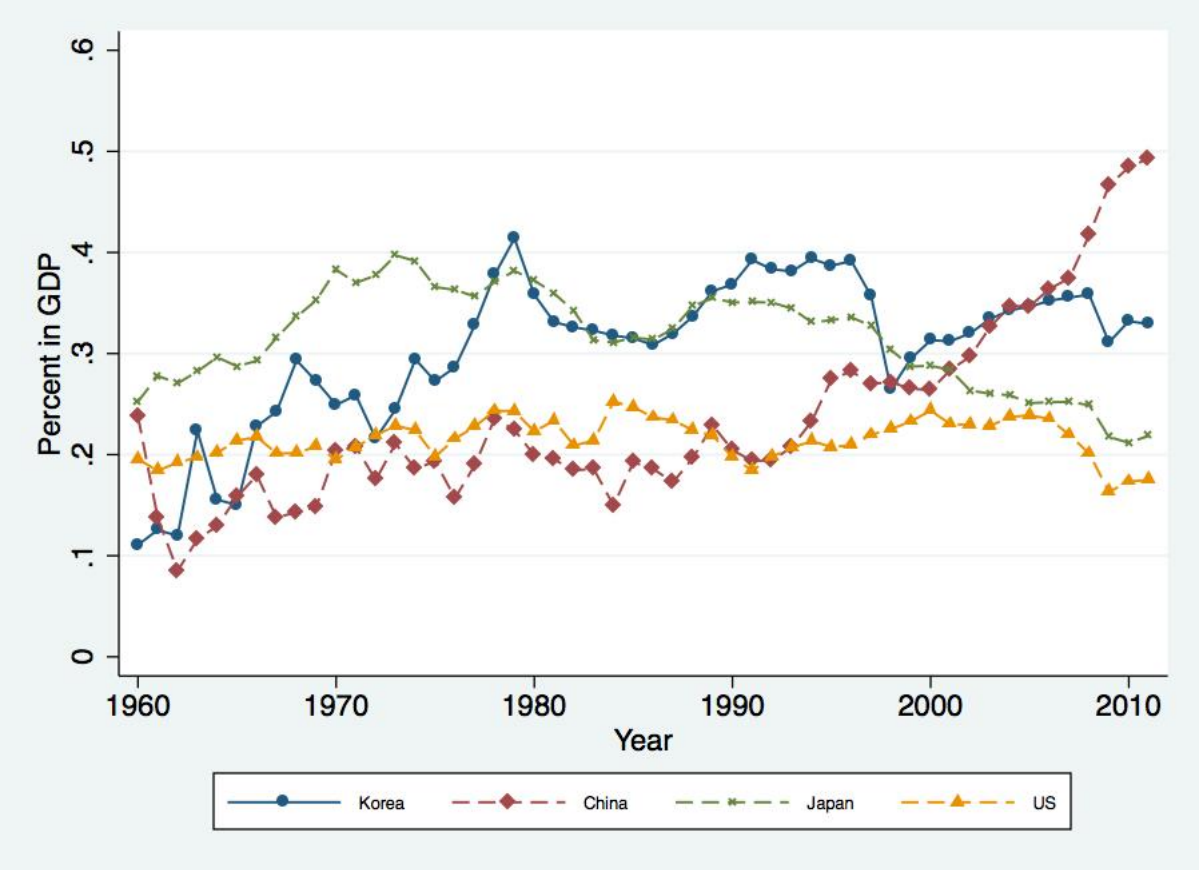

Figure 4. Investment Rates of Korea, China, Japan, and the US, 1960–2014

Source: Penn World Table 8.1 (Feenstra,Inklaar,and Timmer, 2013)

