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China's Productivity Convergence and Growth Potential —A Stocktaking and Sectoral Approach

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China's Growth Potential—A Stocktaking and Reassessment

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Abstract

China's growth potential has become a hotly debated topic as the economy has reached an income level susceptible to the "middle-income trap" and financial vulnerabilities are mounting after years of rapid credit expansion. However, the existing literature has largely focused on macro level aggregates, which are ill suited to understanding China's significant structural transformation and its impact on economic growth. To fill the gap, this paper takes a deep dive into China's convergence progress in 38 industrial sectors and 11 services sectors, examines past sectoral transitions, and predicts future shifts. We find that China's productivity convergence remains at an early stage, with the industrial sector more advanced than services. Large variations exist among subsectors, with high-tech industrial sectors, in particular the ICT sector, lagging low-tech sectors. Going forward, ample room remains for further convergence, but the shrinking distance to the frontier, the structural shift from industry to services, and demographic changes will put sustained downward pressure on growth, which could slow to 5 percent by 2025 and 4 percent by 2030. Digitalization, SOE reform, and services sector opening up could be three major forces boosting future growth, while the risks of a financial crisis and a reversal in global integration in trade and technology could slow the pace of convergence.

Keywords: Potential Growth, China, Convergence

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I. Introduction

China's economic development in recent decades has largely been a story of success. 2018 marked China's 40th anniversary of reform and opening up. In the past four decades, China has achieved great economic success, with annual GDP growth averaging about 10 percent and per capita income more than tripling. Eight hundred million people have been lifted out of poverty. Such success has greatly benefited from the global market. Following WTO entry in 2001, China quickly became the world's manufacturing hub and the largest exporter by 2008. After the global financial crisis, however, as external demand fell, China transitioned from an export-based economy to an investment-driven model, relying heavily on investment to boost GDP growth, and has only gradually shifted to a more consumption-based growth model in recent years.

However, past success is not a guarantee of future achievement as China shifts to a new growth model. Before the global financial crisis, the export-driven growth model contributed to a large external imbalance, with the current account surplus peaking at 10 percent of GDP in 2007. This reflected both an undervalued exchange rate and structural factors that contributed to high savings (Zhang et al. 2018). Since the crisis, external imbalances have been replaced by internal imbalances. As the current account surplus gradually unwound, investment surged to 45 percent of GDP, significantly higher than international norms, including similar fast-growth episodes in South Korea and Japan. Such high investment has led to falling efficiency and a rapid build-up of debt, resulting in rising vulnerabilities. In recent years, China has been switching gears to a more sustainable growth path, led by consumption and services, with an uncertain impact on potential growth.

Growth uncertainty has also risen amid heightening financial fragility and the risk of the "middle-income trap", compounded by China-U.S. tensions. The post-crisis investment model has led to a surge in China's debt, with non-financial sector debt rising from 134 percent of GDP in 2008 to 257 percent in 2018 and bank assets rising from 200 percent of GDP to 298 percent. The overall financial system has also become much more interconnected, opaque, and increasingly reliant on wholesale funding, though recent reforms have helped to reduce some of the risks. With the slowing economy and deteriorating debt-servicing capacity, the risk of a hard adjustment has risen substantially. Furthermore, after years of expansion, China has reached an income level at which many rapidly developing countries have stalled in the past – the so called "middle-income trap". More recently, China's growth outlook has been clouded by the escalation in China-U.S. tensions and risks of deglobalization, which could create headwinds for China's technological convergence.

The estimation of potential growth has critical policy implications for China and the global economy. Setting a growth target and employing policy tools to achieve it is a unique feature of China's policymaking. Given that the growth target is determined by the evaluation of potential growth, an accurate estimate is critical to avoid setting an unrealistic target and using excessive macro policy stimulus to reach it. China's credit surge in the post-crisis period is a good demonstration of the risks resulting from an excessively high growth target, which have led to a build-up of vulnerabilities that now requires significant efforts by the government to unwind. Furthermore, with China being closely integrated into the global economy, both in trade and finance, any economic adjustment in China will have a major global impact.

Structural changes are key to understand China's growth potential. China has gone through a transformation from agriculture to industry and services in the past several decades and will continue to experience within-sector productivity upgrading and sectoral shifts. Where China stands in terms of sectoral convergence today and how sectoral patterns will evolve are two critical factors that will shape future growth. However, despite its importance, few studies have assessed China's potential growth from a sectoral perspective. To fill the gap, this paper takes a deep dive into China's convergence progress in 38 industrial sectors and 11 services sectors, examines past sectoral transitions, and predicts future shifts and their impact on aggregate productivity and growth.

The rest of this paper is organized as follows: Section II reviews the existing literature, explains the differences behind the diverging views on China's potential growth, and compares alternative analytical frameworks for long-term growth. Section III analyzes China's structural changes at macro level, i.e. the shift among agriculture, industry and services, as well as developments in these sectors. Section IV and V studies micro-level structural changes within industry and services and the degree of convergence compared with frontier economies[2]. Section VI presents the baseline long-term growth projection and highlights forces that might reshape the growth trend. Section VII concludes with policy recommendations.

II. Literature Overview

There are diverging views in the literature regarding China's longer-term potential growth, with estimates ranging from 3 to 8 percent for the next five to 10 years (text table). These differences mostly reflect the underlying methodologies. In this section, we first present the existing potential growth estimates, and then explain the methodologies featured in each stream of literature, comparing their pros and cons. Finally, we highlight the importance of using a sectoral-level supply-side approach to analyze China's potential growth, as the structural transition from industry to services will drive the downward trend of potential growth in the medium term as the economy matures.

A. Diverging views in the literature

The Bulls: 7 percent and above: Lin (2016) and NDRC (2016) find that China can still achieve annual GDP growth of 7-8 percent in the next five years. Their analyses are based on comparison with East Asian tigers at the same income level. Despite similar doubts previously about growth potential in those economies (Krugman 1994, and Young 1995), the four Asian tigers maintained 8-9 percent growth later and converged to high-income status.

[2] Frontier in this paper is defined as the U.S. productivity level in most cases, in line with the literature.

The Bears: 4 percent and below: Another stream of the literature is more pessimistic about China's potential growth. Barro (2016) and Pritchett and Summers (2013) project growth to fall below 4 percent within five years. Their analyses are more explicitly based on the convergence theory, i.e., looking at the average growth rate of countries at a similar income stage.

The Moderates: 5-7 percent. In contrast to cross-country studies, the third stream of the literature looks into China-specific factors and gives growth estimates of 5-7 percent. Some studies have used an array of methods to ensure robustness across models (Anand et al. 2013, Maliszewski and Zhang 2014). Lu and Cai (2014) emphasized the impact of demographic changes on labor input and investment, and estimated the potential growth rate to be 6-6.5 percent. Using a "credit-neutral" approach, Chen and Kang (2017) estimated China's potential growth at 5.3 percent during the period 2012-2016 (compared with an actual of 7.3 percent), assuming that credit would grow at a sustainable rate.

Table: Growth Projection Comparison

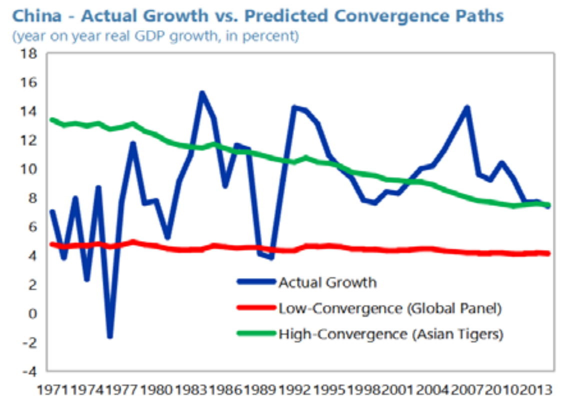
Author	Growth Projection (percent)		
	2016-2020	2021-2025	2026-2030
Robert Barro (2016)	[3, 4]		
Pritchett and Summers (2013)	2.8		
Justin Lin (2016)		8.0	
Bai and Zhang (2016)	6.3	5.6	4.8
Zhang Jun	[7, 8]	[5, 6]	
World Bank (2012)	7.1	6.2	
Lu and Cai (2014)	6.7	6.0	5.5
IMF (2019)	6.5	5.7	

Source: Authors' compilation.

B. What's behind the diverging views?

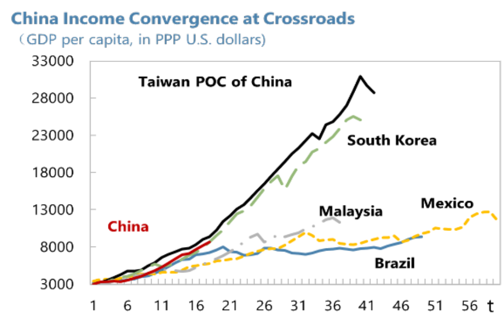
The wide range of potential growth estimates is largely driven by differences of methodology, which can be broadly categorized into three streams:

Convergence theory: It has been well established in economic theory that poor countries, which are further away from the technology frontier, tend to growth faster than advanced economies, and gradually catch up in productivity and income level. These models are tested empirically using cross-country data. Nonetheless, the estimated growth rate is very sensitive to the sample selection. The bull estimates reflect cross-country studies using Asian tigers as references (Lin 2016), while the bear estimates use global panel datasets (Summers 2016). Maliszewski and Zhang (2015) have formalized this sensitivity in their panel analysis (text figure) and highlighted that convergence theory provides only a range of potential growth but does not provide enough accuracy to pin down the exact growth rate.



Sources: Maliszewski and Zhang (2014).

Cross-country experiences suggest that income convergence can vary significantly. In the post-second world war period, South Korea and Taiwan POC stood out as the "A students" of convergence, transforming from low-income to high-income countries in four decades. In contrast, convergence in some Latin American countries, such as Brazil and Peru, has stagnated for several decades as their economies have fallen into the middle-income trap (Aiyar et al. 2013).



Source: Aiyar et.al (2013).
[1] t=0 is defined as the year when the GDP per capita for a particular country reached 3,000 U.S. dollars in PPP terms.

Demand-side approach: This stream of literature extracts information from other macro indicators such as inflation, unemployment, and credit to gauge the underlying output gap, and hence potential output. The model could be a full-fledged Dynamic Stochastic General Equilibrium model, or a reduced form featuring the Philips curve and Okun's law[3]. In recent years, the "financial-neutral" approach (Borio et al. 2014) – where credit is used to gauge the cyclical position of the economy in additional to traditional indicators, such as inflation and employment – has gained increasing attention in the literature. Maliszewski and Zhang (2015) and Chen and Kang (2016) provide such estimates for China. Overall, the demand-side approach is most useful for short-term analysis, and also for medium-term study of advanced economies with no significant structural changes. For transition economies like China, however, it is often difficult to model properly the rapid structural changes, in particular for the medium term. Ma (2017) made attempts to incorporate key structural changes into the DSGE model, but there is a large degree of uncertainty regarding calibration.

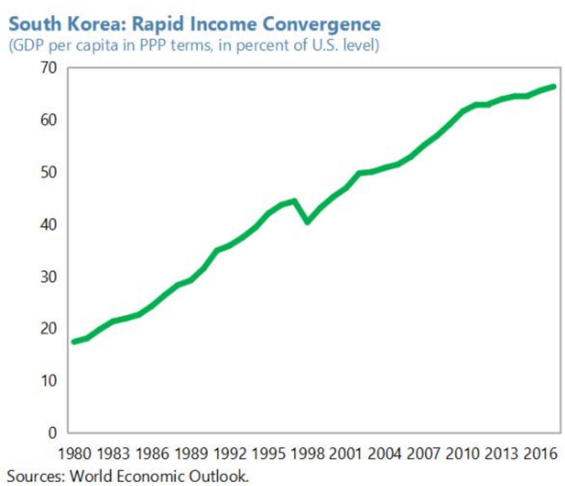
[3] See Maliszewski and Zhang (2015) for an overview of various models to extract potential growth from demand-side models.

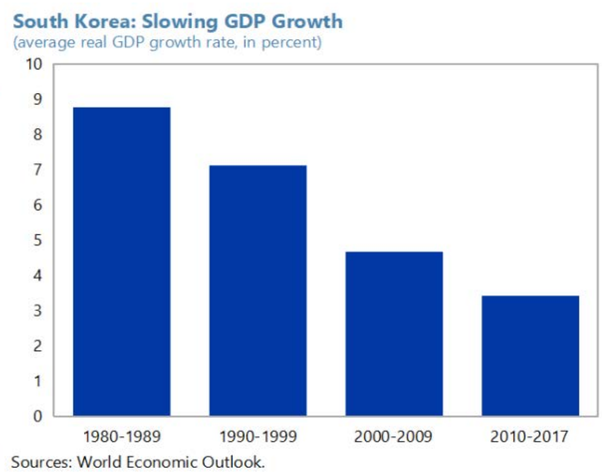
Supply-side approach: This approach uses various versions of the Cobb-Douglas production function to estimate potential growth, and decomposes growth into productivity, investment, labor, and sometimes human capital input. Historical potential growth is derived by applying an HP filter to each factor and summing up, while medium-term growth is estimated by forecasting each production input. This method is often more useful to estimate long-term potential growth, and in particular to reflect envisaged demographic changes. The supply-side model is also better suited for emerging markets, where productivity catch-up is a main growth driver. Nonetheless, most of the literature focuses on the aggregate approach, which overlooks the structural transition between sectors and its impact on overall growth.

Box 1: Convergence success and laggers

Convergence success:

South Korea started its economic reform in the 1970s, when the country was still receiving donor aid. After 40 years, South Korea is now a member of the OECD, and its GDP per capita has risen from 11 percent of the U.S. level to about 70 percent in 2016. Notably, despite the country's successful convergence, headline growth has slowed from 10 percent in the 1980s to 7 percent in the 1990s and to 3 percent recently.



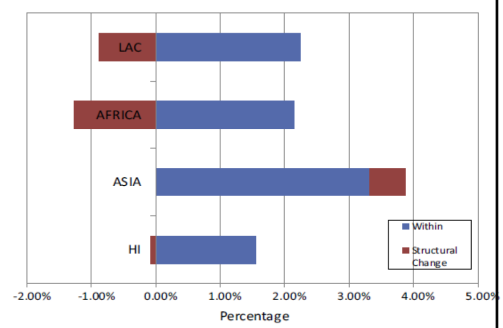


Convergence laggers:

A few Latin American countries, such as Brazil, Mexico and Peru, grew at a brisk pace to reach middle-income level but then stagnated for several decades, driven by significant slowdown in productivity growth (Aiyar et al. 2013). Rodrik (2016) finds that the productivity slowdown was mainly driven by premature deindustrialization, which dampened aggregate productivity, despite continued improvement in productivity within each sector.

