PRODUCTIVITY IN THE GLOBAL ECONOMY

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Abstract

During the last three decades, the global economy has undergone significant transformation due to a number of dynamics, including the emergence of China and India as major growth contributors, the higher degree of globalization, and the increased penetration of information and communication technology (ICT). These factors have helped the global economy to achieve remarkable labor productivity growth, primarily driven by emerging market economies. However, the pace of global labor productivity growth has slowed drastically since the beginning of the current decade. This paper attempts to understand the proximate sources of global labor productivity growth, and documents that the decline in labor productivity growth is primarily driven by decline in total factor productivity growth. The paper discusses various explanations, including the ones already available in the literature, for the ongoing declines in global productivity, and provides insights on potential strategies that can change the gear towards improving productivity growth. In our projections for the next decade, the importance of productivity in driving growth is gaining significant importance relative to capital deepening.

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1. INTRODUCTION

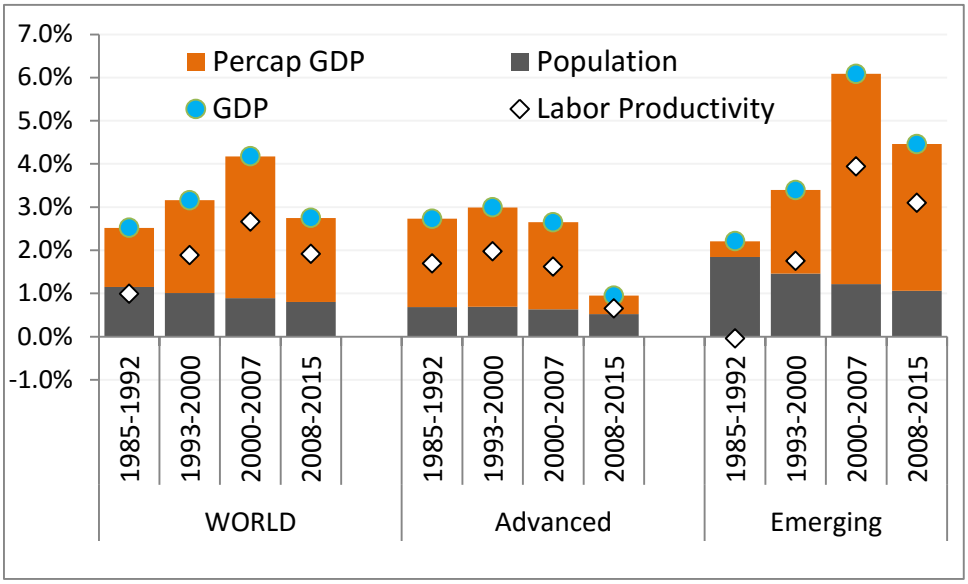
During the last three decades, the global economy has undergone significant transformation due to a number of dynamics, including the emergence of China and India as major growth contributors, the higher degree of globalization, and the increased penetration of information and communication technology (ICT). These developments have helped to greatly improve the well-being of population beyond advanced economies where many of the benefits of post-industrial revolution development process had been concentrated so far. For example, during 1985-1992 period the global economy grew at an average rate of 2.5 percent, with the advanced economies growing faster than the emerging markets (Figure 1). During 1993-2000 period, when the global economy grew at 3.2 percent, the emerging markets overtook the advanced economies. This trend continued during 2000-2007 period with advanced economies seeing a growth of 2.6 percent – more than half a percentage lower than the previous period –, and the emerging markets increasing their growth rate by nearly 2.5 percentage points to 6.1 percent, resulting in a global growth of 4.2 percent.

During the post-financial crisis period from 2008-2015, growth in the global economy has slowed to 2.7 percent, with the emerging markets growing at 4.5 percent and advanced economies by less than 1 percent.[1] This slowdown in global growth is worrying, as it affects the ability of advanced economies to maintain the higher levels of well-being they achieved and the ability of the emerging and developing economies to further improve their income and welfare. Per capita income in the global economy grew at an impressive 3.3 percent during 2000-2007 period, with the emerging markets improving their income levels much faster at nearly 5 percent. The global per capita income growth has declined to 2 percent with both the advanced and the emerging markets seeing notable drop, respectively from 2 percent to a mere 0.4 percent in the advanced economies and from 5 percent to 2.4 percent in the emerging economies (Figure 1).

These declines in GDP and per capita GDP growth rates have been proportionately reflected in slower labor productivity growth. The global labor productivity growth declined from 2.7 percent during 2000-2007 to 1.9 percent during the last 7 years, posing major threats to competitiveness, profitability, wages and living standards.

[1] According to The Conference Board Total Economy Database, almost 80 percent of countries in the global economy had a slower growth rate during the 2008-2015 period compared to the 2000-2007 period.

Figure 1: Growth rates of GDP, population, per capita GDP and labor productivity



Note: All growth rates are expressed in log changes. Population growth and per capita GDP growth adds up to GDP growth
Source: The Conference Board Total Economy Database, November 2016

The objective of this paper is twofold. The first is to identify which proximate sources account for the slowdown in global labor productivity growth. For this purpose, we use The Conference Board's Total Economy Database (TED), which is specifically designed for international comparison of output and productivity, and which provides us with a unique opportunity to apply a growth accounting methodology at a global level. We identify the sources of labor productivity growth in terms of factor accumulation and total factor productivity in about 125 individual countries for the period 1980-2016. Subsequently, the paper discusses various explanations, including the ones already available in the literature, for the ongoing declines in global productivity, and provides insights on potential strategies that can change the gear towards improving productivity growth.

The remainder of the paper is organized in six sections. In section 2 we discuss the importance of looking at productivity, preceded by a discussion on the growth accounting framework to analyse the proximate sources of GDP and labor productivity growth. In section 3, the trends in the global labor productivity and its sources are analysed. We then provide important general explanations for the productivity trend observed in the data in section 4. Section 5 discusses some potential strategies that could help regain productivity growth, and in section 6 we conclude.