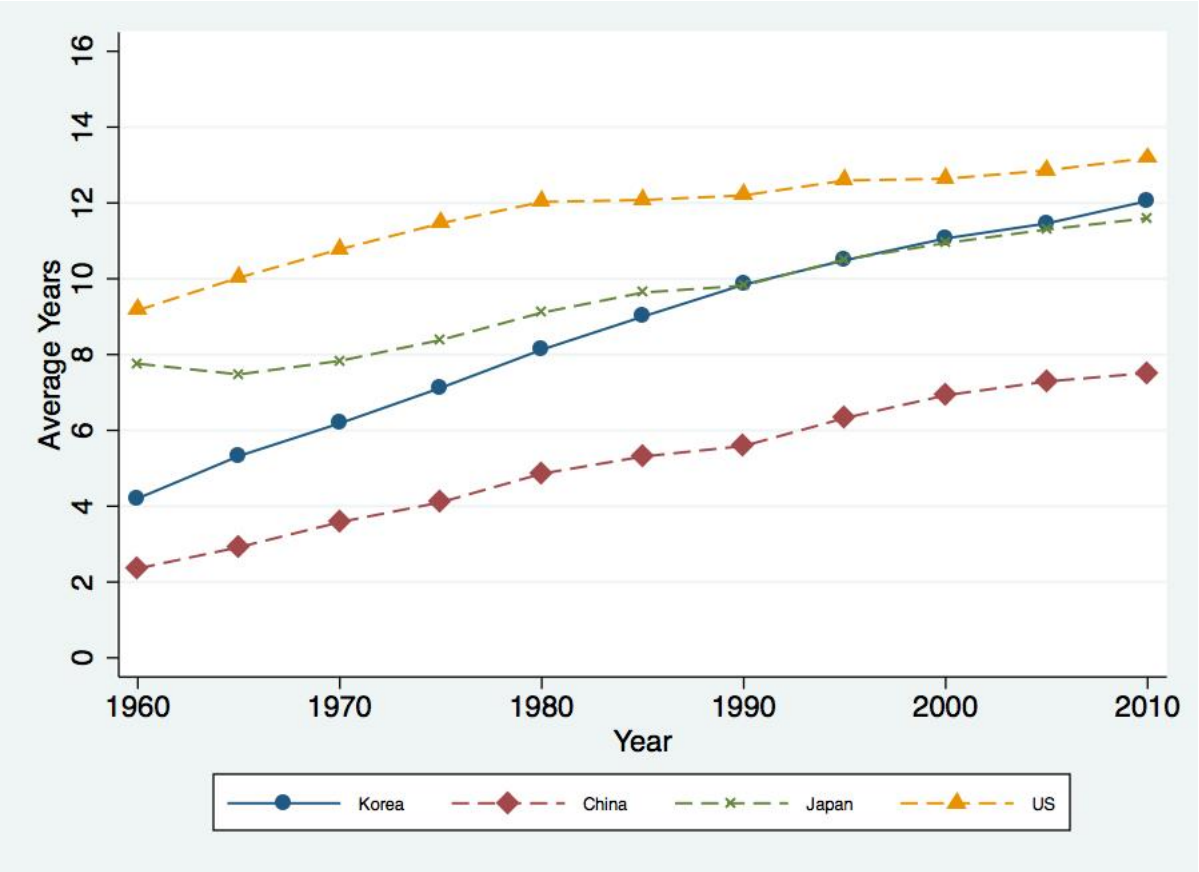

Figure 5. Trends of Average Schooling Years of Total Population Aged 15 Years and Over, 1960–2015

Source: Barro and Lee (2013)