Structural Change Critical to Growth

(contribution to growth, in percentage points)



Source: McMillian, Rodrick and Verduzco-Gallo, 2014
LAC: Latin America

Why China is unlikely to follow the East Asian tiger path?

When they were at China's current income level, South Korea and Taiwan POC were still growing at 8 percent. Hence some of the literature argues that a similar growth rate is achievable in China (Justin 2016). However, despite China's past success, it is not likely to replicate such high growth, reflecting the changing global environment and the size of the Chinese economy, which necessitate an earlier structural shift from exports to domestic demand.

- **Changing global environment**: Global economic growth has slowed substantially since the global financial crisis, from a pre-crisis average of 5.1 percent to a post-crisis average of 3.4 percent, and is expected to stay low in the years to come. This reflects a confluence of factors, such as the stagnation in total factor productivity (TFP) growth, rapid aging, and slow progress in further global trade integration. As argued in Summers (2015), the industrial world could be in secular stagnation for a considerable time. Such a global environment will be less supportive than that faced by South Korea and Taiwan POC when they were at China's current income level, and will thus put downward pressure on China's growth.
- **Size of the economy**: Both South Korea and Taiwan POC have exported their way from low-middle-income to high-income status. Reflecting South Korea's small population, despite its high-income level, the size of the South Korean economy as of today is only about 10 percent of U.S. economy, while the Taiwan POC economy is about 6 percent of the U.S. economy. Their small sizes give these two economies the advantage of maintaining the same export-led growth model throughout their economic transition. Similarly, the Japanese economy is only a quarter the size of the U.S. economy, and Japan remains an export-led economy today. For China, by contrast, the growth model will inevitably need to be redesigned as the economy grows. Even with per capita income at 18 percent of the U.S. level, the size of the Chinese economy is already 76 percent of the U.S. economy. This means that it will become increasingly difficult for the world to absorb the ever-increasing exports from China and that more demand needs to be generated domestically.

Why China is unlikely to converge to the global average?

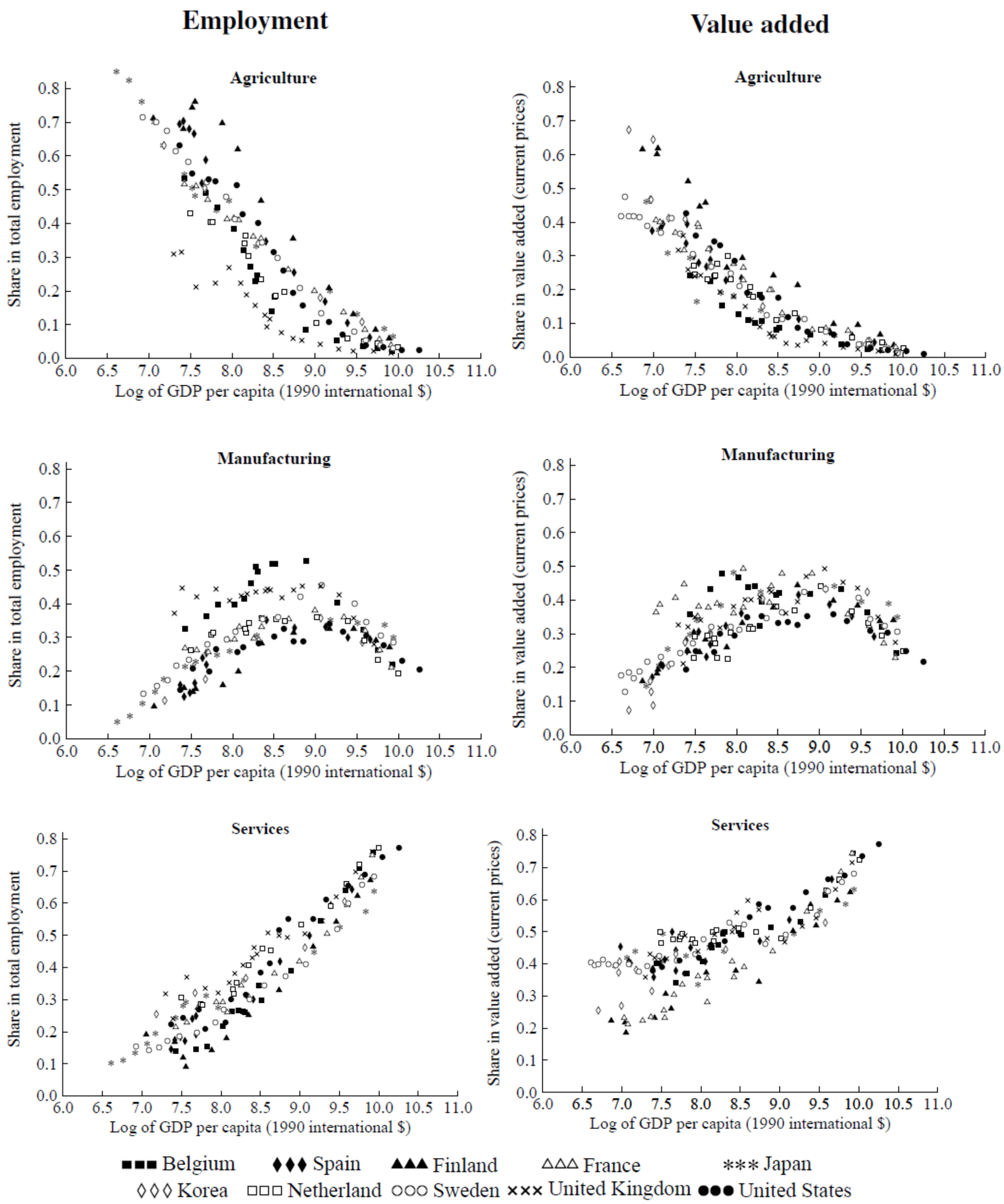
Barro (2016) finds that, at China's current income level, most developing economies were growing at 3-4 percent; hence a mean reversion would suggest that China will grow at the same rate. But there are factors that may mean that China does not converge to an average growth rate. China has been a growth star for the past several decades, reflecting a confluence of factors, including political stability, continued reform and opening up, high savings, strong government investment in infrastructure, etc. These factors will continue to contribute to a higher than global average growth rate (at a given income level) in China. In addition, in contrast to Latin economies that fell into the middle-income trap, the structural shift from industry to services in China has been broadly in line with that seen in the past in advanced economies, hence mitigating the risks of substantial slowdown as a result of "premature deindustrialization".

C. Our Approach

- **A supply-side approach with sectoral transition provides better insights into China's medium-term growth.** As explained earlier, international experiences based on convergence theory provide a useful benchmark, but China-specific analysis is needed to pin down its potential growth rate. While the demand-side approach can shed some light on near-term growth potential, the supply-side approach is more suited to analyzing medium-term growth in a fast-transition economy like China. Moreover, it is critical to conduct the supply-side analysis at the sectoral level, as the transition between sectors will be a major driver of overall growth.

- **Sectoral transition is an integral part of economic development and a key driver of potential growth.** As is well established in the literature, the growth path of most advanced economies has been accompanied by a series of structural transformations (text figure, Herrendorf et al. 2014). In the first stage, the share of agriculture falls, while the share of industry and services increases. As labor is relocated from low-productivity agriculture to high-productivity manufacturing and services, growth will accelerate. In the second stage, as an economy reaches a certain income level, the share of industry will peak and start to decline, while services' share continues to rise and agriculture's share declines further. During this stage, as employment starts to shift from the high-productivity industrial sector to lower-productivity service sectors, such a transition puts downward pressure on overall growth.

Sectoral Shares of Employment and Value Added
(Selected Advanced Countries 1800-2000)



Source: Herrendorf et al. (2014)

Upgrades within industry and services are also key to understanding China's potential growth. While aggregate sectoral transition will impose downward pressure on potential growth, the sectoral transition within industry and services could provide an important buffer to moderate the slowdown. As is well documented in the literature (Jorgenson 2005, Bernard and Jones 1996, O'Mahony and Timmer 2009, Van Ark et al. 2008), there are significant variations of productivity across different industrial sectors, ranging from the relatively low-tech textile sector to the high-tech machinery and IT sectors. Similarly, there is considerable heterogeneity among services (Duarte and Restuccia 2017, Jorgenson and Timmer 2011, Buera and Kaboski 2012, Duernecker et al. 2017), from food catering to financial and legal services. Hence upgrading from low-productivity to high-productivity subsectors within industry and services could be an important driver of productivity growth.

Reforms to buck the downward trend. Reform implementation is another important factor in studying potential growth in China. There is a large literature quantifying the impact of various reforms on productivity in China, in particular state-owned enterprises (SOE) reform. Lam et al. (2017), Zhang (2016) and Lardy (2016) all suggest a sizable boost to productivity growth.

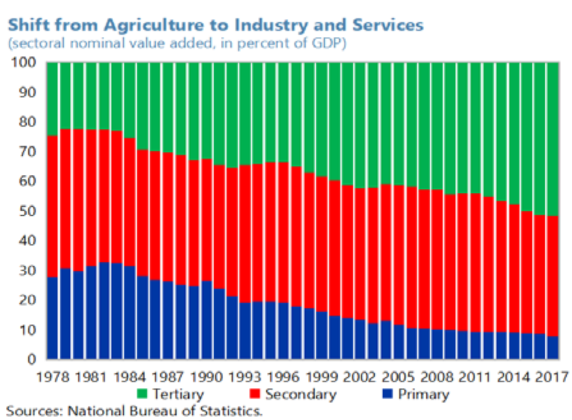
III. Macro Analysis

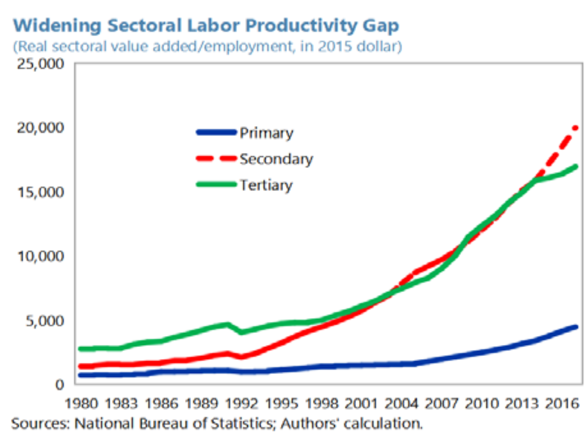
This section provides an overview of the sectoral shift in China over the past four decades, and shows that since 2012 China has started deindustrialization, with the sectoral shift from industry to services putting downward pressure on aggregate labor productivity, despite robust growth at the sectoral level. Productivity convergence in industry and services has been rapid but remains at an early stage. In addition, demographic changes are gradually resulting in a shrinking labor supply and are becoming another drag on growth.

Sectoral transition

China has gone through two stages of sectoral shifts in its development:

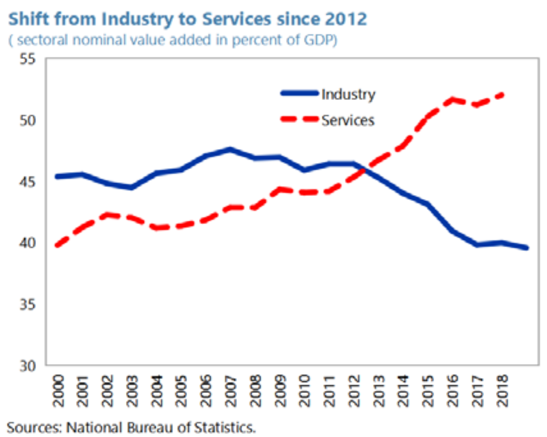
- ***First stage: Industrialization (1965–2012) – shift from agriculture to industry and services.*** The share of agriculture in GDP fell from 50 percent in the early 1950s to less than 10 percent, while agricultural labor productivity surged tenfold during this period. This enhanced productivity created surplus labor in the agricultural sector, which was then absorbed by fast-expanding industrial and service sectors. Given that labor productivity in the industrial and services sectors is two to four times higher than that in agriculture, this structural shift, along with the within-sector productivity catch-up,

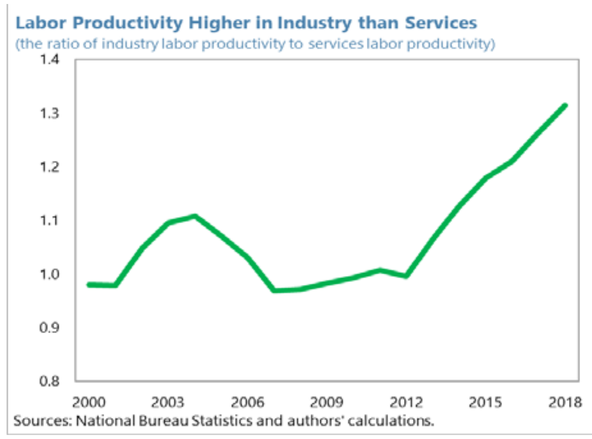




significantly boosted aggregate labor productivity. Overall labor productivity growth was above 9 percent in most years.

- ***Second stage: Deindustrialization (2012-present) – shift from agriculture and industry to services.*** After several decades of steady increase, industry's share in GDP peaked at 46 percent in 2011 and has since declined. This marked the beginning of the second stage of China's development, as the economy started to shift from both agriculture and industry to services. Currently, industrial labor productivity is 30 percent higher than service productivity and is growing at a faster pace. Hence, the shift from industry to services will inevitably exert a drag on total labor productivity, and such downward pressure will increase over time, reflecting the growing productivity gap between industry and services.





The timing of deindustrialization is critical to avoid the middle-income trap. Similar to the experience of advanced economies, China's industrial share in GDP peaked in 2012, at the GDP per capita level of US$10,000 (in 1990 international prices). Since then, the share of industry has steadily declined (Zhang 2015). The income level at which "deindustrialization" starts is critical. As Rodrick (2016) has highlighted, many countries have stalled in income convergence because of premature deindustrialization. In China's case, however, the timing has been in line with the past experiences of high-income countries.