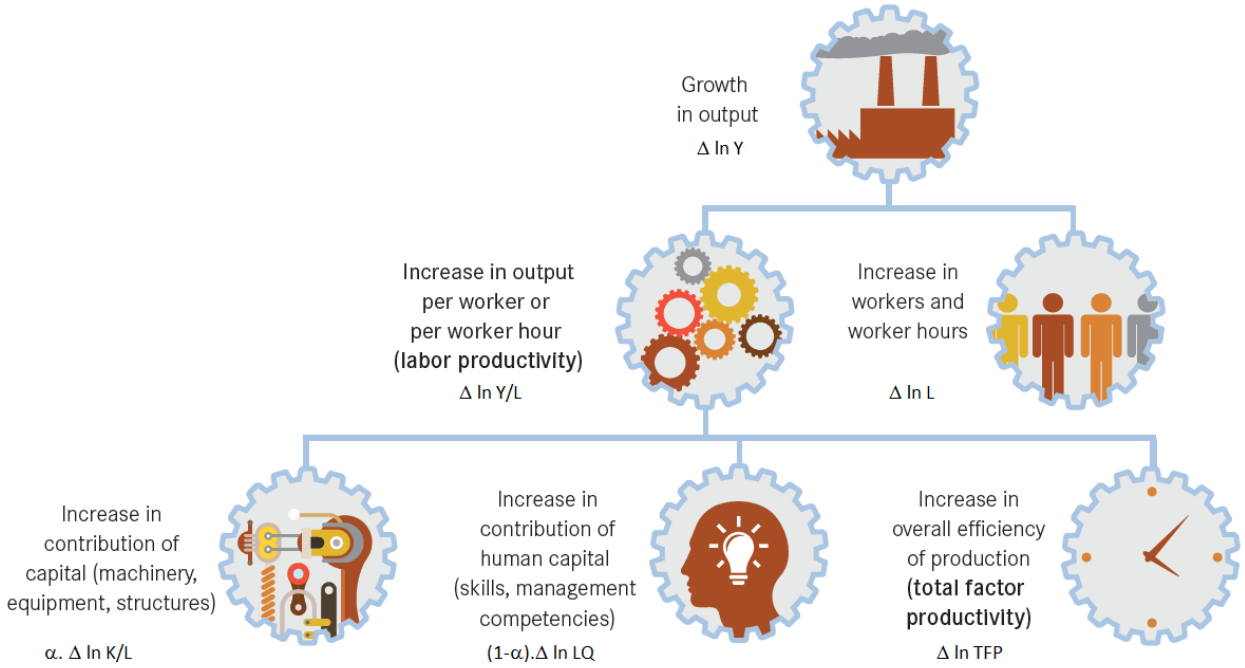
2. UNDERSTANDING PRODUCTIVITY USING GROWTH ACCOUNTING

Figure 1 provides a graphical presentation of how economic growth can be achieved by activating proximate sources of growth.[2] Firms, industries or countries can increase their output either by employing more workers (or increasing working hours) or by increasing the amount of output produced by each worker per working hour, i.e. labor productivity, or both. Increases in labor productivity can be achieved by increasing capital deepening – i.e. by increasing the amount of capital equipment such as machines, computers, trucks etc. with which workers work, by improving the worker skills and competencies (for instance by changing the composition of work force towards higher skill levels), or by improving the overall efficiency by which labor and capital is combined to production process. While the contributions of labor quality and capital deepening to labor productivity growth can be quantified using data on worker skills and investment in capital assets, the contribution of overall efficiency is unobservable. The growth accounting framework allows for quantification of this efficiency change – referred to as total factor productivity growth (TFPG) – as a residual after accounting for contributions from capital accumulation and labor quality. Under strict assumptions of perfect competition and constant returns to scale, this residual – also called the Solow residual following the seminal works of Solow (1957) – measures disembodied technological change. However, when these assumptions are violated – which is often the case in real world – the measure of TFP might also reflect several other things beyond technological change, such as market power, returns to scale, institutional and policy effectiveness, etc.

Regardless of these caveats, aggregate total factor productivity – as measured by Solow residual – has clear welfare implications, as it is directly related to GDP and per capita income: TFPG implies an increase in output per unit of inputs. Since the growth of aggregate output measures a country's consumption potential, subtracting the opportunity cost of factor inputs used to produce the output from it provides a measure of welfare change (Basu and Fernald, 2002). Basu et al (2014) provide a consumer perspective on TFP by measuring it from domestic absorption rather than domestic production, so that the marginal costs are prices faced by consumers rather than producers. They show that this 'household centric Solow residual' is a good representative of welfare, even when it does not measure technical change.

[2] See Maddison (1991) for discussions on the distinction between ultimate and proximate sources of growth. Ultimate sources of growth, which can in fact influence proximate sources, include institutions, historic incidents, and policy changes.

Figure 1: Defining Labor Productivity and Total Factor Productivity under growth accounting framework



Note: the standard growth accounting equation is: $\Delta \boldsymbol{lnY/L} = \propto . \Delta \boldsymbol{lnK/L} + (\mathbf{1} - \propto) . \Delta \boldsymbol{lnLQ} + \Delta \boldsymbol{lnTFP}$, where Y/L is labor productivity (output per workers or worker hour), K/L is capital services per worker, LQ is labor quality and TFP is total factor productivity. **Δln** indicate growth rates (i.e. changes in the log values of each indicator).
Source: van Ark et al (2015)

Viewed from either angle – technological change or welfare –, productivity, in particular aggregate productivity, becomes an important aspect of policy making. Indeed the capital accumulation is essential in fuelling output and labor productivity growth, but the growth achieved through factor accumulation is not sustainable in the longer-run, due to diminishing returns. In this framework TFPG is the only sustainable source of growth, as it ensures improved welfare at no cost from a societal perspective, and improved efficiency, competitiveness and profits from producers' perspective. Past studies indicate the role of TFPG differences across countries in explaining cross-country growth differences (Hall and Jones, 1999; Easterly and Levine, 2001; Caselli, 2004; Jones and Olken, 2008).[3] Basu et al (2014) suggests that TFPG and capital accumulation explains most of the welfare differences across countries. In going forward, the importance of productivity – both from technology perspective and from welfare perspective – will further increase as several countries are likely to see a decline in either absolute number or growth rates of working age population (Levanon et al, 2016).

[3] The importance of capital deepening in driving growth has also been evident in several regional and global studies (World Bank, 1993; Krugman, 1994; Young 1995; Jorgenson and Vu, 2005).

This paper uses the growth accounting framework to examine the sources of labor productivity growth in the global economy and major regions. For this we use the The Conference Board Total Economy Database™, (TED), which provides comprehensive annual data covering GDP, population, employment, hours, labor quality, capital services, labor productivity, and total factor productivity for over 120 countries in the world.[4] Capital input in TED is calculated as capital services, using real investment, depreciation rate, rates of return and asset prices for 6 different asset types – transport equipment, non-ICT machinery, structures, hardware, software and communication. They are finally combined into two main categories, ICT and non-ICT capital.[5] Labor quantity is defined as total employee hours worked. However, when such data is not available, we assume a proportionality between growth rate of employment and hours, and hence we use the growth rate of employment to proxy growth rate of hours. Labor quality is measured using a Tornqvist index of three worker categories – low-skilled, medium-skilled and high-skilled.