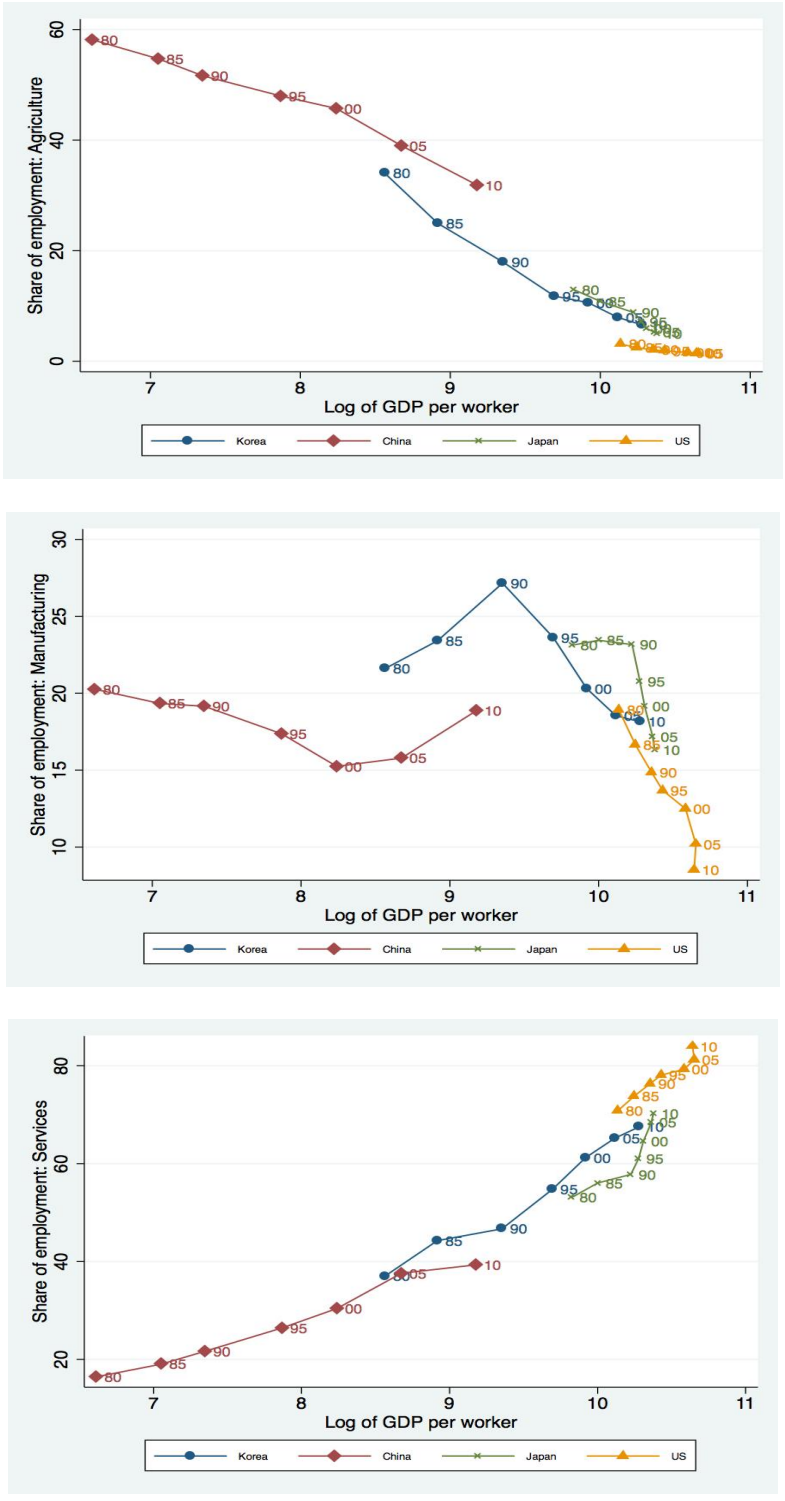

Figure 6. Sector Shares of Employment, 1980–2010 (%)

Sources: Author's calculation based on sectoral employment data from WORLD KLEMS Database (US), ASIA KLEMS Database (Korea, Japan), and CIP 3.0 Database (China). GDP per worker data are from Feenstra, Inklaar, and Timmer (2013).

Table 1. Economic Growth in Selected Countries, 1960–2000

	GDP Per Capita					Average Annual GDP Growth [Per Capita GDP Growth]					
	1960	1970	2010	2010/ 1960	2010/ 1970	1960– 1970	1970– 1980	1980– 1990	1990– 2000	2000– 2010	1960– 2010
Korea	1,633	2,645	29,122	17.83	11.01	7.45 [4.82]	8.58 [6.83]	9.28 [7.90]	6.33 [5.65]	4.07 [3.60]	7.14 [5.76]
Japan	5,638	13,356	32,097	5.69	2.40	9.66 [8.62]	4.37 [3.25]	4.53 [4.00]	1.12 [0.84]	0.74 [0.68]	4.08 [3.48]
US	15,136	20,115	41,858	2.77	2.08	4.11 [2.84]	3.19 [2.26]	3.18 [2.20]	3.37 [2.28]	1.52 [0.58]	3.07 [2.03]
China	449	493	9,696	21.57	19.67	3.24 [0.92]	6.03 [4.15]	8.87 [7.34]	9.92 [8.89]	9.95 [9.40]	7.61 [6.14]