Table: Cross-Country Experiences on Deindustrialization

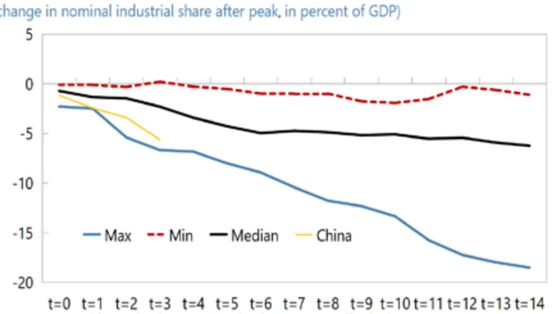
peak of industrial sector	year	GDP/Capita (in 1990 international prices)	industry share of output	service share of output
United States	1953	10,613	33	60
UK	1960	8,645	49	44
France	1970	11,410	41	48
Germany	1970	10,839	47	48
Japan	1970	9,714	42	51
Spain	1975	8,346	46	42
Italy	1976	11,308	46	45
Taiwan POC	1986	7,477	49	44
Korea	1992	9,877	44	47
China	2012	9,719	46	46

Sources: Maddison database; CCGD database: and IMF staff calculations.

The pace of deindustrialization in China has also been in line with that in other advanced economies. Since 2012, the nominal share of industry has been on a steady decline, with the pace of decline comparable to the experience of advanced economies (Zhang 2015). The falling nominal share largely reflects the price effect so far, as the decline in the real share has been much more muted. This is also in line with international experience, as relative price change is an essential part of deindustrialization, especially at the beginning. Resource reallocation will typically accelerate after these price movements. In Japan, for example, the nominal industrial share fell sharply once deindustrialization started, while the real share remained stable and only started to decline four years later. Another indicator for real adjustment is the industrial employment share, which peaked in 2012 in China and has been on a steady decline since.

Deindustrialization Similar to Advanced Economies

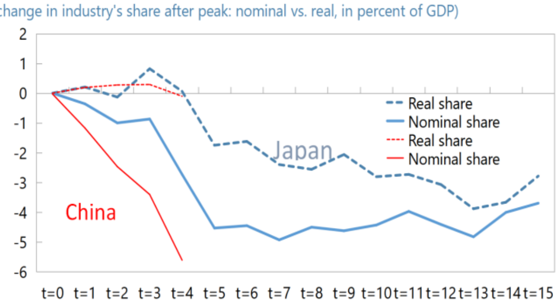
(change in nominal industrial share after peak, in percent of GDP)



Sources: Maddison database;GGDC database; IMF staff calculations.
Note: t=0 is defined as the year when the nominal share of the industrial sector in GDP peaked. Countries in the sample include nine advanced economies.

Fall in Industry's Share Driven by Price Effect

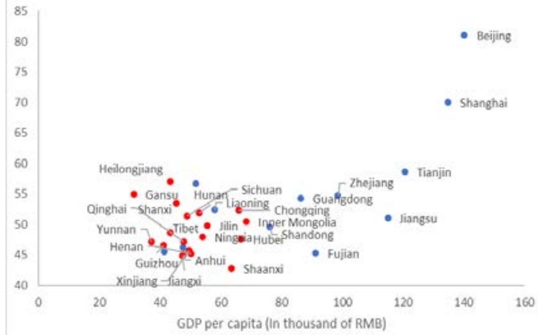
(change in industry's share after peak: nominal vs. real, in percent of GDP)



Sources: IMF staff calculations.
Note: t=0 is defined as the year when the nominal share of industrial sector in GDP peaked.

The share of services will likely rise further in China. The nominal share of services in GDP stands at 52 percent in China, compared with 70-80 percent in the U.S., Japan and Australia, and 60 percent in South Korea. Hence, there remains significant room for catch-up. This will likely be achieved through both the price effect (higher services deflator than industrial deflator) and the real effect as shown in increasing share in real terms and employment. Indeed, in large cities like Beijing and Shanghai services' share has already reached the level in advanced economies, and further increases will hence mostly come from interior regions (text chart).

Services' Share to Rise, Driven by Interior Regions
(services nominal value added in percent of GDP)



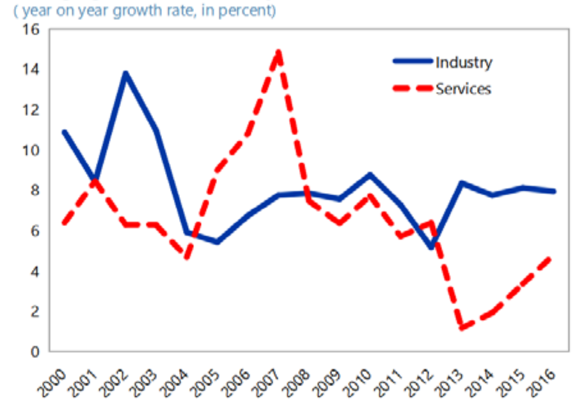
Sources: National Bureau of Statistics: authors' calculations.

Within-sector productivity

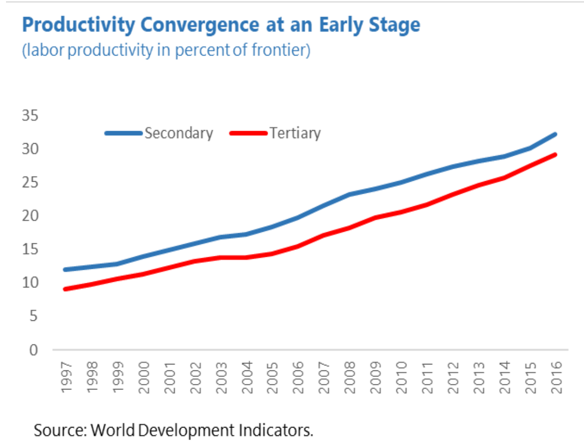
Manufacturing labor productivity growth has remained robust. Despite the slowdown in aggregate labor productivity, industrial productivity growth has been strong, at around 8 percent. This has been supported by continued capital deepening and industrial upgrading. However, TFP growth, which excludes the contribution of capital stock, has shown a significant slowdown in the past decade, though it has stabilized in recent years.

Services labor productivity growth has slowed. Since deindustrialization started in 2012, labor productivity growth in the services sector has slowed substantially, from about 6 percent to less than 3 percent. This likely reflects the changing structure of services. As more than eight million workers have been laid off from the industrial sector, they have then mostly been absorbed into low-skill service jobs, bringing down overall services productivity growth (we will discuss this in more detail in the micro section). Similarly, TFP growth in the services sector has shown a declining trend since early 2000.

Diverging Labor Productivity Growth
(year on year growth rate, in percent)

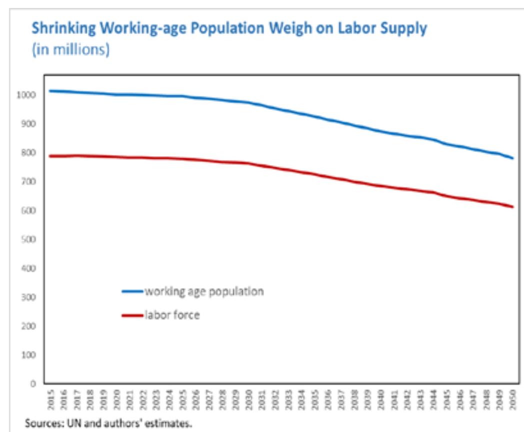


Sources: CEIC; IMF staff estimates.



Productivity levels in both industry and services remain much lower than in frontier economies, hence providing significant room to improve. Industrial labor productivity has surged from about 13 percent of the U.S. level in 1997 to 33 percent in 2015. Similarly, services productivity has also risen, from nearly 10 percent to 29 percent. Hence, despite significant catch-up, there is still plenty of room to converge further for both sectors. As will be explained in Section IV and Section V, part of this convergence will come from the sectoral shift within the industrial and services sectors.

Demographics



Demographic changes are another source of headwinds to growth. After rapid expansion in the past few decades, the working-age population in China peaked in 2010 and is expected to fall from 1,004 million in 2015 to 970 million by 2030, with the pace of decline accelerating over time. The near-term impact of this demographic shift will be limited, as the labor force will remain stable due to a rising labor participation rate, and the average working hour has increased However, in the medium term the shrinking working population will inevitably lead to a falling labor force, putting additional downward pressure on overall growth. Human capital in China has risen steadily, but the pace of increase has slowed and is expected to slow further (Li et al, 2013), hence not likely to offset the impact of population ageing.

IV. Industrial Analysis

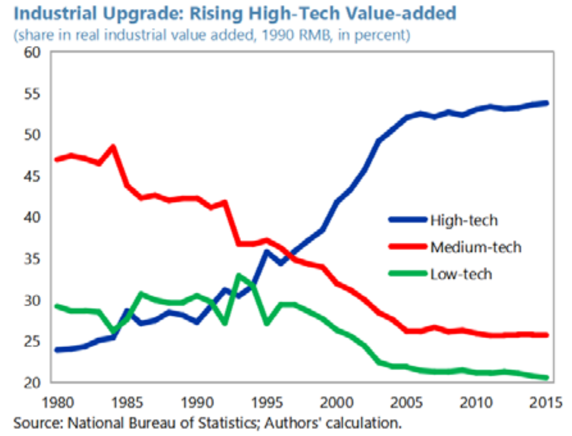
This section provides an overview of China's industrial development over the past few decades. Overall industrial productivity has converged from 13 percent of the frontier at the end of 1990s to 33 percent in 2015, achieved via both the sectoral shift from low-tech to high-tech sectors and productivity increases in each specific industry. It is notable that China has a larger share of high-tech sectors than its income level would suggest. The degree of convergence also varies across sectors, with high-tech sectors lagging low-tech sectors.

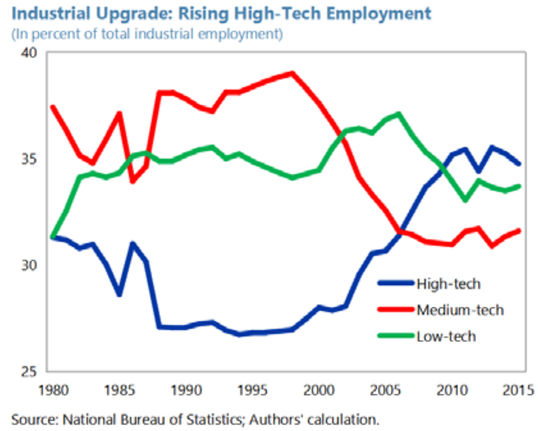
Sectoral shift from low-tech to high-tech sectors

We classified the 38 two-digit industrial sectors into three categories based on the OECD definition of R&D intensities: the *low-tech sector* consists mostly of production of consumer goods, such as apparel, and food and beverages; the *medium-tech sector* consists mainly of production of metal and chemical products; and lastly, the *high-tech sector* refers to the ICT sector, machinery, medicine, etc.[4]. Over the past few decades, China has experienced a significant structural shift from low-tech and medium-tech sectors to high-tech sectors, as evidenced in the changing share in real value added and employment. The shift in nominal share has been more moderate, reflecting the offsetting impact of the lower relative price of the high-tech sectors.

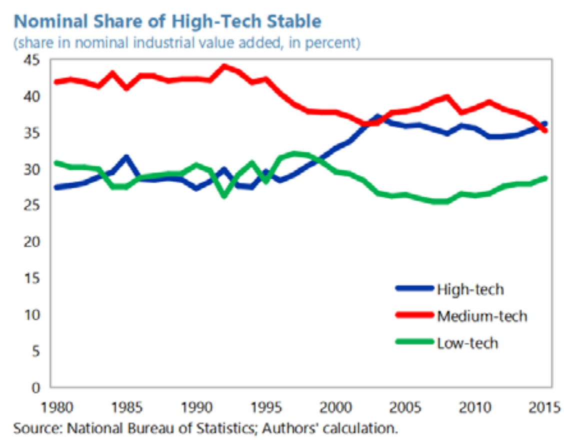
- ***Significant sectoral shift to high-tech in real value added and employment.*** The share of the high-tech sector in real industrial value added at 1990 domestic prices rose from 24 percent in 1980 to 52 percent in 2015, while the share of medium-tech sectors fell from 48 percent to 26 percent. The share of low-tech industry was relatively stable at around 30 percent from 1980 to 1994, but then gradually fell to 20 percent in 2015. As another indicator of real resource allocation, a similar trend can be observed in employment. Here, the share of high-tech has risen from 28 percent in the 1990s to 43 percent today, while the employment share of medium-tech sectors has fallen sharply since 2000, from close to 40 percent to slightly above 30 percent. Interestingly, the employment share of low-tech sectors first increased in the early 2000s, likely reflecting China's entry into the WTO and its booming low-tech exports; but later declined as the impact of industrial upgrading dominated and China gradually shifted from low-tech and medium-tech to high-tech exports.

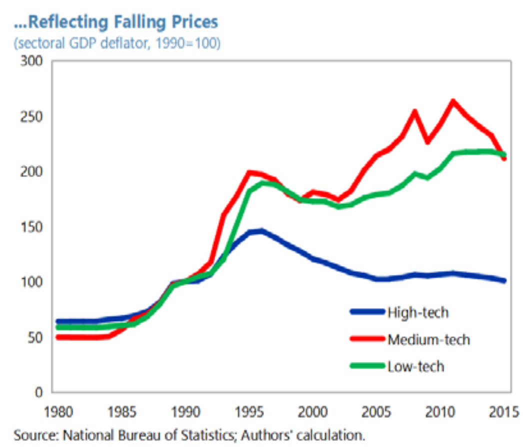
[4] The *high-tech industry* includes Manufacture of Computers, Communication and Other Electronic Equipment, Manufactures of Electrical Machinery, Manufacture of Measuring Instruments, Manufacture of Transport Equipment, Manufacture of General-Purpose Machinery, Manufacture of Special-Purpose Machinery, Manufacture of Medicines. The *medium-tech industry* includes Smelting and Pressing of Ferrous Metals, Smelting and Pressing of Non-ferrous Metals, Manufacture of Non-metallic Mineral products, Manufacture of Rubber and Plastics Products, Manufacture of Chemical Fibers, Manufacture of Raw Chemical Materials and Chemical Products, Processing of Petroleum, Coking and Processing of Nuclear Fuel, Manufacture of Metal Products. The *low-tech industry* includes Processing of Food from Agriculture Products, Manufacture of Foods, Manufacture of Beverages, Manufacture of Tobacco, Manufacture of Textile, Manufacture of Textile, Wearing Apparel and Accessories, Manufacture of Leather, Fur, Feather and Related Products and Footwear, Processing of Timber, Manufacture of Furniture, Manufacture of Paper and Paper Products, Printing and Reproduction of Recording Media, Manufacture of Articles for Culture, Education, Arts and Crafts, Sport and Entertainment Activities.





