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Gone with the Headwinds: Global Productivity

Gustavo Adler, Romain Duval, Davide Furceri, Sinem Kiliç Çelik, Ksenia Koloskova, and Marcos Poplawski-Ribeiro

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Gone with the Headwinds: Global Productivity

Prepared by Gustavo Adler, Romain Duval, Davide Furceri, Sinem Kiliç Çelik, Ksenia Koloskova, and Marcos Poplawski-Ribeiro[1]

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CONTENTS

EXECUTIVE SUMMARY 5

INTRODUCTION 6

THE LONG AND SHORT OF SLOWING GLOBAL PRODUCTIVITY 8

DRIVING FORCES 13

A. Legacies of the Global Financial Crisis 14

B. Long-Term Forces 21

REMEDIES 28

A. Short-Term Remedies 28

B. Longer-Term Remedies 30

FINAL REMARKS 33

Figures

1. Trend Output and Post-Global Financial Crisis Total Factor Productivity Losses 9
2. Total Factor Productivity Growth, 1990–2016 10
3. Cyclically Adjusted Total Factor Productivity Growth, 1990–2014 10
4. A Long-Term View of Total Factor Productivity Growth, 1950–2014 12
5. Mechanisms of Aggregate Total Factor Productivity Growth 13
6. Lasting Effects of Deep Recessions on Total Factor Productivity 15
7. Total Factor Productivity Level Path for Firms with Different Precrisis Balance Sheet Vulnerabilities 16
8. Estimated Impact of Balance Sheet Vulnerabilities and Credit Conditions on Postcrisis Total Factor Productivity Growth and Intangible Investment 17
9. Rising Capital Misallocation in Advanced Economies 18
10. Investment and Its Impact on Capital-Embodied Technological Innovation 19
11. Policy-Related Economic Uncertainty and Estimated Impact on Total Factor Productivity Growth 21
12. Total Factor Productivity Growth in ICT- and Non-ICT-Intensive Sectors in Advanced Economies 22
13. Spillovers from a One Percent U.S. Total Factor Productivity Shock 23
14. Population Aging and Its Impact on Total Factor Productivity 24
15. Contribution of Human Capital to Labor Productivity Growth 26
16. Fading Structural Reform Efforts in Emerging and Developing Economies 27
17. Structural Transformation, 1990–2011 28
18. Stock of Public Capital and Productivity Effect of Infrastructure Spending 29

19. Projected Working-Age Population and Productivity Gains from Immigration_____31
20. Effect of Product and Labor Market Reforms _____33

Boxes

1. Can Mismeasurement of the Digital Economy Explain the U.S. Productivity Slowdown?____ 11
2. Productivity Growth in Commodity-Exporting Countries_____ 20

References_____35

EXECUTIVE SUMMARY

Productivity growth—the key long-term driver of living standards—fell sharply following the global financial crisis, adding to structural headwinds already blowing before the crisis, and has remained sluggish ever since. This note explores the role of crisis legacies and these headwinds in slowing that growth, building on new research using country, industry, and firm-level data. The main findings include the following:

- The drop in total factor productivity (TFP) growth following the global financial crisis has been widespread and persistent across advanced, emerging, and low-income countries. And that decline—alongside weak investment in the case of advanced economies—has been the main contributor to output losses relative to precrisis trends. It cannot be ruled out that growing measurement issues might have played some role, but the bulk of the productivity slowdown appears to be genuine. For advanced and low-income countries, the sharp deceleration in TFP occurred on the back of a precrisis slowdown, while in emerging market economies, it meant a break in a precrisis acceleration.

- As in previous deep recessions, the aftermath of the global financial crisis in advanced economies has displayed "TFP hysteresis"—persistent TFP loss from a large and seemingly temporary shock. Three interrelated factors appear to be behind this pattern: *First*, in contrast to past recessions, weak corporate balance sheets, combined with tight credit conditions, have undermined TFP growth, partly by constraining investment in intangible assets in distressed firms. In a number of advanced economies, the boom-bust financial cycle and its corollary of weak corporates and banks has also increased misallocation of capital within and across sectors. *Second*, an adverse feedback loop of weak aggregate demand, investment, and capital-embodied technological change seems to have afflicted the advanced economies. *Third*, elevated economic and policy uncertainty may have further weakened TFP growth, partly by tilting investment away from higher-risk, higher-return projects. These crisis legacies are gradually waning, but they remain a significant drag on productivity growth, especially in continental Europe.