In general, the TED is consistent with official GDP data published by national statistical offices. One major exception to this is China, where several earlier studies have observed that the offical data is less reliable. Following earlier works of Angus Maddison and Harry Wu, The Conference Board China Center for Economics and Business have systematically revised and updated the Maddison-Wu alternative estimates of China's GDP growth since 1950 by resolving some earlier empirical and data problems.[6] We use this alternative series for China in all our analysis in this paper. A second adjustment that makes TED differ from the official data is an adjustment for the prices of ICT goods (see Erumban and de Vries, 2016 for more details). Byrne and Corrado (2016) shows that the official price deflators for ICT assets in the United States understates the true declines in ICT prices significantly, leading to a downward bias in the real investment in ICT assets and consequently the real GDP. We correct for this

[4] TED was developed by the Groningen Growth and Development Centre (University of Groningen, The Netherlands) in the early 1990s, and starting in the late 1990s, it was produced in partnership with The Conference Board. As of 2007, the database was transferred from the University of Groningen to The Conference Board, which has maintained and extended the database since then. In January 2010, the database was extended with a module on sources of growth, including labor quantity and quality, capital services (non-ICT and ICT), and total factor productivity. For detailed discussion on the sources and methods used in TED, see https://www.conference-board.org/data/economydatabase/.

[5] The ICT investment was originally developed by Jorgenson and Vu (2005) using data from WITSA (also see Jorgenson and Vu, 2013). The current version of TED has built further upon this data to measure ICT investments more accurately.

[6] The spirit of the Maddison-Wu adjustment is by no means to treat official data as totally devoid of credibility. Rather, it aims to systematically dig out the most useful, least-biased information from all available official sources. We estimate that the over-reporting of the official estimates over the past 10 years is about two-thirds attributable to a "misreport effect," including data fabrications at any level of the data-generating process from localities to the central authorities (often to meet official high targets, at any cost); and the remaining one-third to a "price effect," i.e., an underestimation of price changes (or inflation). See Wu (2014a; 2014b) and The Conference Board (2015) for detailed discussions on the methodology of the alternative estimates, and analysis of the results.

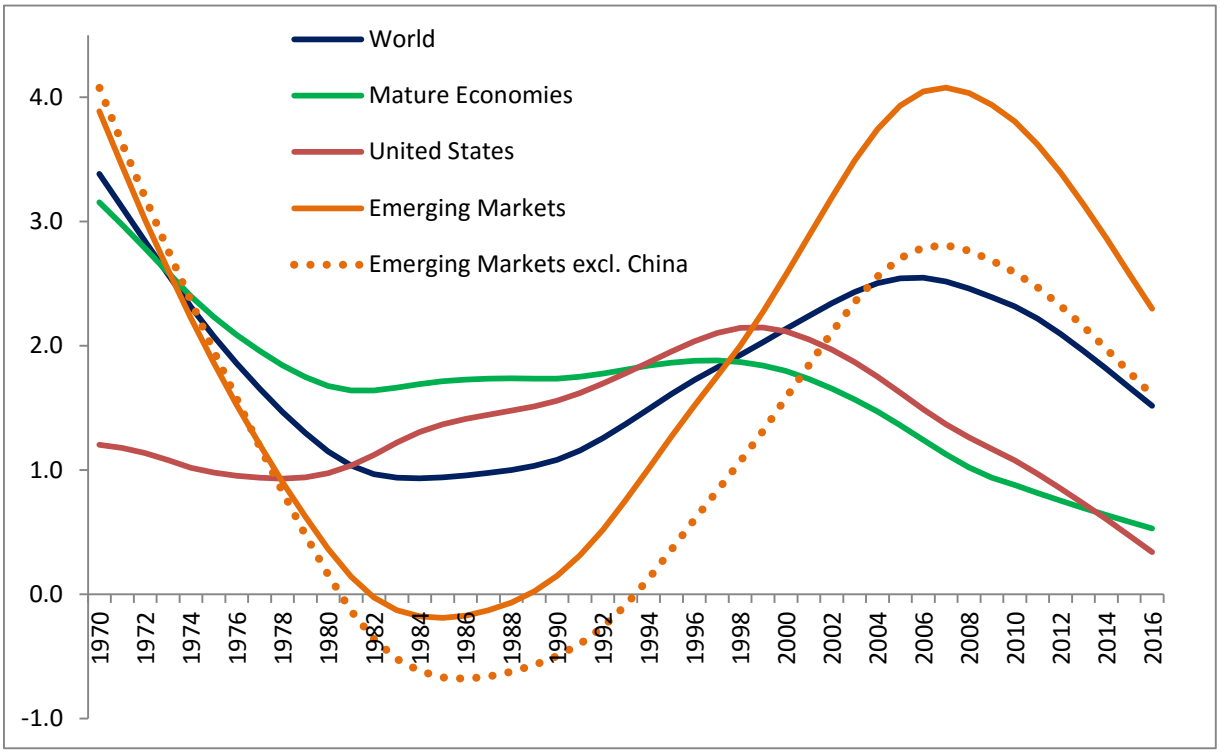
downward bias in investment and GDP by deflating ICT assets by an alternative ICT deflators developed by Byrne and Corrado (2016). Since these deflators are available only for the United States, we use harmonized ICT price deflators for all other countries following the approach suggested by Schreyer (2002). A corresponding correction (i.e. an upward revision) is made to the GDP as well, but only for countries with significant ICT production and exports (Canada, China, Ireland, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and the United States).

3. TRENDS IN AND SOURCES OF THE GLOBAL LABOR PRODUCTIVITY GROWTH

Figure 2 shows the growth trend of labor productivity since 1970 for the emerging markets, the advanced economies, the United States and the global economy. The annual productivity growth series have been smoothed using Hodrick-Prescott (HP) filter.[7] The figure shows that during the period 1985-2007 labor productivity growth increased rapidly in the emerging markets, and moderately in the advanced economies. While China has been an important contributor to this labor productivity surge among the emerging market economies, this was not only due to China. Indeed the emerging market group showed a significant acceleration in productivity growth, even with China being excluded. However, labor productivity growth rates in the advanced economies started falling rapidly since the beginning of this decade. This decline therefore started well before the global financial crisis in 2008/2009, while the decline in emerging markets only started around 2010. This slowing productivity trend has been continuing until today. Just as with the acceleration, a large part of the emerging market decline in productivity is due to substantial slowdown in Chinese labor productivity growth, but the emerging markets group show massive large productivity declines even when China is excluded.