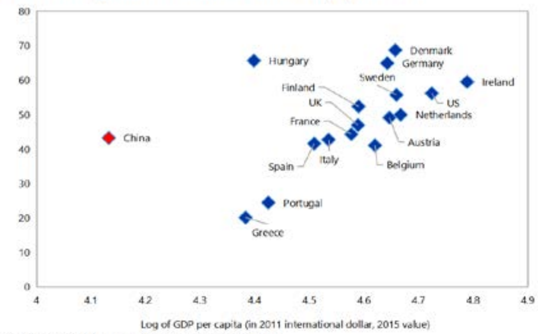
- ***Sectoral shift is less pronounced in nominal value added, reflecting relative price changes.*** Despite the surge in the real share of the high-tech sector, its nominal share has been broadly stable or declining since early 2000. This has mainly reflected the relative price effect, in particular in the ICT sector. Since 2000, the price of ICT products has declined significantly as the underlying technology has gone through constant revolution and as data-processing capacity has doubled every 18 months. On the other hand, the prices of low-tech and medium-tech products have risen consistently. Hence, the falling relative price of high-tech products over time has offset the high-tech sector's rising real share and has led to a stable nominal share.





- **China has a highly advanced industrial structure today.** Cross-country experiences suggest that the share of high-tech sectors in industrial value added tends to increase as income rises. It is notable that China currently has a more advanced industrial structure than its income level would suggest. The share of high-tech in industrial real value added was 43 percent in 2015, based on 2011 international dollar prices[5], similar to the levels in Belgium and Spain, where income levels are about three times as high.

China's Industry Structure is More Advanced than its Income would Suggest
(share of high-tech real value added, in peprcent)



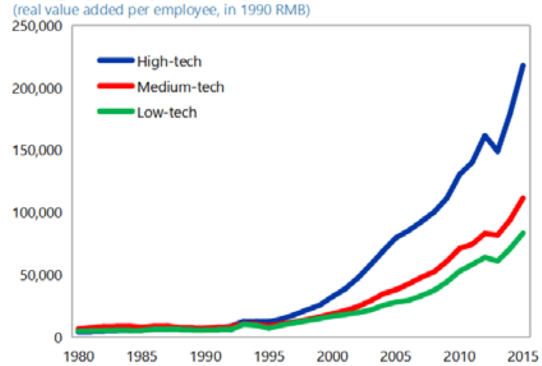
Source: World Klems Database; National Bureau of Statistics.

Productivity within subsectors

Industrial productivity across sectors has diverged over time as higher-productivity sectors have experienced faster growth.

Sectoral labor productivity has diverged since the mid-1990s. The productivity of high-tech industries grew at an average annual rate of 16 percent from 1996 to 2015, compared with 14 percent in medium-tech industries and 13 percent in low-tech industries. This strong growth has driven up labor productivity in high-tech industries, which is twice as high as that in medium-tech industries (mainly raw materials) and nearly three times as high as in low-tech industries (mostly consumer goods).

Diverging labor productivity
(real value added per employee, in 1990 RMB)



Source: National Bureau of Statistics; Authors' calculation.

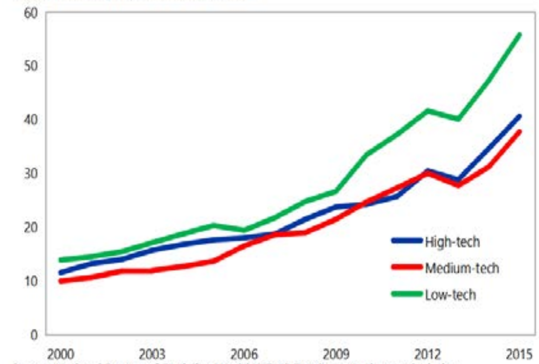
Similar divergence can be observed in total factor productivity (TFP). Since the mid-1990s, TFP growth has increased fivefold in high-tech industries, while it has less than doubled in the low-tech and medium-tech sectors. Medium-tech sectors have lower TFP levels than low-tech sectors. This is in contrast with their higher labor productivity, likely reflecting a large contribution from capital stock. TFP growth rates in the low- and medium-tech sectors are much lower than their respective labor productivity growth rates, which have been driven mainly by capital deepening. Notably, all industrial subsectors suffered a

[5] The share of high-tech industrial value added is computed using 2011 international dollar prices. The classification of high-tech in international comparison includes Manufacture of Raw Chemical Materials and Chemical Products and Manufacture of Chemical Fibers, while in detailed 38-industry analysis they are not included.

temporary slowdown following the global financial crisis, but all of them – in particular the high-tech sector – rebounded afterwards.

Productivity convergence is more advanced in low-tech sectors, while there remains ample room for catch-up in all industries. China's labor productivity in all industries still lags frontier economies, although the distance to the frontier has shrunk significantly in recent years. The catch-up process is more advanced in low-tech and medium-tech industries than that in high-tech industries. Specifically, from 2000 to 2015 labor productivity as a share of the frontier rose from 13 percent to above 55 percent in low-tech industry, from 10 percent to 38 percent in medium-tech industry, and from 11 percent to 40 percent in high-tech industry[6]. In all sectors, there remains plenty of room for further catch-up.

Low-Tech Convergence Faster than High-Tech
(labor productivity in percent of the US level)

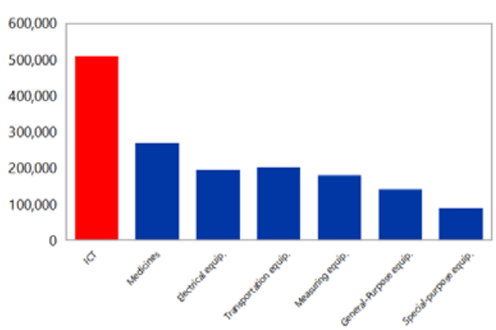


Source: National Bureau of Statistics; World KLEMS Database; Authors' calculation.

Box 2: ICT sector – Driver of High-tech

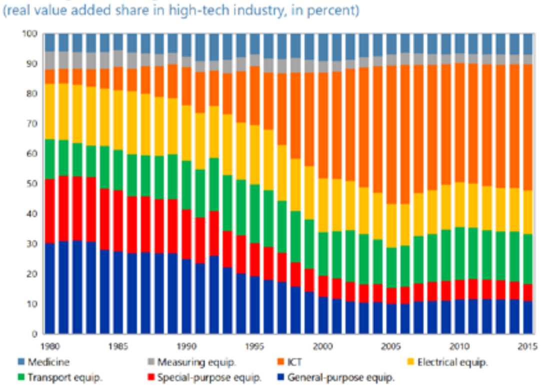
The ICT sector is a key component of the high-tech sector. Over the past two decades, the ICT industry has experienced the fastest productivity growth of all high-tech sectors. Reflecting this rapid growth, its share in high-tech industries' real value added rose from 30 percent at the end 1990s to about 42 percent in 2015. In 2015, labor productivity in the ICT sector was twice as high as in other high-tech sectors. Continued resource allocation to the ICT sector has therefore provided a significant boost to overall high-tech productivity growth, although such allocation has slowed in recent years.

ICT: Highest Labor Productivity among High-Tech subsectors
(In 1990 RMB, 2015 value)



Source: National Bureau of Statistics; Authors' calculation.

ICT: Rising Share in High-Tech
(real value added share in high-tech industry, in percent)



Source: National Bureau of Statistics and authors' calculation.

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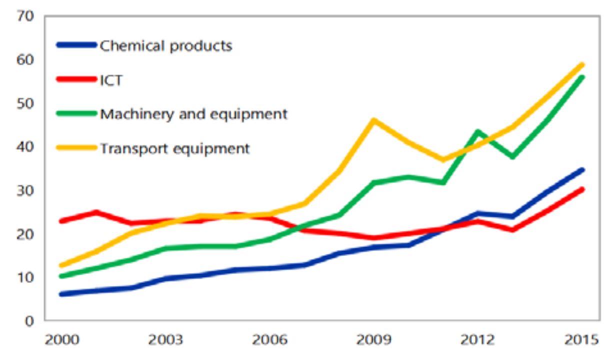
[6] Industrial productivity convergence based on sectoral data is slightly faster (above 35 percent) than at the macro level (35 percent). This may reflect differences in coverage, as the macro industrial data also includes three additional sectors (mining, utilities, and construction), where the convergence may be slower.

However, the convergence of the ICT sector has lagged other high-tech sectors. From 2000, labor productivity in the ICT industry as a share of the frontier fell, and has been picking up only since 2013, while other high-tech sectors, such as machinery and medicine, have experienced rapid catch-up, with productivity rising from around 10 percent of the frontier level to 30-60 percent. The slower convergence of the ICT sector since 2000 likely reflects the fact that since its WTO entry China has specialized in less sophisticated production stages of the global supply chain (e.g., the assembly of cellphones and computers), reflecting its comparative advantage, while advanced economies have focused on chip design and production, where productivity growth has been enormous. Notably, in more recent years the convergence of the ICT sector in China has resumed, as the economy has gradually moved toward the more advanced part of ICT production, benefiting from surging R&D.

Slower Convergence in ICT Sector
(in percent of U.S. level, based on 2011 international dollars)



Source: National Bureau of Statistics; World KLEMS Database; Authors' calculation.

V. Services Sector Analysis

This section provides an overview of the services sector's development over the past few decades. Overall services productivity converged from 10 percent of the frontier in the mid-1990s to 29 percent in 2015, lagging that of the industrial sector. This reflects both the non-tradable nature of certain services and less opening up of the services sector in China. The convergence achieved so far has been driven by both the sectoral shift from non-market services to market services and productivity increases in subsectors. The degree of convergence has varied, with transportation and financial services more advanced and wholesale and retail sales services lagging.

Sectoral shift between non-market and market services

We classify the 11 service sectors into non-market services and market services based on the OECD definition[7]. Non-market services are services provided to communities and individuals for free or at a fee well below 50 percent of their production cost, such as

[7] An alternative classification is based on the productivity level of sub service subsectors, as used in Duernecker, Herrendorf and Valentinyi (2017). The results are similar to those based on OECD definitions, as non-market services generally have much lower productivity than market services.

government, public administration, education, healthcare, etc.[8] Conversely, market services are produced for sale at a price intended to cover production costs and to provide a profit for the producer, such as wholesale and retail sales, finance, and hotel and restaurants (see the table below for detailed classification).

Table: Service sector classification

	Services subsectors	**Abbreviation**
Non-market services	Government, public administration, political and social organizations, etc.	ADM
	Healthcare and social security services	HEA
	Education	EDU
	Cultural, sports, entertainment services; residential and other services	SER
Market services	Hotels and restaurants	HOT
	Financial intermediation	FIN
	Information and computer services	P&T
	Real estate services	REA
	Wholesale and retail trades	SAL
	Transport, storage and post services	T&S
	Leasing, technical, science and business services	BUS

Note: Based on OECD definition.

Instead of a monotonic shift, the sectoral shift has gone through different stages over the past four decades, reflecting China's unique reform path:

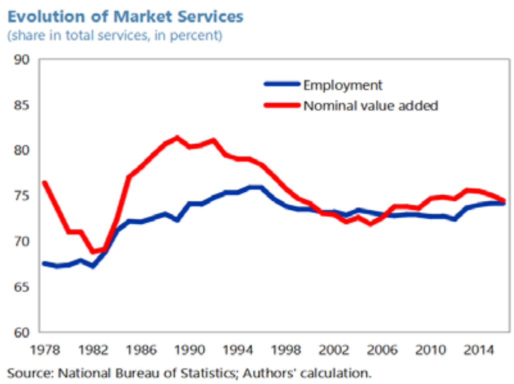
First phase (1980–1990): Following the 1978 reform and opening-up policy, market services expanded rapidly with nominal share in total services surging from 70 percent to 80 percent, partly reflecting the rising relative prices of market services amid price liberalization. The share of employment in market services also increased, driven by wholesale and retail sales as well as the financial sector.

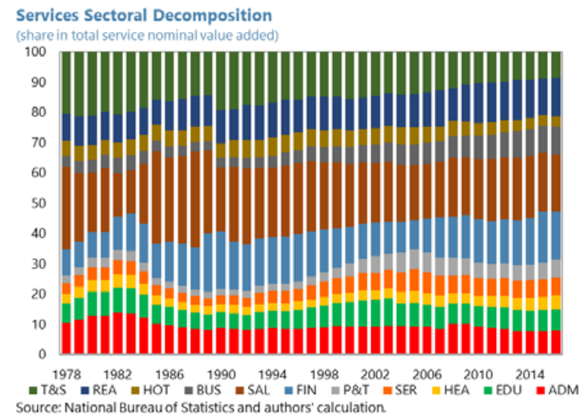
Second phase (1990-2002): The nominal share of market services retreated from 80 percent to 72 percent in the 1990s, while non-market services expanded, driven by culture,

[8] In some of the literature (Duernecker, Herrendorf and Valentinyi 2017, Duarte and Restuccia 2016), government services are excluded from non-market services, given their special nature.

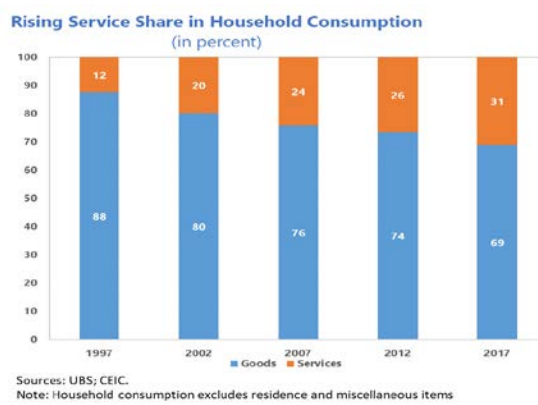
healthcare and education, reflecting government reform in these areas.[9] The employment share of market services increased from 1990-1996 and then declined steadily.