- Crisis-related factors added to important structural headwinds that have been dragging down global TFP growth since before the crisis, particularly including a waning information and communication technology (ICT) boom in the most advanced economies and its spillovers to other economies; an aging workforce, especially in advanced economies; slower human capital accumulation; and slowing global trade integration—including the maturing of China's integration into world trade. In emerging and developing economies, although driving forces have been less clear and the potential for TFP catch-up remains strong, the fading effects of earlier structural reforms and structural transformation seem to have played some role.

- Addressing crisis legacies may be the most promising avenue for boosting productivity growth in the near term, particularly in continental Europe, where the scars from the global financial crisis remain greater than in most other advanced economies. Stimulating demand, including by addressing remaining weak corporate and bank balance sheets, reducing policy uncertainty, and boosting investment on high-return infrastructure projects, would induce greater private investment and risk-taking and improve capital allocation. This could turn around the feedback

loop between investment and TFP, helping lift most advanced economies out of their current low-growth trap.

- Over the medium term, productivity prospects are highly uncertain. A revival driven by artificial intelligence and other breakthroughs is conceivable, although its magnitude and timing are difficult to predict. Until then, and even if crisis legacies are addressed, productivity growth is unlikely to return to the higher rates of the late 1990s (for advanced economies) or the mid-2000s (for emerging and developing economies) given the structural headwinds. Policymakers should proactively address the effect of headwinds, including by advancing structural reforms and nurturing open trade and migration policies, which have delivered sizeable TFP gains in past decades. In doing so, they should ensure gains are widely shared across and within countries. Attention should also be given to strengthening innovation, education, and training policies.

INTRODUCTION

1. Context. Productivity plays a key role in driving living standards. This is particularly true over the long term, and especially so of total factor productivity, a measure of an economy's overall efficiency in the use of its capital and labor. Greater efficiency helps create more of existing goods, but also frees up resources that can be devoted to producing other, new goods and services, thus replacing jobs and creating new ones. This was the case, for example, in past industrial revolutions. After decades of healthy gains in efficiency, however, productivity growth fell sharply in the aftermath of the global financial crisis and has remained subdued since then, most strikingly in advanced economies, but also in emerging and developing economies. This decline has been associated with subpar global economic growth and record-low real long-term interest rates. If sustained, low productivity growth would have profound adverse implications for progress in global living standards, the sustainability of private and public debts, social protection systems, and the ability of macroeconomic policies to respond to future shocks. It is therefore paramount to understand the root causes of the productivity slowdown and address market failures and policy distortions that may have played a role.

2. Technological innovation and diffusion. Much attention in academic and policy debates has naturally focused on whether innovation and technological diffusion have slowed. After boosting aggregate productivity growth in the United States and some other advanced economies in the late 1990s and early 2000s, the gains from the production and use of information and communication technologies (ICT) appear to have waned (Fernald 2015). The debate is heated as to whether this slowdown in innovation is permanent (Gordon 2016) or temporary, as major advances in artificial intelligence and other breakthrough technologies offer the prospect of a productivity revival (Brynjolfsson and McAfee 2014). Such advances, however, may take time to spread throughout the economy, as did major inventions of the past, such as the electric dynamo during the second industrial revolution of the late 19th and early 20th centuries (David 1990). Other recent research highlights instead the role of slowing technological diffusion, pointing out the growing productivity gap between leading and lagging firms across many advanced economies and industries, and declining business dynamism, since the early 2000s (Andrews, Criscuolo, and Gal 2015; Decker and others 2016; Haltiwanger 2011; Haltiwanger, Hathaway and Miranda, 2014; OECD 2015).