Note: Per capita GDP levels and growth rates are based on the international prices of 2005 (adjusted for purchasing power parity), which are based on the Penn World Tables 8.1.

Source: Feenstra,Inklaar,and Timmer (2013)

Table 2. Output Per Worker and its Components: Ratio to US Values, 1960–2010

Country	Year	Per Worker Output	Physical Capital Per Worker	Human Capital Per Worker	Total Factor Productivity
Korea	1960	0.10	0.09	0.46	0.22
	1970	0.13	0.12	0.59	0.24
	1980	0.23	0.17	0.70	0.37
	1990	0.40	0.29	0.83	0.53
	2000	0.55	0.52	0.90	0.68
	2010	0.61	0.79	0.98	0.64
Japan	1960	0.23	0.14	0.81	0.34
	1970	0.43	0.31	0.74	0.63
	1980	0.62	0.63	0.78	0.81
	1990	0.72	0.77	0.85	0.86
	2000	0.72	1.00	0.90	0.79
	2010	0.69	1.01	0.94	0.72
China	1960	0.06	0.02	0.27	0.35
	1970	0.05	0.02	0.35	0.24
	1980	0.05	0.03	0.43	0.20
	1990	0.06	0.04	0.48	0.18
	2000	0.08	0.08	0.57	0.23
	2010	0.15	0.18	0.60	0.37

Notes: Data on output and physical capital stock are sourced from the Penn World Tables (PWT) 8.1, and data on working-age population are sourced from the United Nations (2013). Human capital per worker is measured by the average years of schooling (S) or weighted sum of the shares of workers multiplied by the relative wage rates across six education categories (h). Relative wage rates are constructed assuming that the rates of return to an additional schooling year are constant at 10%.

Source: Author's calculation

Table 3. Cross-country Panel Regressions for Per Capita GDP Growth Rate

	(1)	(2)
Log (per capita GDP)	-0.0167***	-0.0355***
	(0.00217)	(0.00383)
Investment/GDP	0.0388**	0.0439**
	(0.0169)	(0.0213)
Log (total fertility rate)	-0.0235***	-0.0226***
	(0.00464)	(0.00635)
Average years of schooling	-0.00307	-0.00501**
	(0.00190)	(0.00247)
Average years of schooling squared	0.000223*	0.000304*
	(0.000127)	(0.000162)
1/Life expectancy	-2.551***	-1.793*
	(0.677)	(1.002)
Trade openness	0.00531*	0.00971
	(0.00319)	(0.00617)
Government consumption/GDP	0.00105	-0.00231
	(0.0130)	(0.0153)
Rule-of-law index	0.0171***	0.00911
	(0.00599)	(0.00818)
Inflation rate	-0.0116	-0.0238*
	(0.00981)	(0.0129)
Democracy index	0.0534***	0.0421*
	(0.0186)	(0.0221)
Democracy index squared	-0.0532***	-0.0385*
	(0.0168)	(0.0198)
Growth rate of terms of trade	0.0798***	0.0712***
	(0.0270)	(0.0268)
No. of economies	75	75
No. of observations	713	713

Notes: The system has seven equations, corresponding to the periods 1970–1975, 1975–1980, 1980–1985, 1985–1990, 1990–1995, 1995–2000, and 2000–2005. The sample consists of 75 economies. The dependent variables are the growth rates of per capita GDP. Standard errors are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