Third phase (2003-present): Since WTO entry in 2001, market services in China – in particular business services, wholesale and financial services – have experienced a renaissance as they have served the country's rapid industrial expansion, with their share in nominal value added increased steadily. However, the employment share stayed broadly stable at 70 percent until 2012, but it has risen since then, with increasing labor allocation to the sales, ICT service and business sectors.





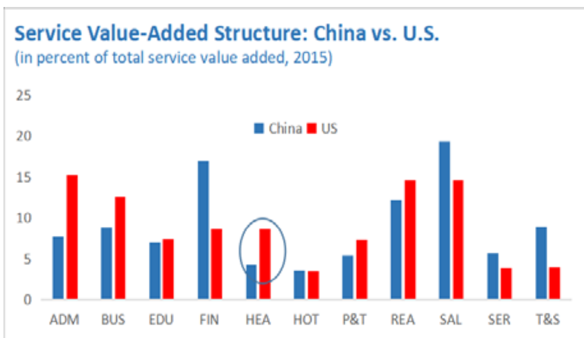
The share of non-market services is expected to increase further. Cross-country experience suggests that the share of market services might decline as income increases. At the early stage, market services tend to expand faster to support industrialization and related business demand; as the economy reaches a certain income level, however, household demand increasingly shifts from industrial goods to consumer services (text chart), and hence the industrial share plateaus, while consumer services, most of which are non-market (such as education, healthcare and sports), surge. Therefore, higher income is often associated with a lower share of market services. The evolution of the services structure in



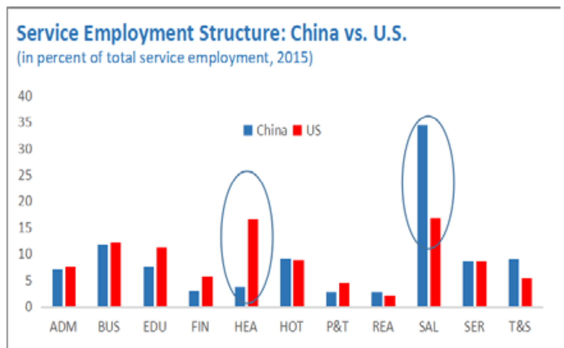
[9] Public healthcare facilities became for-profit entities and their profit-making behaviors were formally legitimized in September 1992 when the State Council issued a document titled "Instructions on Healthcare Reform." The policy also encouraged public hospitals to operate income-earning sideline services and businesses besides regular medical services. The profit motive became dominant at the expense of patient care, which eventually raised healthcare costs. From 1978 to 2011, personal health spending per capita increased by a multiple of 164, from 11 RMB to 1,801 RMB (or from roughly 6 USD to 280 USD), while the Consumer Price Index increased by a factor of 5.65 during this period. A huge portion of this expenditure went on high-tech tests and drugs; about half of Chinese healthcare spending is devoted to drugs, as compared with only 10% in the United States and an OECD average of 16% (Yip and Hsiao 2015).

China has broadly followed such a path, with market services surging in the early 2000 following export-led industrialization, peaking in 2012 at 75 percent and declining thereafter. As seen in other advanced economies, demand for non-market service would be likely to increase further as income rises. The share of market services in China is expected to decline from 74 percent currently to 65-70 percent, as seen in the U.S. and European countries.

The sectoral distribution of services could be improved by relocating labor from sales to healthcare and education. While detailed services structures may vary across countries depending on their comparative advantages and developmental stages, the structure in the U.S. can serve as a rough benchmark for future sectoral shifts. The comparison shows that an outsized labor force in China is devoted to wholesale and retail sales, accounting for 35 percent of total services employment, while the ratio is only 15 percent in the U.S. Despite the large difference in employment share, the share in value added is much more similar. Hence, improving the productivity of wholesale and retail sales could free up much-needed labor for other sectors, in particular health, where employment accounts for only 3 percent, compared with 17 percent in the U.S.



Source: World KLEMS Database; National Bureau of Statistics; Author's calculation.



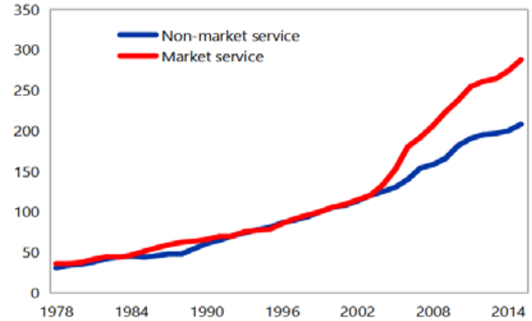
Source: World KLEMS Database; National Bureau of Statistics; Authors's calculation.

Note: ADM=government administration; EDU=education; HEA=healthcare and social security; SER=cultural, sports, entertainment, and residential services; BUS=business services; FIN=financial services; HOT=hotels and restaurants; P&T=information and computer services; SAL=wholesale and retail trades; T&S=transport.

Productivity Within Sectors

Productivity in market and non-market services has diverged in the past decade and reflecting faster growth of market services. From 1980 to the end of 1990s, market and non-market services productivity grew at similar rate of 5-6 percent. Since early 2000, however, productivity growth of market services has accelerated to 7.3 percent with market liberalization and the surge in ICT technology, while non-market service productivity growth has slowed to 4.8 percent. Since 2012 there has also been a slowdown in the productivity growth of market services, likely reflecting the absorption of low-skilled laid-off workers from the industrial sector.

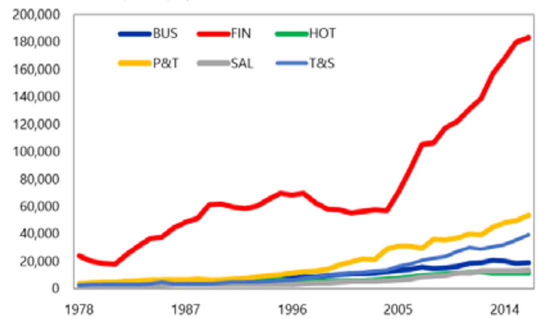
Higher Labor Productivity in Market Services
(Real value added per employee,in 2011international dollars, 2000=100)



Source: National Bureau of Statistics; Authors' calculation.

Finance, transportation, and ICT services have led the expansion of market services. Since early 2000s, financial services have expanded rapidly, with productivity surging threefold by 2015. Similarly, productivity in transportation and ICT services has also doubled. Conversely, in the wholesale and retail sales sector, which accounted for the largest employment share of market services, productivity barely increased from 1978–2003 and has started to rise only slowly since then. Productivity growth in the business service sector has also been slow.[10] Reflecting the differing growth speeds, the productivity levels of different market services have diverged further since 2000.

Diverging Labor Productivity within Market Services
(Real value added per employee, in 2011 international dollars)



Source: National Bureau of Statistics; Authors' calculation.
Note: BUS=business services; FIN=financial services; HOT=hotels and restaurants; P&T=information and computer services; SAL=wholesale and retail trades; T&S=transport.

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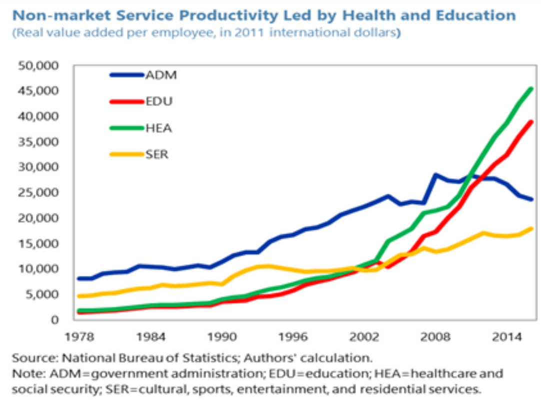
[10] Measurement issues could come from price index and employment data. The NBS may underreport value added of ICT services, as many ICT-service-related activities are not included (Xu 2004).

Productivity growth in non-market services has been led by education and healthcare. Measuring non-market services productivity is difficult, given that price does not reflect market value [11] (Triplett and Bosworth 2003, Byrne et al. 2016, and Syverson 2016). Nonetheless, based on traditional metrics, productivity growth in education and healthcare has accelerated to 14 percent since 2003, reflecting various government policies to strengthen social protection, while productivity growth in culture, sport and entertainment, and household services has been stable at 4 percent. For public administration, the productivity level has fallen in recent years after decades of steady increases, likely reflecting measurement issues.



Convergence of market services has been slow on average, although it has varied across subsectors. Currently, the productivity of market services in China is about 21 percent of the frontier level of the U.S., although the degree of convergence varies across subsectors.

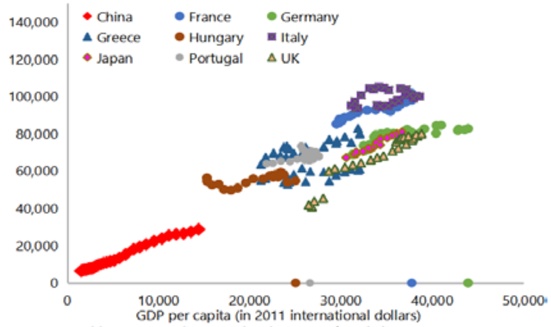
- Financial services in China have higher labor productivity than in most advanced economies based on traditional metrics. While this may reflect the surge of fintech and improved efficiency in financial intermediation, it could also be due to measurement issues, given the rapid expansion of credit after the global financial crisis.

- Convergence in the transportation sector is more advanced, at 40 percent, likely benefiting from China's high level of infrastructure investment and an e-commerce-related improvement in logistics productivity. Convergence has been on track in the ICT sector at close to 30 percent of frontier, but has been slow in business services and in hotels and restaurants, where productivity level stands at 25 percent of frontier.

[11] The International Comparisons Program (ICP) refers to the expenditure components that are difficult to estimate as "comparison-resistant" goods and services. The comparison-resistant services highlighted by the ICP are housing, collective government consumption, health, and education, which are included in our non-market services category. Quality of service may also be mismeasured, as argued in Triplett and Bosworth (2003), Byrne et al. (2016) and Syverson (2016). Allowing quality improvement in services will lead to higher growth.

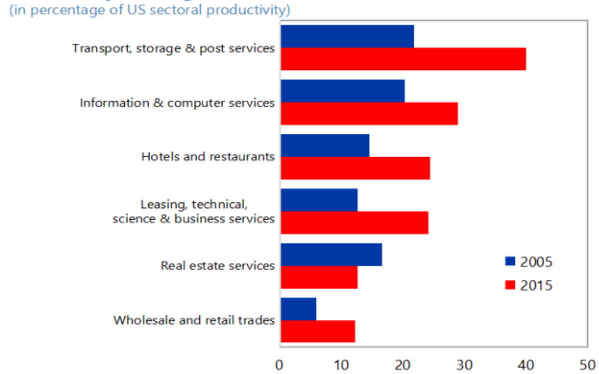
- Convergence rates in wholesale and real estate services are lagging, with productivity levels below 15 percent of frontier, likely reflecting restrictive regulation for entry.

Slower Productivity Convergence in Market Service
(real value added per employee, in 2011 international dollars, 1990-2015)



Source: World KLEMS Database; National Bureau of Statistics.

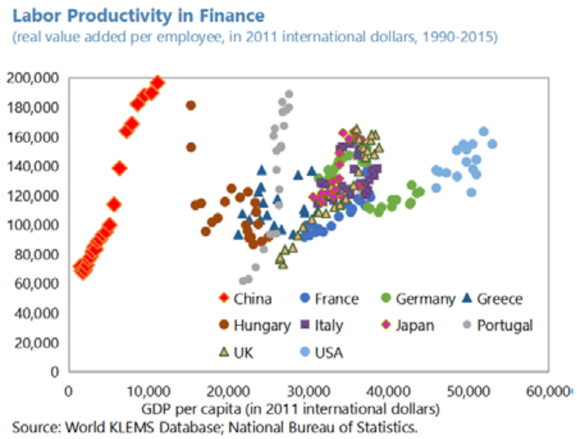
Productivity Convergence within Services
(in percentage of US sectoral productivity)



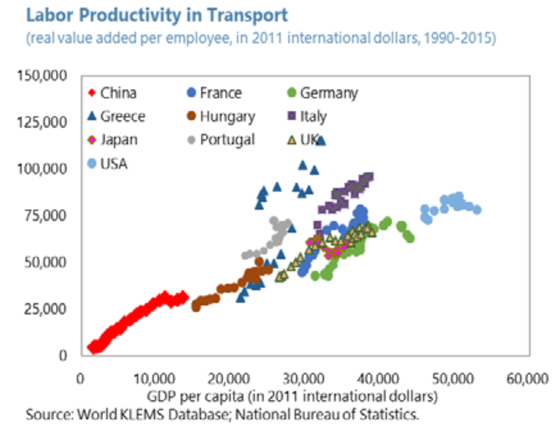
Sources: National Bureau of Statistics; World KLEMS Database.

Figure. Productivity Convergence in Market Service Sectors

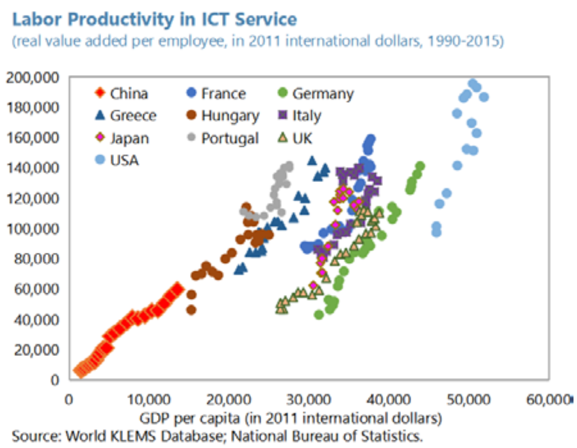
Financial services have been catching up at a rapid pace…



… and so has been transportation

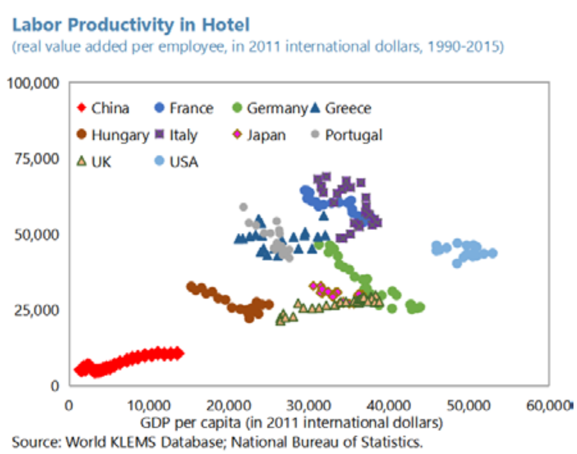


Convergence is broadly on track for ICT services…



… but slow for business services

… and hotel and restaurants



Convergence is particularly slow in wholesale and retail trade

Non-market services have converged more rapidly. Labor productivity of non-market services has reached 35 percent of the U.S. level and 48 percent of the level in other developed countries, such as Germany. The convergence has been mostly driven by healthcare and education, reflecting government reform in these areas, while productivity in the cultural and sports sector, and in government administration, is lagging (text figure). It should be noted that measurement of non-market services productivity is often subject to considerable uncertainty, reflecting the varying degree of price subsidy, which may prevent meaningful cross-country comparison (Triplett and Bosworth 2003, Byrne et al. 2016, Syverson 2016, Atkinson 2005, Griliches 1992).