3. Structural headwinds. Various policy and non-policy barriers to innovation and diffusion in advanced economies have been put forward as possible culprits. These include, among other things, changes in product market structure (such as the growing importance of specific knowledge-based capital and winner-takes-all dynamics) or mismatches and deficiencies in skills (Adalet McGowan and Andrews 2015a,b; Bloom, Sadun, and Van Reenen 2016). They also include insufficient labor and product market reforms (Cette, Fernald, and Mojon 2016) in the context of disruptive ICT-related technological change, and reduced fluidity in labor markets (Davis and Haltiwanger 2014; Molloy and others 2016). Other structural headwinds may have dragged on productivity growth by slowing innovation or technological adoption. These include adverse spillovers from a slowdown at the technological frontier across several industries (Dabla-Norris and others 2015), demographic factors such as aging populations (Feyrer 2007 and 2008; Maestas, Mullen, and Powell 2016), and slowing global trade integration (IMF 2016a). Slower economic transformation and structural reforms may be adding to these trends in emerging and developing economies.

4. The legacies of the global financial crisis. However, the abruptness, magnitude, and persistence of the slowing of productivity after the crisis cautions against blaming low productivity growth solely on slow-moving noncyclical forces. Despite extraordinary policy stimulus, aggregate demand has been weak since the global financial crisis and a key driving force behind sluggish investment (IMF 2015a). Likewise, to varying degrees across advanced countries, elevated economic and policy uncertainty, pockets of weak corporate balance sheets, as well as tight access to credit amid legacy assets and capital shortfalls in the banking sector, have characterized the environment since the crisis. Economic theory and evidence suggest that such conditions can bias business investment toward more liquid, low-risk/low-return projects (Aghion and others 2012; Baker, Bloom, and Davis 2016; Bloom and others 2014). In turn, these forces might have slowed technological progress—which is often embodied in new capital goods or results from risky investments (Greenwood, Hercowitz, and Krusell 1997; Solow 1959; Wolff 1991)—and led to an adverse feedback loop between weak and low-risk investment, TFP, and potential growth.

5. Key questions and roadmap. This note builds on new cross-country aggregate, sector- and firm-level research to shed light on the extent and nature of the productivity slowdown and assess the respective roles not only of secular headwinds, but also, importantly, crisis legacies. As such it complements previous IMF work (Dabla-Norris and others 2013a and 2015) that identified and underlined the need for policy reforms to lift productivity growth in advanced economies and emerging and developing economies. Specifically, this note addresses four groups of questions:

- **Timing, extent and nature of the productivity slowdown.** Has it taken place mostly before or after the global financial crisis? How widespread has it been? And is it primarily structural or cyclical?

- **Legacies of the global financial crisis.** Has the global financial crisis left permanent productivity scars? If so, what are these legacy issues? In particular, what are the roles of weak aggregate demand, weak corporate and bank balance sheets, and elevated policy uncertainty?

- **Structural factors.** What longer-term forces have been driving the global productivity slowdown? In particular, what have been the roles of the pace of innovation at the technological frontier—notably in ICT—and various factors that may have slowed innovation and adoption of new technologies, such as population aging, slowing growth of global trade, or a diminishing rate of human capital accumulation?

Are trends in emerging and developing economies related to other secular forces, like economic transformation and the pace of structural reforms?

- **Policies to revive TFP growth.** What are the possible remedies to the productivity slowdown? In particular, what immediate policy actions are needed to address global financial crisis legacies, and what policies should be implemented to tackle the structural headwinds?

6. In the remainder of the note, section II presents stylized facts documenting the extent and magnitude of the slowdown in productivity and section III analyzes its causes, assessing the role of both crisis legacies and secular forces. Section IV discusses possible remedies to the identified impediments to productivity growth. Section V concludes.