[7] The HP filter helps decompose a time series into trend and cyclical components (see Hodrick and Prescott, 1997). It requires a smoothing parameter λ, the value of which determines the smoothness of the trend line. The larger the value of λ, the smoother the resulting trend will be. For instance, a $\lambda = 0$ would imply the trend is the same as the original series and as λ gets larger, the trend gets closer to a linear OLS regression line. We assume a $\lambda = 100$, which is most commonly used in the literature to smooth annual time series data. A major drawback of HP filter is endpoint bias, but that does not affect our observation that productivity growth has been declining for a longer period of time.

Figure 3: Trend in Labor Productivity Growth, 1970-2016

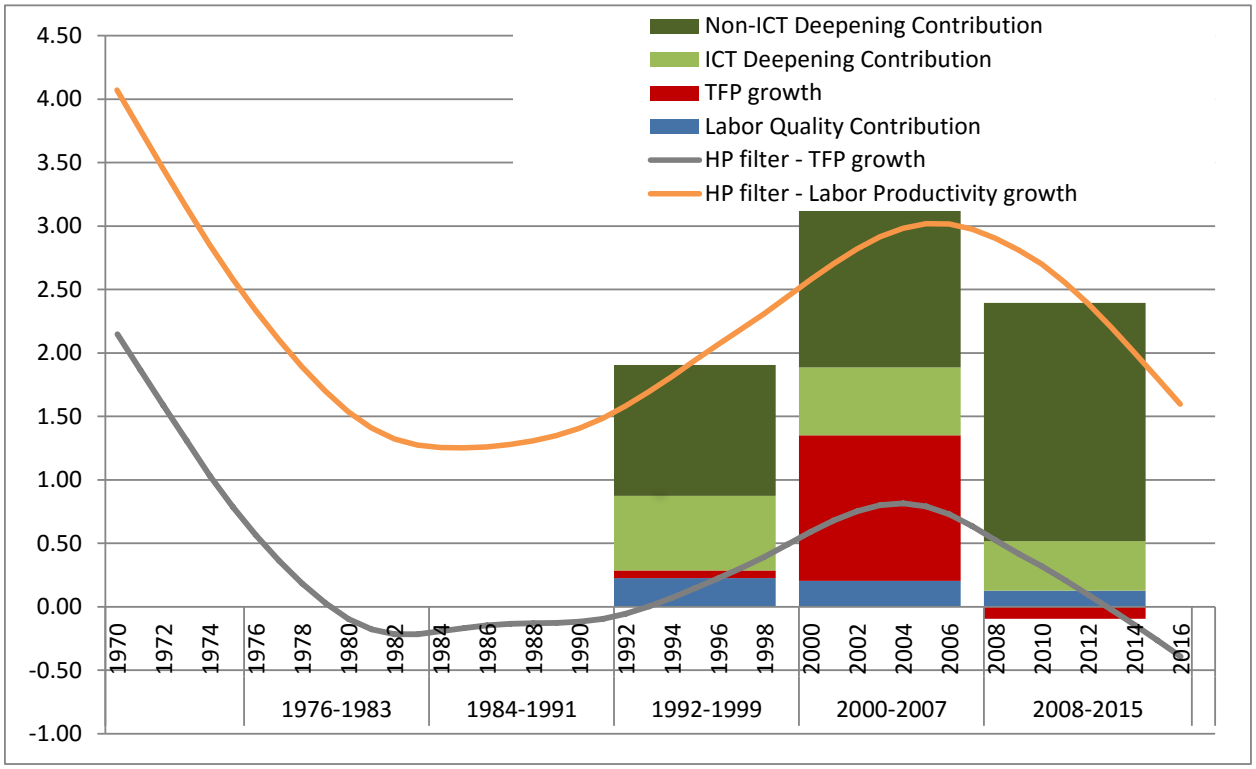


Note: Trend growth rates are obtained using HP filter, assuming a λ=100
Source: The Conference Board Total Economy Database, November 2016

An obvious question is which proximate factors drive these productivity trends we observe. In Figure 4, we replicate the HP filtered labor productivity trend, along with HP filtered TFPG. We also superimpose the contribution of factor deepening and TFPG averaged over 5 time periods since 1992. The figure allows making some important observations on the dynamics of productivity. Firstly, there is a strong correlation between the trend in labor productivity and TFPG. The simple correlation between TFPG and labor productivity growth for the entire period 1970-2015 is 0.90, whereas it is only 0.3 for capital deepening. Indeed factor input (capital and labor) growth is a more constant growth factor than the variety of drivers of total factor productivity. The period 1992-2007 was clearly a period of ICT deepening, and especially during 2000-2007 – a period of significant increase in global trade, and the widespread use of information and communication technology – the global economy witnessed massive TFPG gains. The decline in labor productivity growth since 2007 is primarily driven by decline in TFP growth, as the weakness in demand in mature economies and the more slowdown global trade have been important brakes on TFPG. The global labor productivity growth has declined by almost 1 percentage point, from 3.2 to 2.3 percent, whereas the TFPG has decelerated from 1.1 percent to -0.1 percent (Table 1). Meanwhile the contribution of non-ICT capital deepening has in fact increased from 1.3 percent to 1.9

percent, especially because of investment in emerging markets. The contribution of ICT capital, which is characterized by higher returns, however, has declined marginally from 0.5 percent to 0.4 percent, thus suggesting a lesser impact of technological change on labor productivity. In fact TFPG has weakened much more than labor productivity growth during this period.