The specification and data closely follow those in Barro and Lee (2015, Chapter 4), but use the updated national accounts data from the Penn-World Tables 8.1 (Feenstra, Inklaar, and Timmer, 2013). Per worker GDP levels and growth rates are based on 2005 international prices (adjusted for PPP). The investment ratio is the ratio of real investment (private plus public) to real GDP. The government consumption measure is the ratio of real government consumption to real GDP, based on

the World Tables 6.2. They are averaged over the period. Schooling data represent the average years of schooling for the population aged 15 years and higher from Barro and Lee (2013). Life expectancy at birth and the fertility rate are from the World Bank's *World Development Indicators*. The rule-of-law index, expressed on a zero-to-one scale, with one being the most favorable, is based on the maintenance of the rule-of-law index of the Political Risk Services' *International Country Risk Guide*. The inflation rate is the growth rate over each period of a consumer price index. The trade openness variable is the ratio of exports plus imports to GDP. The democracy index, expressed on a zero-to-one scale, with one being the most favorable, is based on the indicator of political rights compiled by Freedom House. The growth rate of the terms of trade is the change of export prices to import prices over the period.

Table 4. Contributions to Growth Differentials between Korea and the US 1960–1980, 1980–2000, 2000–2010, and 1960–2010 (percent, annual average)

	Contributions to the difference in per worker GDP growth of Korea relative to the US			
	1960–1980	1980–2000	2000-2010	(2000–2010)
A. Random effects				
Difference in				
actual Growth	*0.0395*	*0.0387*	*0.0294*	
predicted Growth	*0.0123*	*0.0232*	*0.0268*	*(100.0%)*
Initial income	0.0309	0.0196	0.0112	(41.5%)
Investment rate	0.0025	0.0049	0.0043	(16.2%)
Fertility	-0.0117	0.0021	0.0126	(47.0%)
Schooling	-0.0038	-0.0044	-0.0020	(-7.3%)
Life expectancy	-0.0054	-0.0022	0.0003	(1.2%)
Government consumption	0.000003	0.000003	0.000021	(0.1%)
Rule of law	-0.0086	-0.0076	-0.0020	(-7.4%)
Inflation rate	-0.0010	-0.0002	-0.0001	(-0.3%)
Democracy	0.0112	0.0097	0.0031	(11.4%)
Openness	0.0009	0.0016	0.0020	(7.3%)
Terms of trade	0.000002	-0.0003	-0.0026	(-9.6%)
B. Fixed effects				
Difference in				
actual Growth	*0.0395*	*0.0387*	*0.0294*	
predicted Growth	*0.0517*	*0.0475*	*0.0408*	*(100.0%)*
Initial income	0.0656	0.0416	0.0237	(58.0%)
Investment rate	0.0028	0.0055	0.0049	(12.0%)
Fertility	-0.0112	0.0021	0.0121	(29.7%)
Schooling	-0.0020	-0.0043	-0.0021	(-5.1%)
Life expectancy	-0.0038	-0.0015	0.0002	(0.5%)
Government consumption	-0.00001	-0.00001	-0.00005	(-0.1%)
Rule of law	-0.0046	-0.0041	-0.0011	(-2.6%)
Inflation rate	-0.0021	-0.0004	-0.0002	(-0.4%)
Democracy	0.0062	0.0058	0.0020	(4.8%)
Openness	0.0016	0.0030	0.0036	(8.8%)
Terms of trade	0.000002	-0.0002	-0.0023	(-5.7%)

Note: The predicted per capita growth rates in panels A and B are based on the estimation results of columns (1) and (2) in Table 3, respectively.

Table 5. Population and Working-Age Population Growth for Korea, Japan, China, and the US, (per year, %)