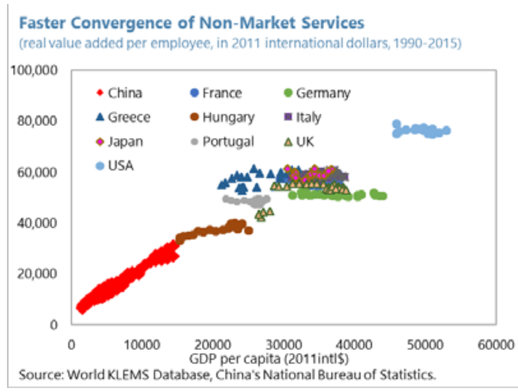
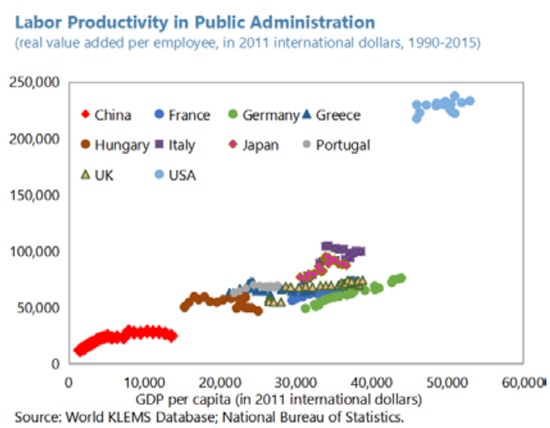
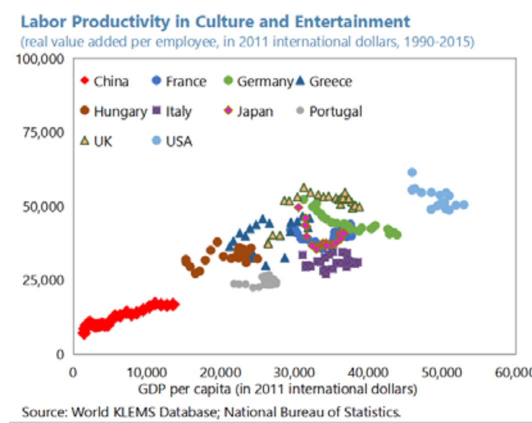


Figure. Productivity Convergence in Non-Market Service Sectors

China's public administration efficiency lags the U.S. level considerably.



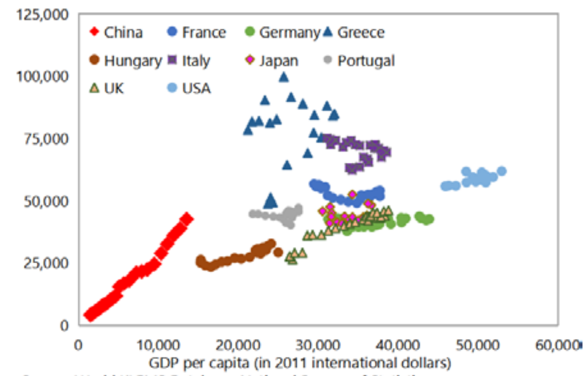
Convergence in the cultural and sports sector is also slow



Nonetheless, convergence in the healthcare sector has accelerated in recent years …

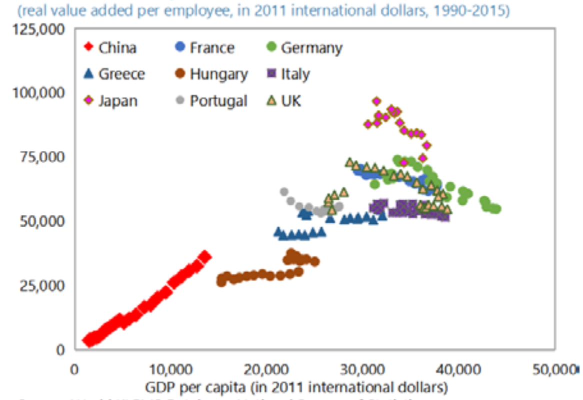
… and so has convergence in the education sector

Labor Productivity in Healthcare
(real value added per employee, in 2011 international dollars, 1990-2015)



Source: World KLEMS Database; National Bureau of Statistics.

Labor Productivity in Education
(real value added per employee, in 2011 international dollars, 1990-2015)



Source: World KLEMS Database; National Bureau of Statistics.

VI. The Future

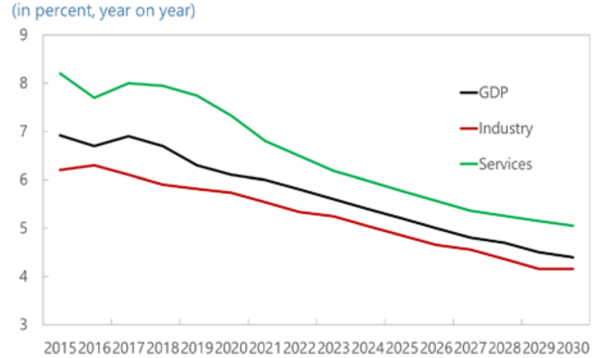
Reflecting the fact that it is still at an early stage in productivity convergence, China has the potential to maintain robust growth in the coming decade, although growth is forecast to be on a gradual downward trend, reflecting the structural transition from industry to services and the shrinking distance to the frontier. This section presents a baseline for China's structural evolution and the implied potential growth path. In addition, we highlight three forces that could reshape the growth path by accelerating within-sector productivity convergence: SOE reform, opening up of the services sector, and digitalization. Lastly, we illustrate how the reversal of global integration in trade and technology and the risks of financial crisis might hinder China's convergence.

Baseline potential growth and structural shift

Using a bottom-up approach, we first project productivity growth in each subsector based on the convergence model, then forecast sectoral employment shares based on recent trends, and finally derive the aggregate productivity growth based on the projected sectoral shares and productivity level.

Sectoral productivity growth is projected to remain robust, but moderate over time. Reflecting the fact that China is at an early stage of its convergence process, sectoral productivity growth is estimated to remain robust in the coming decade, although it will decline over time as sectors move closer to the frontier. Applying the convergence speed based on cross-country experiences in Rodrik (2013) and Bourlès et al. (2010), both industrial and services productivity growth are expected to slow to 3-4 percent by 2030. More granular studies

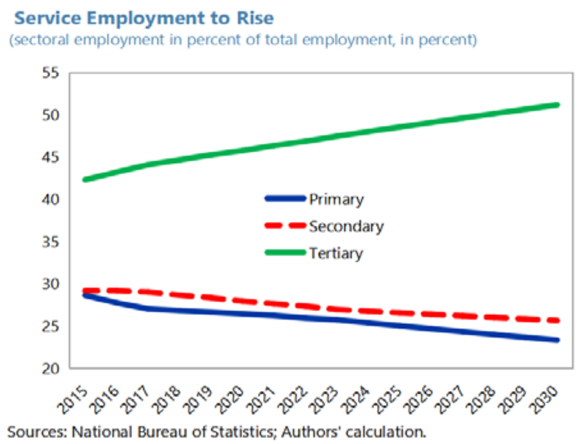
Baseline Growth Projection
(in percent, year on year)

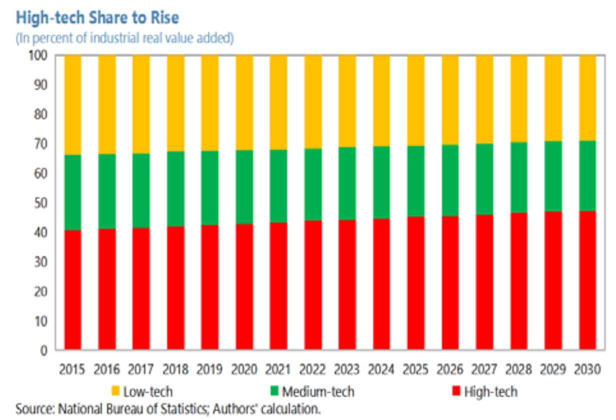


Source: Authors' estimates.

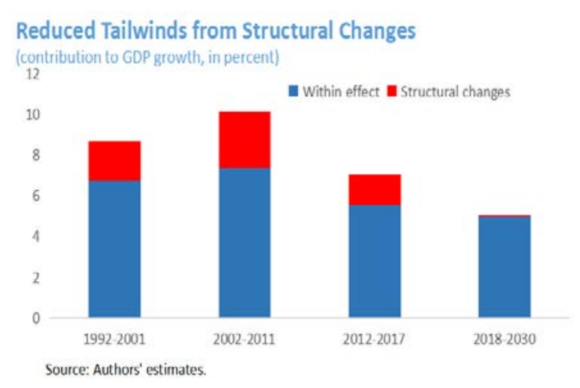
based on 10 industrial sectors and 11 service sectors give similar estimates (see Appendix B for technical details).

The structural shift from industry to services and within-sector upgrading is expected to continue. In terms of economic structure, following the trend evident since 2012, the share of services is expected to rise to 65 percent in value added and 51 percent in employment. The share of industry is expected to fall to 30 percent in value added and 25 percent in employment, and the share of agriculture is expected to fall to 5 percent in value added and 23 percent in employment. Within industries, the share of high-tech sectors is estimated to rise to 50 percent by 2030, while the share of low-tech sectors would fall to 30 percent. For services, the share of non-market services is likely to rise further to nearly 30 percent by 2030, driven by expansion in education and healthcare. Within market services, ICT, finance, and business services are expected to gain importance, while the shares of wholesale and retail, transportation, and hotels are expected to decline over time.



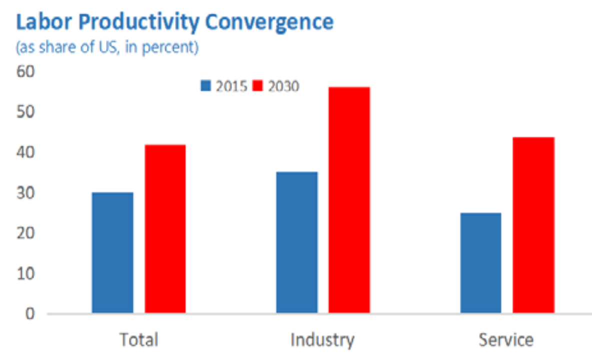


Overall potential growth is projected to moderate to 4 percent by 2030. Based on the projected sectoral shift and productivity growth within each sector, aggregate labor productivity growth is forecast to slow from 6.6 percent in 2018 to 4.2 percent in 2030. Historically, structural shifts from agriculture to industry and services (the "between effect" or structural changes) have been a major driver of overall productivity growth, contributing about 25 percent in the past three decades. Going forward, while more labor will shift out of agriculture, the relocation from industry to services is expected to put downward pressures on productivity growth, with the contribution of the between effect diminishing to zero. Hence, future productivity growth will mostly rely on upgrading within industry and services. In additional, the aging population and shrinking labor force will put downward

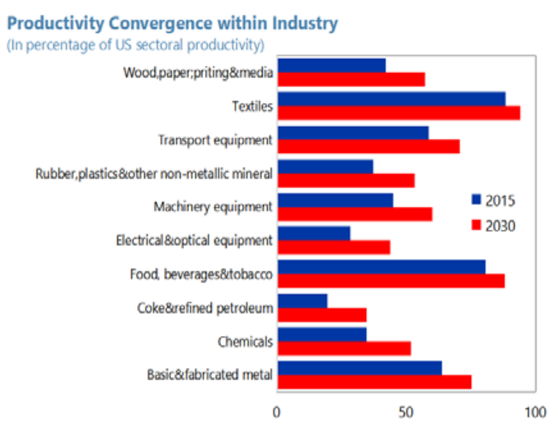


pressure on labor supply, but the impact of this is expected to be only marginal, contributing 0.1 percent to the decline in growth. Overall, this would imply that GDP growth will slow from 6.5 percent currently to around 5 percent in 2025 and to 4-4.2 percent by 2030.

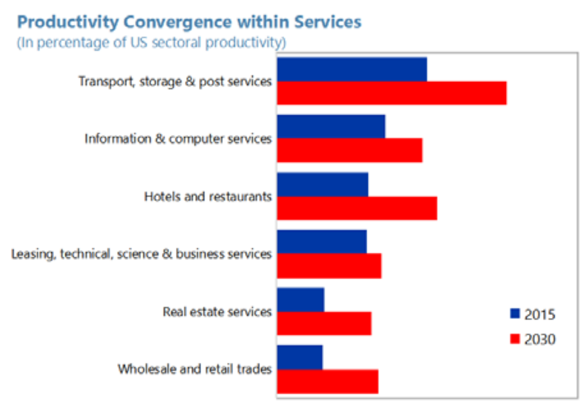
China's productivity is forecast to converge to 45 percent of the U.S. level by 2030. Assuming that productivity at the frontier will continue to grow at a stable rate, by 2030 overall labor productivity in China is likely to reach 45 percent of frontier, from 30 percent in 2015. The industrial sector will lead the convergence, increasing to 56 percent of frontier from 35 percent currently, while in the services sector convergence is expected to reach 44 percent, from 25 percent currently. Within the industrial sector, low-tech sectors such as wood, food and beverages are forecast to converge to around 80 percent of frontier, while mid-tech sectors such as chemicals and optical products would reach about 50 percent of frontier, and high-tech sectors, such as the ICT sector, are projected to reach 40 percent of frontier. Within the services sector, education, health, and transportation would continue to lead the convergence, reaching 65 percent of frontier, while business services, real estate services, and government administration may converge slowly and remain below 30 percent of the U.S. level.