Figure 4: Sources of Global Labor Productivity Growth



Note: Trend growth rates are obtained using HP filter, assuming a λ=100. All growth rates are expressed in log changes.
Source: The Conference Board Total Economy Database, November 2016

Table 1: Sources of Labor Productivity Growth, 2000-2007 and 2008-2015

	2000-2007					2008-2015				
		Contributions from:					*Contributions from:*			
	Labor Productivity Growth*	*ICT capital deepening*	*non-ICT capital deepening*	*Labor quality*	*TFPG*	**Labor Productivity Growth***	*ICT capital deepening*	*non-ICT capital deepening*	*Labor quality*	*TFPG*
World**	**3.2**	*0.5*	*1.3*	*0.2*	*1.1*	**2.3**	*0.4*	*1.9*	*0.1*	*-0.1*
Advanced Economies	**2.3**	*0.6*	*1.0*	*0.3*	*0.4*	**1.1**	*0.4*	*0.7*	*0.1*	*-0.2*
United States	**2.5**	*0.7*	*1.2*	*0.3*	*0.3*	**1.2**	*0.4*	*0.6*	*0.1*	*-0.1*
Japan	**2.0**	*0.7*	*0.8*	*0.4*	*0.2*	**0.9**	*0.4*	*0.5*	*0.1*	*-0.1*
Europe	**1.8**	*0.4*	*0.8*	*0.2*	*0.4*	**0.6**	*0.3*	*0.7*	*0.1*	*-0.5*
of which: Euro Area	**1.4**	*0.4*	*0.7*	*0.2*	*0.1*	**0.5**	*0.3*	*0.7*	*0.1*	*-0.6*
Other Advanced Economies	**3.7**	*0.9*	*1.5*	*0.3*	*1.0*	**2.3**	*0.6*	*1.4*	*0.2*	*0.2*
Emerging & Developing Economies**	**4.2**	*0.4*	*1.7*	*0.1*	*2.0*	**3.4**	*0.4*	*3.0*	*0.1*	*0.0*
China	**8.5**	*0.7*	*4.7*	*0.2*	*2.9*	**6.6**	*0.3*	*5.8*	*0.1*	*0.4*
China (official data)	**9.7**	*0.9*	*5.2*	*0.2*	*3.4*	**8.4**	*0.4*	*6.5*	*0.1*	*1.4*
India	**4.0**	*0.8*	*2.8*	*0.1*	*0.3*	**6.5**	*1.3*	*4.2*	*0.1*	*0.9*
Other Developing Asia	**3.4**	*0.4*	*0.8*	*0.2*	*2.0*	**3.2**	*0.3*	*2.0*	*0.2*	*0.7*
Latin America	**1.4**	*0.2*	*0.6*	*0.1*	*0.6*	**0.9**	*0.1*	*1.4*	*0.1*	*-0.8*
Brazil	**1.4**	*0.1*	*0.2*	*0.1*	*1.0*	**1.1**	*0.1*	*1.3*	*0.2*	*-0.5*
Mexico	**1.8**	*0.3*	*1.8*	*0.1*	*-0.4*	**-0.2**	*0.2*	*0.8*	*0.1*	*-1.3*
Other Latin America	**1.2**	*0.1*	*0.2*	*0.2*	*0.8*	**1.3**	*0.2*	*1.8*	*0.1*	*-0.8*
Middle East & North Africa	**1.2**	*0.2*	*0.5*	*0.1*	*0.3*	**0.2**	*0.3*	*1.6*	*0.0*	*-1.7*
Sub-Saharan Africa	**3.4**	*0.2*	*0.5*	*0.1*	*2.7*	**3.1**	*0.3*	*2.0*	*0.1*	*0.8*
Southeast Europe, Russia & Central Asia	**5.5**	*0.3*	*0.2*	*0.0*	*5.0*	**1.1**	*0.2*	*0.7*	*0.0*	*0.2*

Note: All growth rates are expressed in log changes. * Labor productivity is defined as GDP per hour. If hours data is not available, it is measured as GDP per worker. ** World and Emerging & Developing Economies aggregates are with alternative estimates for China, and therefore, will not reflect the official Chinese data.
Source: The Conference Board Total Economy Database, November 2016

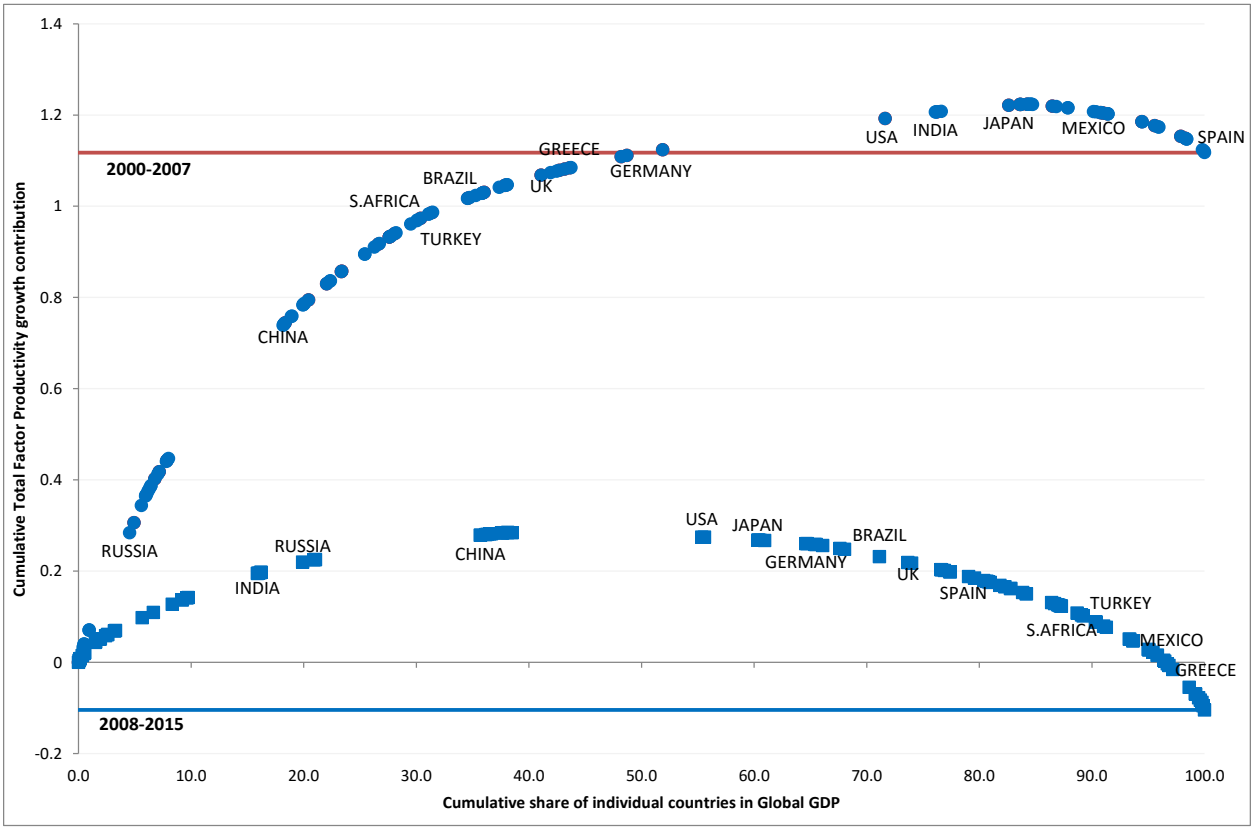
Table 1 further provides the sources of labor productivity growth for 2000-2007 and 2008-2015 periods for major regions and countries of the global economy. The United States and Japan, two technologically leading advanced economies, have witnessed a significant drop in their labor productivity growth rates, from 2.5 percent to 1.2 percent in the U.S. and from 2 percent to 0.9 percent in Japan. In both countries, this decline has been driven by declines in capital deepening – both ICT and non-ICT, though non-ICT decline was much larger – and TFPG. TFPG has entered negative territory in both countries. European countries, especially Euro Area countries also did see substantial losses in TFPG – again moving into negative territory –, bringing their labor productivity growth to less than half of the rate at which they were growing in the pre-2007 period. While the contributions from capital deepening – both ICT and non-ICT – declined marginally or stayed the same, the TFPG decline was substantial, and dominant in driving the labor productivity growth decline in Europe.