THE LONG AND SHORT OF SLOWING GLOBAL PRODUCTIVITY

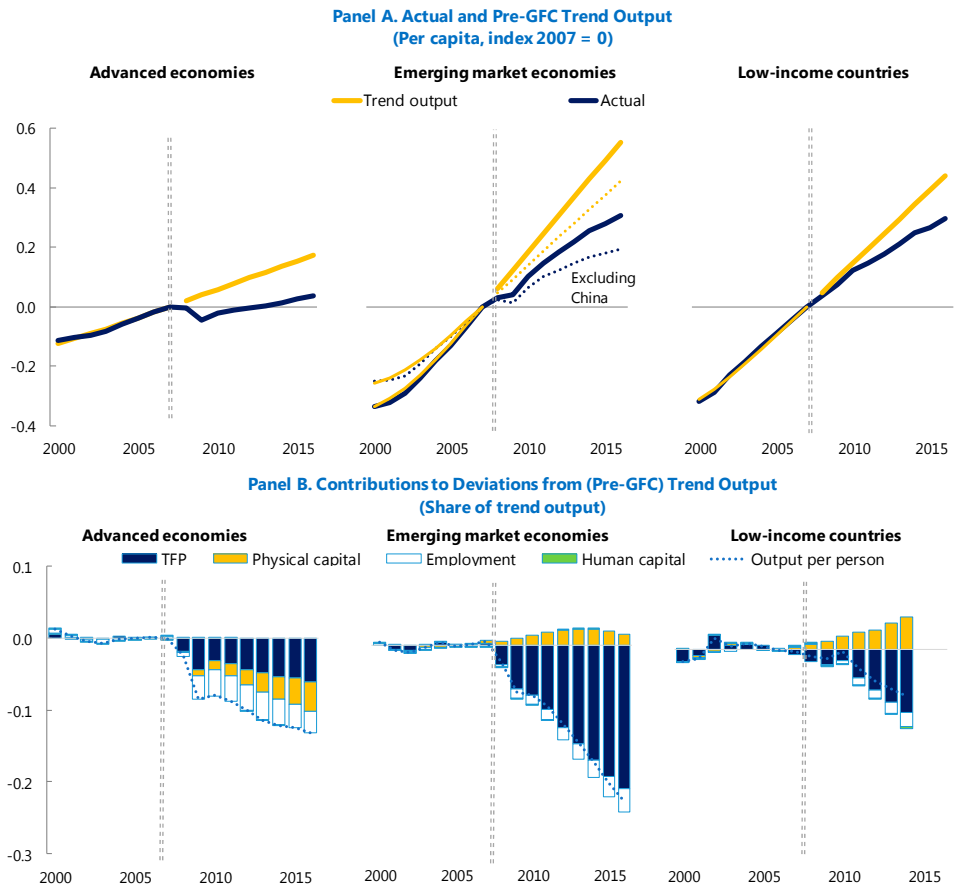
7. Stagnant growth and the role of TFP. Growth has been largely stagnant in the advanced economies, emerging market economies, and lower-income countries since the global financial crisis, with significantly slower growth than precrisis trends (Figure 1).[2] A supply-side decomposition of the drivers of potential output indicates that a marked deceleration in TFP growth contributed on average about 40 percent of the output loss in advanced economies. This reflected not only the immediate impact of the crisis, but also persistent effects—TFP growth in recent years remained below precrisis levels for three-quarters of advanced economies.[3] In emerging market economies and low-income countries, slower TFP growth represented an even greater share of output losses, although largely reflecting the rapid and possibly unsustainable speed of technological catch-up in the years immediately preceding the global financial crisis.[4] Idiosyncratic country circumstances played a role in some large emerging market economies (such as Brazil, China, and Russia), but the productivity slowdown is a broader phenomenon, encompassing most countries within this income group. The experience of low-income countries has been more heterogeneous, likely reflecting a greater importance of idiosyncratic factors at play. As such, the note focuses mostly on developments in advanced and emerging market economies.

[2] See also Blanchard, Cerutti, and Summers (2015).

[3] A noticeable exception is the United States, where TFP growth recovered more rapidly toward its precrisis pace, in part because of already low TFP growth in the years immediately preceding the global financial crisis. Nonetheless, cumulative TFP losses have been significant in the United States, with levels remaining below the precrisis trend.

[4] Unlike in the advanced economies, capital formation in the emerging market economies continued supporting output growth immediately following the global financial crisis, reflecting record-low global interest rates, a recovery of commodity prices, and a public investment boost—all of which gradually weakened. See IMF (2015a and 2015c).