Source: Author's calculation



Source: National Bureau of Statistics; World KLEMS Database.

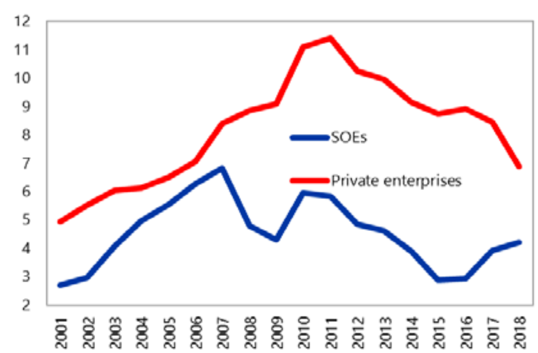


Source: National Bureau of Statistics; World KLEMS Database.

State-owned enterprise reform

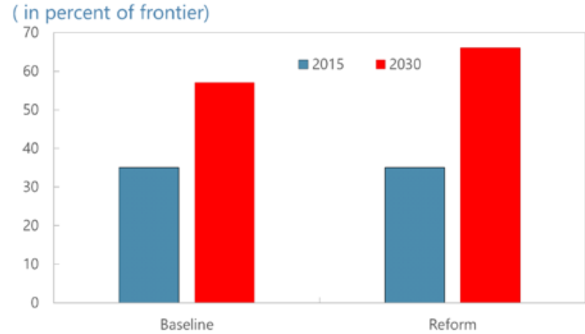
The role of SOEs in China's economy has diminished considerably in the past two decades, in terms of both value-added and employment. Nonetheless, SOEs still account for a large share of total assets. In the industrial sector, SOEs account for 38 percent of total industrial assets, while their return has been persistently below that of private companies. In 2017, the return on assets (ROA) of industrial SOEs was 4 percent, compared with 10 percent for private firms. With their asset size standing at 60 percent of GDP, raising the ROA of industrial SOEs to 6 percent could boost GDP growth by around 1 percentage point. In addition, using firm-level data Lam et al. (2017) show that progress in SOE reforms could raise productivity and GDP growth by 0.7-1.2 percent per year; required policies include more proactive exits of zombie firms and hardening the budget constraints of SOEs to improve credit allocation efficiency. With faster productivity growth, the convergence of the industrial sector would accelerate, reaching 66 percent of frontier by 2030, compared with 56 percent in the baseline.

Return on Assets Lower in SOEs
(in percent)



Source: National Bureau of Statistics and authors' calculation.

Industrial Productivity Convergence: Baseline vs. Reform
(in percent of frontier)

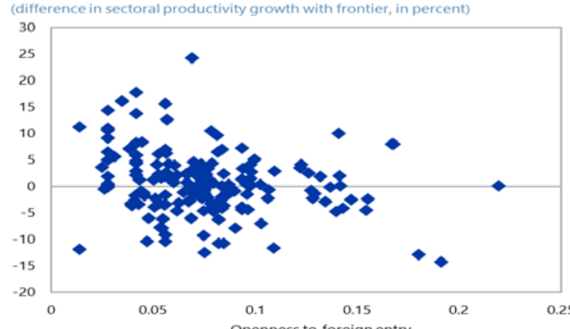


Sources: Authors' estimates.

Opening up

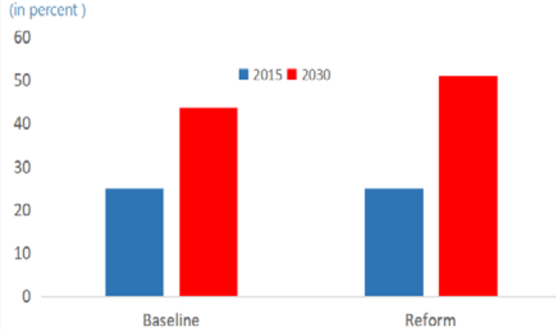
Cross-country experiences suggest that convergence of services productivity is highly correlated with the degree of opening to foreign entry (text chart). In contrast to the industrial sector, which is already highly open following WTO entry, China's services sector is still very restrictive. The OECD indicator suggests that entry barriers are particularly high in business services, where productivity stands at only 17 percent of the frontier level; hence, faster opening up and bringing in foreign expertise could accelerate the convergence process. According to Bourlès et al. (2010), services sector liberalization has significantly boosted productivity growth in OECD countries. Assuming that services sector restrictions in China are lifted to the OECD average by 2030, this will accelerate convergence and improve overall services productivity to 57 percent of frontier,

Productivity Convergence Faster with Services Opening up
(difference in sectoral productivity growth with frontier, in percent)



Sources: OECD Service Trade Restrictiveness Index; OECD statistics.
Note: The sample includes OECD member countries. 0 is least restrictive to foreign entry.

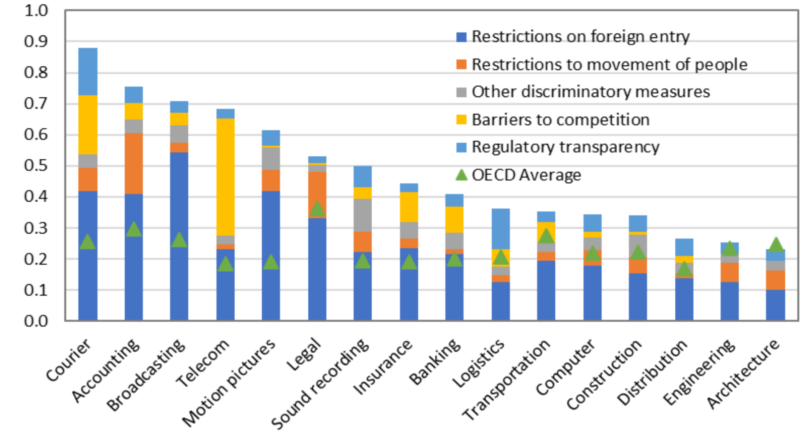
Services Productivity Convergence: Baseline vs. Reform
(in percent)



Source: Authors' estimation

compared with 47 percent in the baseline, boosting annual GDP growth by around 0.5 percentage points.

China Has Further Room to Open up Services Sector
(index between 0 and 1, higher index is more restrictive)



Source: OECD Service Trade Restrictions Index (2018).

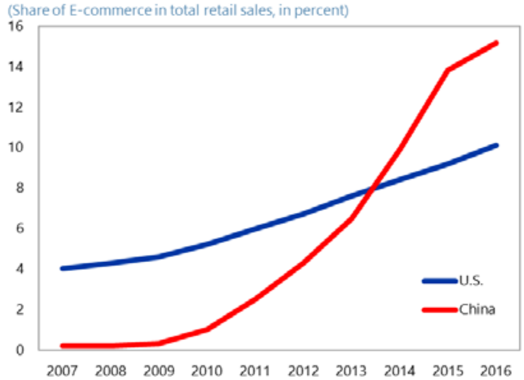
Digitalization

Digitalization has been driving the 'fourth industrialization" and redefining the productivity frontier of many new sectors. While overall digitalization in China still lags that of advanced economies, China has emerged as a global leader in a few digital sectors, such as e-commerce, fintech and artificial intelligence. Integration of digital technologies with the traditional industrial and services sectors has been and will likely continue to be a major driver of productivity enhancement. Measured in broad terms, about 33 percent of China's GDP is digitalized, and the size of the digital economy has been expanding at above 15 percent annually. The baseline has assumed continued high-speed digitalization, while any potential slowdown in digitalization could drag down the forecast growth path. As shown in Chen and Zhang (2018), a 1-percentage-point increase in the overall digitalization of the economy is associated with an increase of 0.3 percentage points in GDP growth, with a two-year lag. A slower pace of digitalization could therefore slow growth by 1-4 percentage points.

The success of China's digitalization so far has been driven by the dynamism of the private sector, and the key to continued success is to promote the healthy development of private companies. In addition, the government could further support digital development by investing in digital infrastructure, implementing an active labor and education policy to prepare for the technological revolution, and strengthening the social safety net to protect laid-off workers during the transition[12].

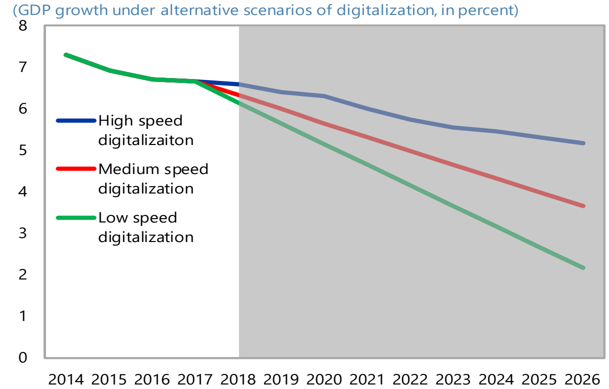
[12] For more detailed discussion of China's digital economy and needed policy response, see Zhang and Sally (2018).

Penetration of E-commerce
(Share of E-commerce in total retail sales, in percent)



Sources: Alibaba.

Digitalization to Buck the Downward Trend
(GDP growth under alternative scenarios of digitalization, in percent)

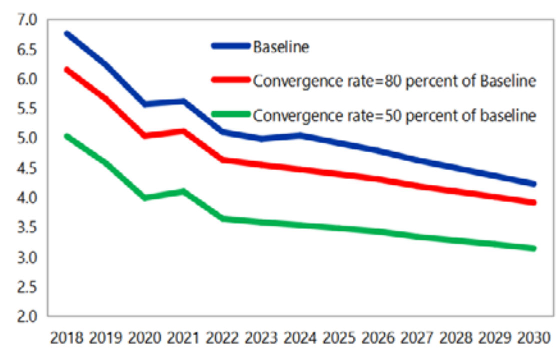


Sources: IMF staff estimates.

Reversal of global trade integration

Trade integration has been an important driver of cross-country productivity convergence via technology transfer and assimilation (Feenstra 1998). The recent escalation of China-U.S. tensions, including tariffs and sanctions on high-tech firms, is likely to hinder further global integration in trade and technology and to weigh on China's (and the world's) growth outlook. As evidenced in Rodrik et al. (2013), the speed of convergence in the period from 1995–2005, before the surge in global trade and value chains occurred, was significantly slower than in the period since then. While it is hard to predict how the global environment will evolve going forward, for illustrative purposes we project growth in two adverse scenarios, one with the convergence speed at 80 percent of the baseline, and the other with the speed at 50 percent. The analysis suggests that potential growth in China would slow to below 4 percent and 3 percent in the two adverse scenarios respectively by 2030, which could drag down the world economy significantly. To avoid such scenarios, it is critical to resolve the trade tensions under a multilateral framework and reform the global trading system to enable it to serve the global economy better.

Slower Convergence with Trade Disintegration
(potential GDP growth rate, in percent)



Source: National Bureau of Statistics; Authors' calculation.

Risks of a financial crisis

As evidenced in the aftermath of the global financial crisis, an abrupt financial adjustment could have a long-lasting negative impact on economic growth. For China, after years of rapid credit expansion, financial vulnerabilities have risen significantly and the risk of a financial crisis has increased (IMF, 2016). Since 2017, the government has launched a deleveraging campaign with regulatory tightening, credit growth has slowed, and interconnectedness between banks and non-bank financial institutions has been reduced.

However, financial vulnerabilities remain elevated, and further efforts are needed to unwind the financial risks that have accumulated and to avoid an abrupt adjustment of the economy.

In sum, reflecting the fact that it is at an early stage of productivity convergence, China's potential growth in the baseline will slow but will remain robust at around 4 percent by 2030, and could be boosted to 5 percent if faster SOE reform and services sector opening up take place. However, there are also headwinds, including a reversal in global trade and technology integration, and the risk of an abrupt financial adjustment, which could drive down 2030 growth to about 3 percent.

VII. Conclusion and policy implications

China has achieved great economic success in the past four decades, with per capita income rising from 5 percent of the U.S. level to 30 percent, and with 800 million people lifted out of poverty. However, past success is not a guarantee of future achievement. Uncertainty about China's long-term potential growth has risen as the economy enters the middle-income level, where many countries have seen their economic convergence stall. Elevated debt levels and a changing growth model from export- and investment-led growth to consumption-driven growth also make future growth less predictable and potentially lower. The uncertainty has been further compounded by the recent escalation of China-U.S. tensions. Against such a background, there has been a heated debate about China's long-term growth potential, both in academia and among policymakers.

This paper reviews existing potential growth estimates for China in the literature and explains how the diverging views have been driven by different methodologies. In particular, cross-country studies are sensitive to the reference group and can provide only a wide range of estimates, with the most bullish estimates reflecting the experience of Asian tigers and the bearish estimates reflecting global averages. To get a better anchor for China's potential growth in the medium term, a supply-side approach that takes account of structural transformation is needed.

We examine in detail the structural transformation in China in the past few decades and the convergence process in 38 industrial sectors and 11 service sectors. The analysis shows that industrial productivity reached 35 percent of frontier in 2015, with significant sectoral variation. Low-tech industrial sectors, such as textiles, are more advanced in catching up, while high-tech industries, and in particular the ICT industry, are lagging, likely reflecting China's less sophisticated position than advanced economies in the global supply chain. Overall services productivity reached 25 percent of frontier in 2015, also with large sectoral variation. In particular, business services, wholesale and retail services, and public administration are lagging, while transportation, ICT and financial services are more advanced.

In terms of structural transformation, there has been continued productivity upgrading within industry and services. But more importantly, since 2012 China has reached a developmental stage at which the transition from high-productivity industry to low-productivity services has started and – based on international experiences – will continue, putting sustained downward pressure on aggregate productivity growth. This is in contrast to the previous four decades, during which labor shifted from the low-productivity agricultural sector to the high-productivity industrial sector, hence providing a structural boost to productivity growth.

Going forward, reflecting its early stage of convergence, we expect China's growth to remain robust as a result of continued upgrading of productivity within industry and services, but to slow gradually to around 4 percent by 2030 as the economy moves closer to the frontier and as the structural shift from high-productivity industry to lower-productivity service sectors continues. A shrinking labor force will also be a drag on growth, albeit only marginally. There are certain reforms in particular that may boost China's potential growth: SOE reforms, services sector opening up, and digitalization.