The emerging market economies also witnessed huge declines in TFPG, while the factor inputs contributions remained relatively strong. TFPG declined by 2 percentage points to zero, whereas the contribution from ICT capital in these economies remained by and large the same in absolute terms and the non-ICT capital contribution increased by more than 1 percentage points. The only country, among the regions and countries in the table that has registered an improvement in labor productivity growth is India since 2008. India's labor productivity growth increased by almost 2.5 percentage point from 4 percent to 6.5 percent, with most of it coming from capital deepening – both ICT and non-ICT, but also with notable improvement in TFPG. It has been observed that India's aggregate growth is primarily spurred by the services sector, for which TFPG has been crucial in fostering growth (Verma, 2012; Das et al, 2016). Much of the ICT gain in India was also concentrated in the service sector whereas its manufacturing sector did not gain much (Erumban and Das, 2016). China, the other major player in driving global labor productivity growth, experienced a TFPG of nearly 3 percent in the pre-crisis period, which has declined to just 0.4 percent since 2008 while capital deepening in fact increased. This trend remains unchanged even if we use official national accounts data for China, even though the rate of growth is then of course higher. China's economy, which has become increasingly dependent on capital deepening, is now experiencing a "soft fall", as it is moving to a service sector – domestic oriented economy, and witnessing diminishing returns on capital (Hoffman and Polk, 2014). Both capital and TFP contributions declined in other developing Asian economies and in Latin America and Middle East & North Africa regions productivity have declined substantially towards even negative territory.

4. EXPLAINING PRODUCTIVITY SLOWDOWN

The slowing trend in total factor productivity growth since the mid-2000s is quite substantial, long-lasting, and across the board. Figure 5 provides a Harberger diagram which depicts the cumulative share of individual countries in the global GDP on the X axis vis-à-vis the cumulative contribution of these countries into the global TFPG on the Y axis. The upper plot is for 2000-2007 while the lower one is for 2008-2015. The two horizontal lines represent the global TFPG in each period. The decline in the global TFPG from 1.1 percent to -0.1 percent between the two periods was caused by a deceleration in TFPG in more than 60 percent of the countries included in the chart and lower TFPG in 85 percent of countries compared to the previous period. The decline in TFPG is evident across the board, even though exactly when the slowdown began varies by country and region, notably with the declining starting earlier in the advanced economies compared to the emerging markets.

Figure 5: Contribution of individual countries to aggregate the global TFPG: Harberger diagram



Note: Each point represents a country's contribution to aggregate TFP growth (Y axis) against its share in global GDP. All growth rates are expressed in log changes.
Source: The Conference Board Total Economy Database, November 2016

One cannot attribute the slowdown in productivity to any one single factor, but given the fact that the decline has been a global phenomenon, some important general explanations can be made.

The recession effect: Productivity growth – both labor productivity and TFP – is known to be pro-cyclical. During recessions, when output drops productivity growth mostly declines as well because firms hold on to their people and other assets, awaiting the recovery. This was clearly the case in several advanced economies, where productivity declined even when unemployment remained relatively slow in the post-crisis period.[8] Some other countries, for example Spain and the United States, showed a very different picture with massive layoffs during the crisis.[9] Yet their TFPG has declined, on average, in the post-crisis period (see Figure 5). It is undoubtedly true that the financial crisis has played a crucial role in nurturing the ongoing slowdown in the global productivity growth. The loss of output was much larger than the loss of employment and investment, thus suggesting a larger impact of the crisis on TFPG. In addition to the direct impact of the recession on output and productivity, tighter credit conditions in the post-crisis period might have weakened the entry of new firms into the market, limiting increased competitiveness and TFP particularly in the advanced countries.

The secular stagnation hypothesis: A second explanation refers to an even bigger problem than just the pace of technology diffusion and adoption. It relates to an ongoing slowdown in demand and weak investment in physical and human capital as well as other intangible assets. This view sees the advanced economies going into long-term stagnation, exacerbated by slow growth in labor supply and low inflation, which is at the heart of the so-called "secular stagnation" hypothesis reducing firms' incentive to invest in new capital goods that could accelerate productivity (Summers, 2014). Gordon (2016) has referred explicitly to a supply-side version of the stagnation hypothesis. The argument here is that a combination of slow growth in labor supply, together with increased inequality and an unimpressive innovation phase compared to past periods of innovation, account for ongoing slow productivity growth.

The role of the emerging markets: As we observed above, much of the slowdown in the global TFP growth stems from several emerging market economies. To a large extent the productivity slowdown in these economies is a result of their success in previous decades. During the 1990s and early 2000s several large emerging markets benefited from a productivity catch-up; often as the result of major public policy

[8] For instance in countries such as Germany, Japan, and the United Kingdom, unemployment rates remained relatively low since the 2008-2009 global economic and financial crisis but productivity growth weakened.

[9] For instance, at the end of 2007, the U.S. unemployment rate was 5 percent, which increased to 10 percent by end of 2009 (BLS, 2012).

shifts, such as greater access to the global markets, the quick adoption of technologies from the advanced economies, and social and economic reforms that created more domestic demand.

China, for example, generated a huge productivity boost after it became a member of the World Trade Organization in 2001, unleashing its potential to develop into the world's largest manufacturing hub, benefiting from low labor cost and high infrastructure investment. Other emerging markets, including Brazil, Mexico, India, South Africa, and Turkey, also went through period of rapid catch-up growth.