Figure 1. Trend Output and Post-Global Financial Crisis Total Factor Productivity Losses
(Per capita)



Sources: Penn World Table 9.0; IMF, *World Economic Outlook*; and IMF staff calculations.
Note: GFC = global financial crisis, TFP = total factor productivity. Purchasing power parity GDP weighted average of largest 20 economies per income group is reported. Trend output refers to a projection based on the Hodrick–Prescott filter trend in the years preceding the GFC.

8. Secular forces. Consistent with previous findings for the United States—such as in Fernald (2014) and Furceri Celik, and Schnucker (2016)—measured TFP growth points to an incipient productivity slowdown in advanced economies before the global financial crisis (Figure 2). This fact has elicited discussion about possible mismeasurement issues, especially related to the increasing importance of ICT-related services and products, as they may not be properly accounted for in national accounts statistics. This remains a lively debate, but the evidence so far indicates that, while mismeasurement exists—including because TFP is measured as a residual after all—it is unclear whether it has worsened. It is therefore unlikely to account for the magnitude of the observed slowdown in TFP growth, especially its abrupt drop after the financial crisis (Box 1).[5] Similarly, while cyclical factors that cannot be fully adjusted for may affect measured TFP—such as capacity utilization and labor hoarding—different adjustment approaches all point to a slowdown (Figure 3).[6] Yet, the observed pattern of the slowdown in emerging market economies is quite different from advanced economies, with TFP growth in the former peaking in the years immediately preceding the global financial crisis, followed by sharp deceleration afterwards, albeit at pace still faster

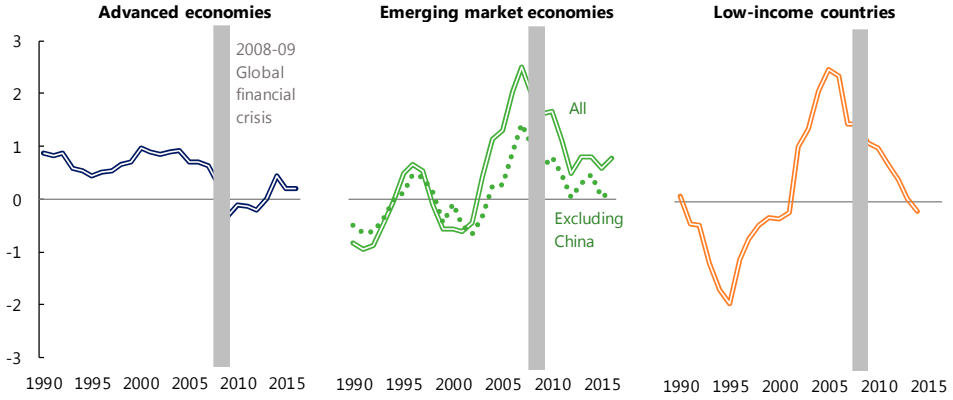
[5] See also Byrne, Fernald and Reinsdorf (2016) and Syverson (2016).

[6] See further discussion of TFP measurement issues in Feenstra Inklaar, and Timmer (2015) and O'Mahony and Timmer (2009).

than in previous decades. In the low-income countries, after picking up during the late 1990s and early 2000s, TFP growth has also fallen sharply since the global financial crisis. That said, these patterns in the emerging market economies and, especially, the low-income countries should be interpreted with caution given data limitations and greater difficulty in properly adjusting for cyclical factors.