For the industrial sector, more progress in zombie SOE exits and in hardening the budget constraints of SOEs could raise GDP growth by around 1 percentage point annually and accelerate the rate of convergence, with the latter reaching 65 percent of frontier by 2030. For the services sector, the most pressing issue is tight regulation and entry barriers. Lifting these regulations to the OECD average and bringing in more foreign expertise could lead to substantial productivity gains, bringing convergence to 57 percent of frontier by 2030 and boosting annual growth by 0.4-0.7 percentage points. Boosting the role of digitalization requires minimizing state intervention and promoting the dynamism of the private sector, while further strengthening digital infrastructure and widening the social safety net to protect laid-off workers.

Conversely, the potential global trade and technology disintegration and the risk of a financial crisis in China could have a long-lasting impact on its growth and convergence, with negative spillovers to the rest of the world. It is therefore critical to resolve China-U.S. tensions under a multilateral framework and to continue domestic deleveraging reforms.

In sum, reflecting its early stage of productivity convergence, this analysis suggests that, under the baseline, China's potential GDP might grow at around 4 percent by 2030. The baseline assumes further digitalization based on continuing private innovation and avoiding excessive government intervention. In addition, faster SOE reform could boost annual potential growth by about 1 percentage point, while greater opening in the service sector could increase growth by around 0.5 percentage points. In all, if both reforms are implemented, potential GDP growth could reach up to 5½ percent. Making full use of these reform opportunities is even more important given the headwinds to productivity growth from a possible reversal in global trade and technology integration.

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Appendix A: Data

Data on secondary industry:

Data before 2004 is based on Chen (2010). We extended the dataset to 2015 based on Chen's method and made additional adjustments to ensure data consistency, including adjusting for the industrial classification change in 2011, extrapolating from above-scale to all-scale industrial data, and industrial matching for international comparison.

- **Adjustment for industrial classification changes**

The industrial classification standard changed in 2011, switching from GB/T 4754 1994 to GB/T4754 2011. The differences lie in the following industries: Support Activities for Mining, Manufacture of Rubber and Plastic Products, Manufacture of Transport Equipment, and Repair Service of Metal Products Machinery and Equipment. We have made the following adjustments to make sure the data is comparable.

Support Activities for Mining: Detailed 3-digit fixed capital investment data suggests that investment in Support Activities for Mining is mainly driven by investment in Support Activities for Petroleum and Natural Gas industry, which accounts for more than 90 percent. We have therefore added the variable of interest for Support Activities for Mining back to Extraction of Petroleum and Natural Gas industry.

Manufacture of Rubber and Plastics Products: The NBS has stopped reporting Manufacture of Rubber and Plastics Products separately since 2012, and instead reports the sum of the two industries. We reconstructed the two series by applying historical ratios to the reported sum. For both value added and employment, Manufacture of Rubber accounts for about 32 percent of Manufacture of Rubber and Plastics, and this ratio has been fairly stable in the past.

Manufacture of Transport Equipment: We take the sum of the data for Manufacture of Automobiles and Manufacture of Railway, Ship, Aerospace and Other Transport.

Repair Service of Metal Products Machinery and Equipment: This industry is created after 2011 by consolidating the repair service component of the following manufacturing industries: Manufacture of Metal Products, Manufacture of General Purpose Machinery, Manufacture of Special Purpose Machinery, Manufacture of Transport Equipment, Manufacture of Electrical Machinery and Equipment, Manufacture of Communication Equipment, Computers and Other Electronic Equipment, Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work. We extrapolated repair services for each industry by applying historical shares to the reported consolidated data.

Other Industries: Other Industries is defined as the sum of Mining of Other Ores, Other Manufacture, and Utilization of Waste Resources. Since 2011, Other Manufacture has not included Manufacture of Artwork, which is now classified in Manufacture of Articles for

Culture, Education, Arts and Crafts, Sport and Entertainment Activities. As a result, reported data for Other Manufacture after 2011 is significantly lower than earlier data. However, we lack detailed 3-digit level data for Manufacture of Artwork and so are unable to make any adjustment.

- **Adjustment from above-scale to all-scale:**

After 1998, the NBS reports data for above-scale industrial enterprises only. To obtain a time series that is as long as possible, we adjusted post-1998 above-scale data to all-scale data using 2004, 2008 and 2013 census data. More specifically (take value added, for example), we adjusted as follows:

Step 1: Obtain above-scale gross output $Q_{\text{above}-scale}$ and all-scale gross output $Q_{\text{all}-scale}$ in 2004, 2008 and 2013 respectively.

Step 2: Calculate gross output multiplier $\dfrac{Q_{\text{all}-scale}}{Q_{\text{above}-scale}}$ for the years of 2004, 2008 and 2013.

Step 3: Use linear interpolation method to obtain gross output multiplier for other years, which provides a time series for gross output multiplier from year 2004 to 2015 at 2-digit level.

The same procedure is applied to employment data. The employment data comes from the China Labor Statistical Yearbook, which reports urban unit employment. We use the multiplier from the census to scale it up to employment for all units.

The NBS does not report the level of industry value added since 2008, but reports the year-on-year growth rate since 2006. We calculated the value-added data after 2006 based on the following steps:

Step 1: Obtain the growth rate of real value added after 2006, nominal above-scale value added from 2004 to 2015 and Producer Price Indices for Industrial products from 2004 to 2015 from the NBS website.

Step 2: Take 2007 as base year, calculate nominal industrial value added after 2007 based on the formula $Y_t = \frac{Y_{\text{t-1}}}{P_{\text{t-1}}} \, \mathrm{g}_t \mathrm{P}_t$ in which Y stands for nominal value added, P represents Producer Price Indices, g stands for growth rate of real value added.

Step 3: Check consistency. Since we have both the level and the growth rate of value added for the years 2006 and 2007, we repeated Step 2 for year 2006 and estimated the 2007 level data. We compared the estimated level with the actual data and found the error to be within 5-10 percent. It should be note that the bias may grow over time as we roll over the estimates year by year using value added growth rate.

Step 4: Deflate the estimated nominal value added using Producer Price Indices.

- **Adjustment for international comparison**

We consolidated the 38 industrial sectors reported by the NBS to 11 sectors as reported by KLEMS for international comparison. Detailed matching is listed in Table A1.

Data on services:

Data for service sectors is from the NBS and the KLEMS dataset. The following adjustments were made to the original datasets:

Adjustment to the NBS dataset

- **Nominal value added and employment**. The NBS publishes sectoral nominal value added and employment for different types of firms, including urban unit, urban private and self-employed unit, rural private and self-employed, and township and village enterprises. We first calculated the share of each service sector by aggregating firms of all types, and then applied the shares to the aggregate service nominal value added and employment reported by the NBS under the national account. Note that the NBS changed the classification standard in 2003. Data prior to 2003 were first converted to the new standard, GB/T4754 2003, for consistency.

- **Price index.** The NBS only publishes data for five major service sectors, with the rest being aggregated into "Other sectors". For missing series, we used the relevant consumer price index and wage index as substitutes. To be more specific, for administration and environmental administration we used the wage index; for scientific research and technology development we used the average service price index, since we lacked relevant price information; for others, we use the relevant components of the consumer price index.

- Real value added: Real value added is then computed by dividing revised nominal value added using price index.

For international comparison, we convert 14 service sectors reported by the NBS to 10 industrial sectors and 11 service sectors based on KLEMS classification. See table A2 for detailed sectoral matching. Data on real value added is converted to 2011 international dollars in PPP terms. Data for other countries is from the KLEMS database.

Table A1: Matching between industry codes in KLEMS and NBS

KLEMS industry	NBS industry
Food products, beverages and tobacco	Processing of Food from Agriculture Products
	Manufacture of Foods
	Manufacture of Beverages
	Manufacture of Tobacco
Textiles, wearing apparel, leather and related products	Manufacture of Textile
	Manufacture of Textile, Wearing Apparel and Accessories
	Manufacture of Leather, Fur, Feather and Related Products and Footwear
Wood and paper products; printing and reproduction of recorded media	Processing of Timber
	Manufacture of Furniture
	Manufacture of Paper and Paper Products
	Printing and Reproduction of Recording Media
	Manufacture of Article for Culture, Education, Arts and Crafts, Sport and Entertainment Activities
Coke and refined petroleum products	Processing of Petroleum, Coking and Processing of Nuclear Fuel
Chemicals and chemical products	Manufacture of Chemical Fibers
	Manufacture of Raw Chemical Materials and Chemical Products
	Manufacture of Medicines.
Rubber and plastics products, and other non-metallic mineral products	Manufacture of Non-metallic Mineral Products
	Manufacture of Rubber and Plastics Products
Basic metals and fabricated metal products, except machinery and equipment	Smelting and Pressing of Ferrous Metals
	Smelting and Pressing of Non-ferrous Metals
	Manufacture of Metal Products
	Advertising and Market Research
	Other Professional, Scientific and Technical Activities; Veterinary Activities
	Administrative and Support Service Activities
Electrical and optical equipment	Manufacture of Computers, Communication and Other Electronic Equipment
	Manufacture of Measuring Instruments
Machinery and equipment n.e.c.	Manufacture of Electrical Machinery
	Manufacture of Special Purpose Machinery
	Manufacture of General Purpose Machinery,
Transport equipment	Manufacture of Transport Equipment

Table A2: Matching between services codes in KLEMS and NBS

KLEMS code	**NBS code**
SAL	Wholesale and retail trade
T&S	Transport, storage and post
HOT	Hotel and catering service
P&T	Information transmission, computer service and software
FIN	Financial Intermediation
REA	Real estate
BUS	Leasing and business service
	Scientific research, technical services and geological prospecting
ADM	Public management and social organization
EDU	Education
HEA	Health, social security and social welfare
SER	Management of water, conservancy, environment and public facilities
	Services to households and other services
	Culture, sports and entertainment

Appendix B: Forecast

We forecast potential GDP growth using a supply-side bottom-up approach, combined with a convergence framework at the sectoral level. The bottom-up analysis was conducted both at a three-sector level and a more granular 21-sector level, covering 10 industrial sectors and 11 service sectors.

Baseline forecast

For the baseline scenario, we first forecast labor productivity for each sector, then derive the aggregate productivity based on the projected sectoral shares in the economy. To forecast productivity at sectoral level, we follow the approach used by Bourlès et al. (2010). More specifically, Rodrik (2013) studies industrial sector convergence based on a panel covering 118 countries with the following specification:

$$\hat{y}_{ijt} = \beta \ln y_{ijt} + D_{it} + D_j + \varepsilon_{ijt}$$

in which i stands for industry, j for country and t for year. $\hat{y}_{ijt}$ is the growth rate of labor productivity for sector i and country j at time t. y_{ijt} is the level of labor productivity. D_{it} is the industry-year fixed effect and D_j is the country fixed effect. ε_{ijt} is the error term. β is the estimated convergence rate.

For the service sector, we assume the same convergence rate as estimated for the industrial by Rodrik (2013), that is $\beta^{service} = \beta^{industry} = 0.029$. The forecast growth rate of sectoral labor productivity is given by

$$E(\hat{y}_{it}^{f,china}) = \hat{y}_{it}^{f,frontier} + \beta(\ln y_{it}^{f,china} - \ln y_{it}^{f,frontier}) + (D_{it}^{china} - D_{it}^{frontier})$$

The expected value of labor productivity growth is determined by the distance to the frontier and labor productivity growth in frontier country-sector. f represents forecast. We adjusted country fixed effects to reflect historical forecast errors.

After obtaining sectoral labor productivity, we derive aggregate productivity by applying the forecast sectoral share, which is assumed to follow the same trend as in 2012–2016. Finally, we add the aggregate labor productivity growth rate and the forecast employment growth rate to derive GDP growth.

We apply the above method both at the three-sector level and at the more detailed sectoral level based on KLEMS classification. Historically, there has been a large discrepancy between sectoral data and macro data in China. We made several adjustments to ensure consistency for the forecast period, which are explained in detail later.

Reform scenario

To estimate the effect of services opening up on productivity, we rely on Bourlès et al. (2010), in which TFP growth is conditional on the initial productivity level and economic reform:

$$\hat{y}_{ijt} = \alpha_1 \hat{y}_{it}^{Frontier} + (1-\alpha_0)\ln(\frac{y_{i,t-1}^{Frontier}}{y_{ij,t-1}}) + \alpha_3 REG_{ij,t-1} + \alpha_3 REG_{ij,t-1} * \ln(\frac{y_{i,t-1}^{Frontier}}{y_{ij,t-1}}) + D_i + D_{jt} + \varepsilon_{ijt}$$

where the definitions of $\hat{y}_{ijt}$ and y_{ijt} are the same as in Rodrik (2013). The second term represents the labor productivity gap with the frontier. REG represents sectoral regulation index collected from the OECD product market regulation database. D_{jt} and D_i are country-year and industry fixed effect. Assuming the same country fixed effect but a different industry fixed effect, the forecast labor productivity growth rate is

$$E(\hat{y}_{it}^{f,china}) = \alpha_1 \hat{y}_{it}^{f,frontier} + (1-\alpha_0)(\ln\frac{y_{it-1}^{f,frontier}}{y_{it-1}^{f,china}}) + \alpha_3 REG_{it-1}^{f,china} + \alpha_4 REG_{it-1}^{f,china} * (\ln\frac{y_{it-1}^{f,frontier}}{y_{it-1}^{f,china}})$$
$$+ (D_{jt}^{china} - D_{jt}^{frontier})$$

where the third and fourth terms capture the effect of reform. For the reform scenario, we assume that the regulation index falls to the lowest level in the OECD sample (the lower the index, the less restrictive is the regulation), and the marginal impact of the deregulation is based on the estimated value in Bourlès et al. (2010).

Discrepancy between macro and sectoral data

Historically, there has been a large discrepancy between sectoral data and macro data reported under the national account. The gap between services labor productivity based on macro data and that calculated from 11 subsectors is 14 percent in 2016, with 4 percentage points reflecting the gap in employment data and 10 percentage points reflecting the price index used to deflate nominal value added. The bias is even larger for the industrial sector, because the sectoral value added and employment do not add up to the aggregate figure reported under national account. In addition, for industrial employment, it is possible that our adjustment from above-scale to all-scale employment data may still not be sufficient.

To correct the aggregation bias, we make the following adjustments. We first compute the average aggregation bias in 2011–2015 as the average difference between historical data and in-sample forecast of labor productivity growth from 2011–2015. We assume that the aggregation bias for both industry and services is largest at the beginning of the forecast sample (that is, in 2016) and that it gradually declines to zero by the end of forecast period in 2030. Finally, we add the aggregation bias to the model forecast to obtain the final GDP growth rate.