Today, however, emerging markets like China are in the process of transitioning from a dependency on large investment and manufacturing exports as growth drivers to greater domestic consumption of goods and especially services, even if most of those economies are still at middle-income level. As a result, there is a gradual shift underway in these economies from high-productivity manufacturing industries to low-productivity consumer services. For instance, the share of service sector in Chinese GDP has increased from about 25 percent in 1980 to above 40 percent in 2010 (China Industry Productivity Database, 2015). Also, as labor costs begin to rise, workers need to be equipped with new skills and competencies to move their production activities higher up in the value chain. Innovation and new technologies can no longer be simply borrowed from foreign firms. Many of these economies are also currently under severe skill challenges (Levanon et al, 2016). Organizational investments will become much more important as production processes become more complex, and optimizing the mix of labor, capital, and access to shared services becomes harder and requires deeper collaboration with partners in the supply chain. Several emerging economies, including China, India, Brazil, and Mexico, have been struggling recently to make appropriate policy reforms that would ease supply-side bottlenecks and strengthen the performance of markets so that faster productivity growth can be achieved.[10]

Policy and regulatory environment: Several factors that have an impact on productivity are beyond the purview of firms, such as a non-conducive regulatory and policy environment. During the past decade several of those external factors have added to the productivity slowdown. For example, new financial sector reforms in the United States, while necessary to avoid the negative effects from unregulated financial innovations that were some of the important causes of the financial crisis, have stifled the ability of banks to provide ample lending for new investment by firms, especially for small- and medium size enterprises. Access to venture capital and other types of lending for high-risk projects, which are often the source of bringing new technology and innovations to the fore, has become more difficult. In Europe, the failure to complete a single market for goods and services across the member states of the European

[10] For a more detailed analysis of productivity challenges in China, see Hoffman and Polk (2014) and Wu (2014 a). And for analysis on India's productivity trends and challenges see Das et al (2016).

Union has seriously reduced the region's ability to scale economic activity and achieve higher productivity. In particular, new applications in the area of ICT have been hampered by the lack of a single digital market, with fragmented regulations related to several ICT related services. Europe has been lagging behind the United States in terms of ICT adoption for quite a long time now. Regulations to protect privacy and increased cybersecurity, while necessary to sustain the technology, can have sharply negative effects on productivity. Weak policy environments and poor institutional quality have also been major impediments to attain higher productivity growth in several emerging market economies. For instance, rigid labor market policies play an important role in fostering expansion of informal economy in India, which reduces aggregate productivity growth (Das et al, 2016).

***Measurement issues*:** For better understanding of productivity dynamics, it is essential to have well measured inputs (capital and labor) and output. The nature of production and consumption has changed drastically in the recent years – be in is in the form of increased fragmentation of global production and consequent increases in trade in intermediate goods (see Timmer et al, 2014) or increasing role of digital and shared economy and cash-less payments. In an increasingly "weightless" economy, with increasing role of services than manufacturing and increasing role of digital than physical output, conventional macroeconomic statistics such as GDP might not be appropriate for capturing productivity and welfare. While measurement issues are a great challenge for statisticians and academics, one cannot be nihilistic about what the major biases are, and how to correct for them.

In our most recent analysis, we have deviated from official government statistics on investment in information and technology, which are notoriously understating the quality gains and price declines embodied in these new technologies. We make a partial correction for the faster declines in ICT investment prices, by deflating ICT investment by alternative quality adjusted prices developed by Byrne and Corrado (2016). The faster declines in ICT goods and services prices, and the increased role of shared services, should ideally also increase real output – both in terms of increased availability of real output and increased consumer surplus. In our results so far we only made an adjustment to GDP in select countries with relatively larger production and export of ICT goods. This correction, however, does not help eliminate the large declines in productivity growth, observed in this paper.[11]

The pace of technology translating into productivity growth: As is evident from Figure 4, the global decline in productivity growth started earlier than the 2008/2009 crisis and has continued throughout its aftermath. Despite ongoing technological advances in many areas, the speed by which innovation translated into faster productivity growth has been disappointing since around 2005. Technology

[11] The findings of Syverson (2016) and Byrne et al (2016) for the United States also indicate that the productivity decline is a larger problem and is not related to mismeasurement of ICT only.

pessimists hold the view that the boom in ICT during the late 1990s and early 2000s was short-lived and that the current pace of technology has moved back to its natural slow path, as it was before the mid-1990s (Gordon, 2016). For example, since mid-2000s the emerging technologies related to ICT have had less of an impact on productivity than on the value of new devices and applications to consumers.[12] Moreover, the newly available technologies are highly skill-biased, and therefore, the adoption of technology gets delayed due to the mismatch between skill availability and skill requirement.

Optimists argue that the current slowdown is just a timing issue because new technologies need time to diffuse within firms before showing a productivity payoff. In this line of thinking technology use will expand even more rapidly in the coming years even challenging the creation of future jobs (Brynjolfsson and McAfee, 2011). The impact of new digital technologies and applications—including big data analytics, artificial intelligence, and the internet of things—may help strengthen productivity growth, but that has yet to come to fruition. There is substantial evidence that the current phase of innovation in the New Digital Economy represents an installation phase. Firms are undertaking efforts to make changes in their business models, represented by significant organizational disruptions which have not yet translated themselves into a full deployment of technologies which might ultimately accelerate productivity growth (van Ark et al. 2016).

5. THE FUTURE OF GLOBAL PRODUCTIVITY

The observed declining trend in global productivity is indeed alarming, as it may have severe implications for the future progress in global income and welfare. While most of the factors that were driving the productivity surge in the 2000s – e.g. the ICT, the rapid phase of globalization, expansion of global trade following the onset of WTO, significant inflow of FDI to emerging market economies, the catch-up of some of the emerging market economies like China, the de-regulation of financial markets etc. – are unlikely to have similar impact in going forward, the bigger question is what is the future of global productivity. The Conference Board Global Economic Outlook 2017 provide projections of GDP growth for about 65 major economies across 11 regions in the global economy, including 33 mature economies (the United States, Europe, Japan and other mature economies) and 32 emerging and developing economies.[13] The projections cover the period 2017-2026, with separate projections for the medium term (2017-2021) and the long term (2022-2026). To arrive at GDP projections, we use a supply side growth accounting model. The model estimates the factor inputs, which are labor quantity, educational composition of workers, capital services and Total Factor Productivity (TFP). The measures for labor

[12] For instance, Byrne et al (2016) shows that consumer well-being increases more due to several 'new economy' technologies without necessarily shifting the market economy production functions.