Figure 2. Total Factor Productivity Growth, 1990–2016

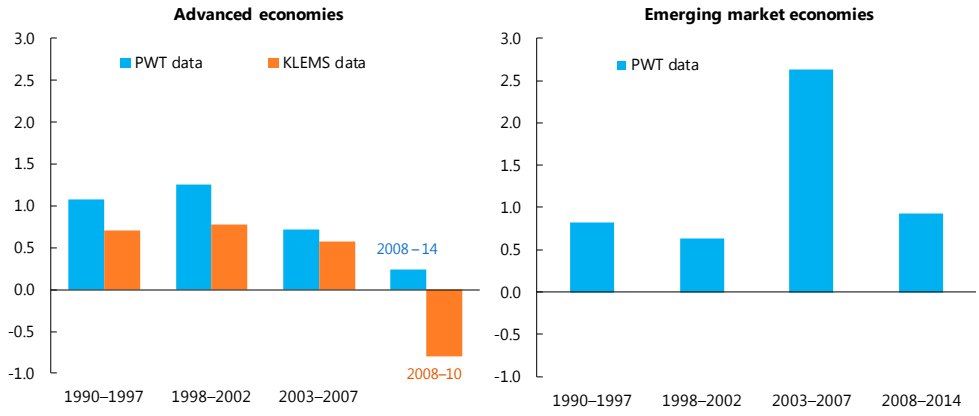
(5-year average growth rate, percent)



Sources: Penn World Table 9.0; IMF, *World Economic Outlook*; and IMF staff calculations.
Note: Group averages are weighted using purchasing power parity GDP.

Figure 3. Cyclically Adjusted Total Factor Productivity Growth, 1990–2014

(Annual average, percent)



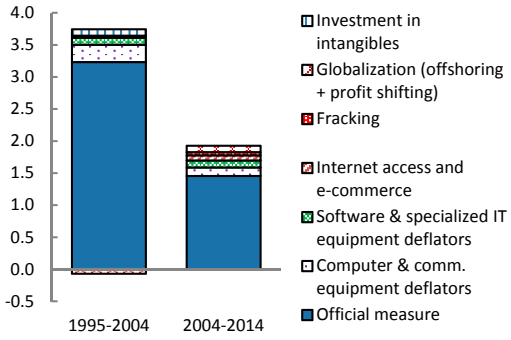
Sources: Penn World Table 9.0; EU KLEMS and WORLD KLEMS data; Furceri, Çelik, and Schnucker (2016); and IMF staff calculations.
Note: Purchasing power parity GDP weighted average by group, based on IMF, *World Economic Outlook* country classification. Cyclically adjusted measure based on Basu, Fernald, and Kimball (2006). Average hours worked used as a proxy for capacity utilization. Post-global financial crisis data on total factor productivity from KLEMS is available only for 2008–10.

Box 1. Can Mismeasurement of the Digital Economy Explain the U.S. Productivity Slowdown?[1]

Productivity growth has slowed sharply in most advanced economies. Because the pace of innovation in the hard-to-measure digital economy seems as rapid as ever, measurement error has been put forward as an explanation. The presence of effects causing underestimation of GDP growth is not in doubt, but a stable measurement error in the GDP growth rate would not cause productivity growth to slow. The question, therefore, is whether measurement error got larger around the time the estimated rate of productivity growth slowed.

Byrne, Fernald, and Reinsdorf (2016) find that the measurement error in the deflators for computers and communication equipment is, indeed, larger after the information and communications technology (ICT) boom period (2004–14) than in the boom years (1995–2004). However, the weight on those deflators in U.S. GDP growth calculations is smaller because production of ICT equipment moved offshore. Including the measurement error in the software deflator implied by Byrne and Corrado (2016), adjustment for measurement errors in ICT equipment and software prices adds 24 basis points to average annual labor productivity growth in the United States over 2004–14, compared to 38 basis points in the ICT boom years (Figure 1.1).

Figure 1.1. U.S. Productivity Growth: Official and Adjusted Measures
(Annual average, percent)



Sources: Byrne, Fernald, and Reinsdorf (2016); IMF staff calculations.

Other forms of mismeasurement affect the estimation of productivity growth. As Figure 1.1 shows, Byrne, Fernald, and Reinsdorf (2016) estimate upward adjustments to U.S. labor productivity growth that are larger in 2004–14 for improvements in internet access and outlet substitution bias from e-commerce, as well as for new fracking technology. Also, in 1995–2004, they estimate an upward adjustment for unmeasured investment in intangible assets and a downward adjustment for unmeasured declines in input prices from offshoring to China and other emerging market economies, as documented in Houseman, Kurz, Lengermann and Mandel (2011) and Reinsdorf and Yuskavage (2016). Together, these bring the total adjustment to labor productivity growth in the post-ICT boom to 37 basis points, compared with 41 basis points during the ICT boom years. In other words, measurement error stemming from these various factors does not appear to have increased.