		1960–1970	1970–1980	1980–1990	1990–2000	2000–2010	2010–2020	2020–2030	2030–2040
Korea	**Gpop**	2.630	1.751	1.375	0.676	0.466	0.568	0.385	-0.190
	Gwork	2.116	3.065	2.466	1.004	0.660	0.220	-0.870	-0.953
	Gwork–Gpop	-0.514	1.314	1.091	0.328	0.194	-0.348	-1.255	-0.763
Japan	**Gpop**	1.034	1.113	0.532	0.280	0.065	-0.122	-0.408	-0.513
	Gwork	1.856	0.899	0.874	0.056	-0.544	-0.927	-0.700	-1.232
	Gwork–Gpop	0.821	-0.213	0.342	-0.224	-0.609	-0.805	-0.291	-0.719
US	**Gpop**	1.266	0.928	0.974	1.089	0.941	0.733	0.638	0.493
	Gwork	1.503	1.570	0.965	1.184	1.049	0.305	0.046	0.406
	Gwork–Gpop	0.237	0.642	-0.009	0.094	0.107	-0.428	-0.592	-0.087
China	**Gpop**	2.318	1.880	1.528	1.030	0.556	0.624	0.092	-0.149
	Gwork	2.143	2.542	2.560	1.335	1.449	-0.066	-0.307	-1.062
	Gwork–Gpop	-0.175	0.663	1.032	0.305	0.893	-0.690	-0.399	-0.912

Note: Gpop = Population growth and Gwork = working-age population growth

Source: Author's calculation based on the United Nations (2013)

Table 6. Ratio of Each Sector's Per Worker Value Added to Manufacturing Per Worker Value Added in 2010

Industry	Korea	Japan	China	US
Agriculture, hunting, forestry, and fishing	0.24	0.22	0.18	0.55
Manufacturing	1.00	1.00	1.00	1.00
Services	0.48	0.94	0.64	0.64
Wholesale and retail trade, hotels, and restaurants	0.25	0.60	0.56	0.38
Transport, storage, and communications	0.61	1.00	1.06	0.83
Finance, real estate, and business services	0.83	1.55	1.79	1.25
Community and government services	0.47	0.84	0.31	0.48
Others	0.74	0.95	0.83	0.82
Mining and quarrying	1.99	1.14	1.82	2.44
Electricity, gas, and water	3.64	6.41	2.70	2.90
Construction	0.59	0.72	0.50	0.48
Aggregate Economy	0.58	0.91	0.58	0.68

Notes: Japan uses 2009 values for 2010. For international comparison, the relative level of per worker value-added is calculated using nominal value-added.

Sources: WORLD KLEMS Database (US), ASIA KLEMS Database (Korea, Japan), CIP 3.0 Database (China)

Table 7. Growth Rate of Per Worker Value Added by Sector (%)

Industry	Korea			
	1980–1990	1990–2000	2000–2010	1980–2010
Agriculture, hunting, forestry, and fishing	7.02	5.58	4.73	5.78
Manufacturing	7.58	9.94	5.47	7.66
Services	2.45	1.22	1.13	1.60
Wholesale and retail trade, hotels, and restaurants	4.90	1.34	2.56	2.94
Transport, storage, and communications	3.72	5.14	4.13	4.33
Finance, real estate, and business services	-0.55	-1.05	-1.37	-0.99
Community and government services	-0.20	-0.08	-1.06	-0.45
Others	5.54	2.09	1.20	2.94
Mining and quarrying	5.12	14.84	-2.07	5.96
Electricity, gas, and water	11.40	10.08	3.20	8.23
Construction	5.21	0.80	0.59	2.20
Aggregate Economy	5.54	4.14	2.56	4.08
	Japan			
	1980–1990	1990–2000	2000–2009	1980–2009
Agriculture, hunting, forestry, and fishing	3.92	2.33	1.34	2.57
Manufacturing	3.25	1.48	2.00	2.25
Services	1.39	0.45	0.26	0.71
Wholesale and retail trade, hotels, and restaurants	2.02	1.41	-0.53	1.02
Transport, storage, and communications	2.43	0.96	1.93	1.77
Finance, real estate, and business services	-0.09	0.05	-0.81	-0.27
Community and government services	0.16	-0.61	0.47	-0.01
Others	2.91	-2.30	0.66	0.42
Mining and quarrying	1.94	-0.42	-1.98	-0.09
Electricity, gas, and water	6.16	2.69	2.39	3.79
Construction	2.53	-3.41	0.37	-0.19
Aggregate Economy	2.43	0.63	0.72	1.28

Table 7. (continued)