[13] See https://www.conference-board.org/data/globaloutlook/. For a discussion on the recent update of the Conference Board Economic Outlook see van Ark (2017).

quantity are based on projections of employment (2017-2020) and labor force participation rates (2021-2026) from the International Labor Organization (ILO, 2015), combined with working-age population projections from the United Nations (UN, 2015). The measures on labor composition are based on projections of educational attainment by the Wittgenstein Centre for Demography and Global Human Capital (2015) and Barro-Lee (2014). Capital services and total factor productivity are estimated using regression models which are largely based on relevant past-period variables (See Erumban and de Vries, 2016). Projections of all input factors and TFP are combined to provide projections of trend GDP growth.In Table 2 we provide the projections of GDP and labor productivity growth rates for the global economy, along with mature and emerging market economies. Note that the projections are based on the 2016 May update of the Total Economy Database. The global economy is projected to grow at 2.8 percent during the next decade, with a labor productivity growth 2.3 percent. Thus almost 80 percent of global GDP growth has to come from labor productivity growth, and, with the potential labor shortage problem, primarily in – but not limited to – mature economies, the importance of productivity is even more, and is likely to constitute above 90 percent of GDP growth. Capital deepening will still play an important role in driving global labor productivity growth, but the importance of total factor productivity (TFP) in driving labor productivity will be pronounced. More than 70 percent of the global labor productivity growth economy is to come from capital deepening, and 1/5th is to come from TFP. This is important given that the TFP was negative in the previous decade. In the mature economies, the importance of TFP is even more, it is expected to contribute 1/3rd of labor productivity growth, and in emerging markets more than 15 percent of labor productivity growth is to come from TFP. In both regions, labor productivity was almost entirely driven by capital accumulation during the last ten years, which is likely to change in the next decade.

Table 2: Projections of GDP and Labor Productivity Growth

	Emerging markets		Mature Economies		World	
	2008-2016	**2017-2026**	**2008-2016**	**2017-2026**	**2008-2016**	**2017-2026**
GDP	4.5	3.5	1.2	1.9	2.9	2.8
Labor Productivity	3.2	2.8	1.0	1.7	2.1	2.3
Capital	3.2	2.2	1.0	1.0	2.2	1.7
Labor Composition	0.3	0.1	0.3	0.2	0.3	0.2
TFPG	-0.4	0.4	-0.3	0.6	-0.4	0.5

*Note: * The historic data is based on 125 countries in Total Economy Database, May 2017*
Source: Source: The Conference Board Total Economy Database (adjusted version), May 2017 and The Conference Board Global Economic Outlook, November 2016

It remains an important question, whether this expected increase in the prominence of TFP over capital accumulation is realistic, and whether the global economy can sustain this projection of GDP

growth with relatively larger contribution from technology. Given the increased risk of labor shortage, and the ageing population, it is quite likely that mature economies in general, and European economies in particular, will be forced to increase the capital intensity of their productivity process, which should be accompanied by increased spending on innovation, and improving both technology and management of production, by investing in innovation and knowledge capital. These are likely to pay off in the form of increased TFP growth. For emerging market economies, where the catch-up potential is eroding rapidly, if they have to sustain their growth, it would be essential to change gear from a low-wage production mode to more innovation-led production mode. This will require more investment in innovation and intangibles, helping them climb the value chain further, and hence implying an increasing role for TFPG.

6. CONCLUDING REMARKS

The pace of the global labor productivity growth has slowed drastically since the beginning of the current decade. This paper has documented that the decline in labor productivity is primarily due to continuous decline in TFPG. A multitude of factors have shown to beimportant in explaining the decline of TFP growth in the global economy.

The question is what is needed to counter the downward trend. This challenge is especially large as the growth of the working-age population is expected to decline (in advanced economies) or at least moderate (in emerging markets) in the coming decade. The direct implication of this demographic change will be a shortage of workers for several jobs in the advanced economies. In several emerging market economies, an acceleration in already existing skill shortage problem may occrr as the competition for skilled workers will intensify. Peri et al (2015) suggests that the role of foreign STEM workers in raising aggregate total factor productivity growth in the United States was pivotal, as they explained 30 to 50 percent of aggregate TFPG between 1990 and 2010. For the advanced economies, increasing participation of female and retired workers, creating and securing workforce skills (such as those of millennial and digital workers), opening up boarders for immigrants, and even off-shoring or teleworking will therefore remain important human capital strategies (Levanon et al, 2016). New approaches to investing in knowledge-based assets (such as research and development, design, training, brand, and organizational improvements), strengthening better management competencies within firms, and embracing reforms in product, labor, and capital markets—will all help firms reallocate labor and capital to more productive uses. Finally, the fruits of the transition towards new digital technologies and applications also critically depend on companies' ability to access digital services, create digital skills, strengthening inter and intra-firm collaboration (van Ark et al., 2016).

For many emerging market economies there is still catch-up potential, as they most are far below the productivity level of advanced economies. For instance, even today China and India, two of the fastes growing economies in Asia during the last decade, are still at 19 percent and 14 percent of the United Stats labor productivity level respectively (The Conference Board Total Economy Database, 2016). The potential for catch-up growth from low levels of development is still available to many smaller emerging and developing markets. Productivity levels of many economies in sub-Saharan Africa, Asia, and Latin America are still well below those of the BRICS (Brazil, Russia, India, China, South Africa) economies, and many of them have large consumer populations and an ample supply of low-wage labor. Policies that enhance structural change, by which resources can be relocated from low productive use to high productive sectors, is an essential aspect of the growth process of several of these emerging market economies. Most emerging markets also need to increase their focus on improving human capital to regain growth and productivity.

Several uncertainties surrounding the global economy – for instance the scale of creative destruction that the new technologies could bring –limits our ability to foresee which direction we are heading towards. Whether the digital revolutions will boost productivity growth sufficiently to offset the slowdown in labor supply due to aging, but also because of the technology bias against jobs is still unclear. The fact that TFPG has weakened much more than labor productivity indicates that the productivity decline is not primarily a matter of inefficient workers. It reflects insufficient and ineffective investment in other inputs that should have helped firms to combine factors efficiently such as knowledge based assets (intangibles, ICT, R&D and competencies). It is also clear that the ultimate sources of growth, which includes institutional and policy changes, are crucial both in the emerging and the advanced economies to fuel their future productivity growth.

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