Byrne, Fernald, and Reinsdorf 2016 also find no increase in the measurement error for total factor productivity when its growth rate slowed.

Another likely source of underestimation of U.S. output that appears to be larger in the post-ICT boom period is the reporting of income in low-tax jurisdictions that really comes from U.S. activity. Multinational enterprises use techniques such as re-domiciling intellectual property assets to shift the location where income is reported and lower their tax bill. Rassier (2014) finds that profit shifting could have caused underestimation of nominal U.S. GDP levels of 0.9 percent in 2005–09. If the annual growth of the underestimation is an order of magnitude smaller than its level, the productivity growth rate effect is around 10 basis points per year during 2004–14, with a smaller effect in earlier years. In addition, increasing the weights on the deflators for ICT equipment to include the production wrongly attributed to other economies might add a few basis points to the adjustment to U.S. productivity growth in 2004–14.

Internet platforms and smartphone apps have also been suggested as sources of measurement error. One concern is the exclusion from GDP of the value to consumers of the free information, social networking, and entertainment that is funded by revenue from advertising and selling information about the users. Putting consumption of free products in GDP would, however, be inconsistent with the conceptual framework that underlies the measurement of productivity, because, in that framework, prices provide the correct measure of value. Furthermore, Nakamura, Samuels and Soloveichik (2016) find that alternative approaches to consumption of advertising-funded products have virtually no effect on U.S. productivity growth.

The introduction of peer-to-peer services intermediated by internet platforms (such as Uber and Airbnb) raises a different set of issues. These services appear to be fully captured in GDP levels (which are in nominal terms), but not in GDP growth rates. Incorporating a new product in the relevant deflator in a way that reflects its relative price level is difficult because of the need to adjust for quality differences (Ahmad and Schreyer, 2016). Commonly used procedures for bringing a new product into a deflator implicitly assume that the quality-adjusted prices of the new product and the product that it competes with are the same. But if the new peer-to-peer services have lowered the quality-adjusted prices, as suggested by their popularity, their contribution to growth is underestimated by the standard methods.

Box 1. Can Mismeasurement of the Digital Economy Explain the U.S. Productivity Slowdown? (Concluded)

Nonetheless, new kinds of peer-to-peer services remain a very small part of U.S. output, so improving the deflators to better capture the price declines would not have much of an effect on productivity.

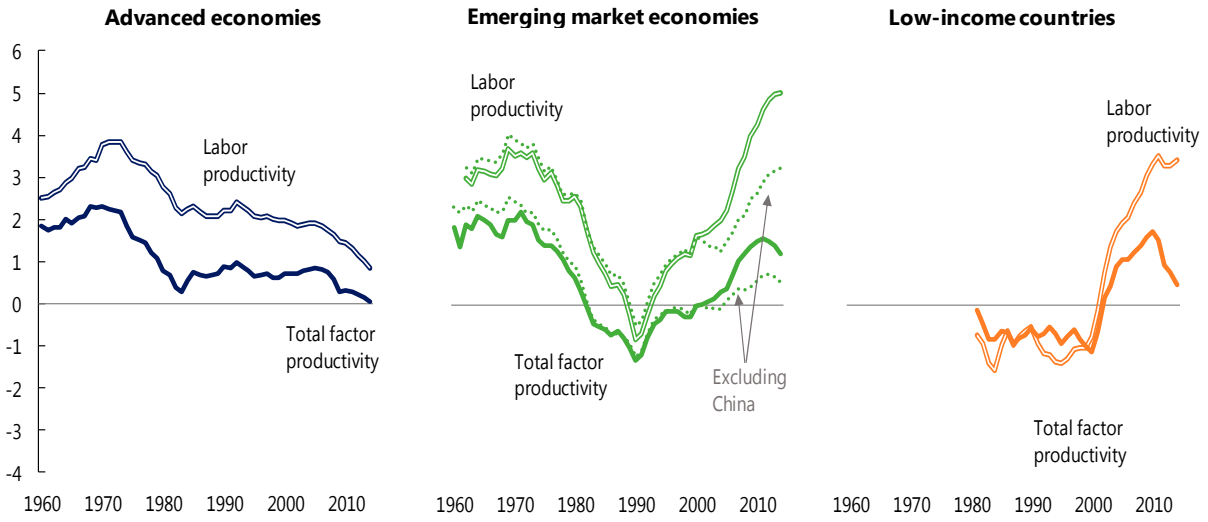
Overall, while there is no doubt that measurement error is an issue, to be the main factor behind the observed productivity slowdown, measurement error must have become much larger over time. Adding all the possible adjustments discussed above, the change in measurement error accounts for less than one- tenth of the slowdown in the United States productivity growth rate. Measurement issues go beyond the digital economy; for example, they affect the area of health care, where quality improvements are difficult to capture in full and the weight in GDP has grown. However, growing mismeasurement in these other areas is unlikely to account for a significant share of the productivity slowdown.