	China			
	1981–1990	1990–2000	2000–2010	1981–2010
Agriculture, hunting, forestry, and fishing	2.34	2.73	4.14	3.03
Manufacturing	10.64	19.51	14.54	14.75
Services	-0.70	-1.33	5.78	1.06
Wholesale and retail trade, hotels, and restaurants	-16.02	-2.76	8.64	-3.14
Transport, storage, and communications	0.87	4.83	11.22	5.21
Finance, real estate, and business services	11.02	3.41	-3.00	3.80
Community and government services	-2.35	-8.90	2.63	-3.14
Others	-1.31	-0.19	4.78	0.90
Mining and quarrying	-3.65	6.39	1.43	1.22
Electricity, gas, and water	6.63	-8.75	12.46	3.27
Construction	-3.87	-1.93	3.38	-0.92
Aggregate Economy	4.72	7.25	9.94	7.24
	US			
	1980–1990	1990–2000	2000–2010	1980–2010
Agriculture, hunting, forestry, and fishing	8.67	3.33	2.54	4.85
Manufacturing	4.07	4.82	4.12	4.34
Services	0.34	1.16	1.32	0.94
Wholesale and retail trade, hotels, and restaurants	3.29	3.76	1.29	2.78
Transport, storage, and communications	1.40	2.09	3.59	2.36
Finance, real estate, and business services	-1.56	0.78	2.32	0.51
Community and government services	-0.12	-0.36	0.01	-0.15
Others	0.24	-0.73	-1.25	-0.58
Mining and quarrying	6.36	1.67	-3.46	1.52
Electricity, gas, and water	-0.26	1.26	2.08	1.03
Construction	-0.55	-0.45	-3.03	-1.34
Aggregate Economy	0.98	1.45	1.33	1.25

Notes: Chinese data are from 1981 to 2010 and Japanese data are from 1980 to 2009.

Sources: WORLD KLEMS Database (US), ASIA KLEMS Database (Korea, Japan), CIP 3.0 Database (China)

Appendix Table. Summary of Key Variables for the World, Korea, Japan, China, and the US, 1970–1975 and 2005–2010

	Korea	Japan	China	US	World
			1970–1975		
Per worker GDP growth	0.072	0.090	0.015	0.018	0.032
Per worker GDP in 1970	3,018	14,797	865	20,480	6,976
Investment/GDP	0.237	0.317	0.153	0.208	0.191
Fertility rate in 1970	4.864	1.987	5.849	2.617	4.646
Schooling in 1970	6.131	8.023	3.542	10.758	4.376
Life expectancy in 1970	58.527	71.178	56.447	70.288	55.556
Trade openness	0.165	0.186	0.018	0.096	0.363
Government consumption	0.147	0.162	0.164	0.143	0.166
Rule-of-law index	0.500	1.000	0.500	1.000	0.576
Inflation	0.117	0.053	0.040	0.042	0.062
Democracy index	0.474	0.951	0.117	0.946	0.643
Terms of trade	0.002	-0.001	0.002	0.001	0.002
			2005–2010		
Per worker GDP growth	0.040	0.015	0.075	0.012	0.019
Per worker GDP in 2005	22,808	32,761	5,218	42,535	15,140
Investment/GDP	0.324	0.271	0.304	0.234	0.200
Fertility rate in 2005	1.253	1.318	1.707	2.038	2.583
Schooling in 2005	12.036	11.945	7.655	13.058	8.215
Life expectancy in 2005	76.818	81.568	71.590	76.907	66.667
Trade openness	0.560	0.322	0.214	0.263	0.535
Government consumption	0.128	0.162	0.236	0.103	0.163
Rule-of-law index	0.700	0.867	0.750	0.933	0.637
Inflation	0.033	-0.004	0.013	0.025	0.052
Democracy index	0.867	1.000	0.000	1.000	0.735
Terms of trade	-0.033	-0.008	-0.002	-0.001	-0.002

Notes: For the world, the figures are unweighted averages of the sample of the 75 economies that are used in the regressions in Table 3. See the notes to Table 3.