[1] Prepared by Marshall Reinsdorf.

9. A long-term perspective. The recent TFP slowdown in advanced economies does not just mark a return to low but steady growth rates after some ICT-related uptick during the late 1990s and early 2000s. Average TFP growth has been nearly zero over the last 10 years, below any similar period in the last 6 decades (Figure 4). Slower capital accumulation has added to slowing TFP growth, leading to a greater deceleration in labor productivity. While far less dramatic than in the 1970s, the productivity slowdown of the 2000s has been substantial. For emerging market economies and low-income countries, labor productivity grew rapidly—in historical terms—during the 2000s, but driven primarily by rapid capital accumulation including in the post-crisis period, likely reflecting an environment of historically low borrowing costs. TFP growth, while slowing, has remained above the average of the previous two decades—although, in emerging market economies, not above the rates of the 1960s and 1970s.

Figure 4. A Long-Term View of Total Factor Productivity Growth, 1950–2014

(10–year growth rate)

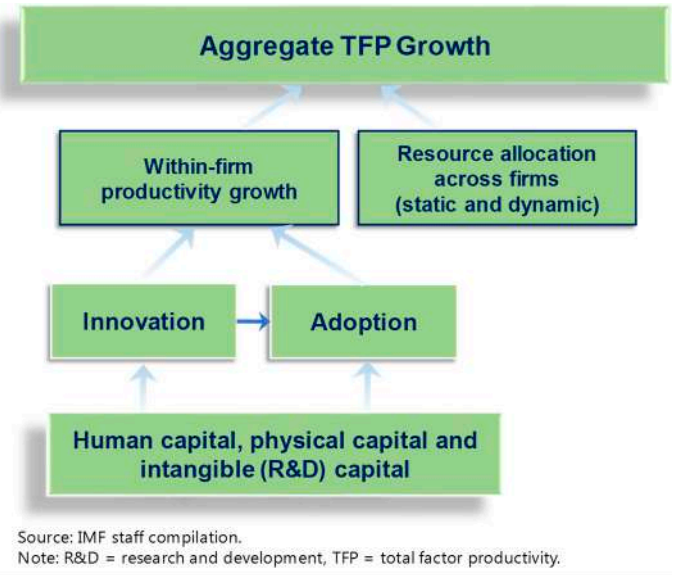


Sources: Penn World Table 9.0; IMF, *World Economic Outlook*; and IMF staff calculations.
Note: Purchasing power parity GDP weighted average of largest 20 economies per income group is reported.

DRIVING FORCES

10. Aggregate TFP growth reflects improvements in both productive efficiency within firms and allocative efficiency between them. Figure 5 presents a simple illustration of the mechanisms that drive TFP growth. Within-firm TFP growth originates from innovation by leading firms, and adoption of better, more efficient existing technologies and management practices by lagging firms (productive efficiency within firms). In turn, innovation and adoption generally require investments in tangible (physical) and intangible (research and development [R&D], human) capital. Improvements in aggregate TFP growth can also result from reallocation of capital and labor toward firms that use these resources most productively at the margin (allocative efficiency). This is achieved when resources move away from less productive to more productive businesses, and through the entry and exit of firms.

Figure 5. Mechanisms of Aggregate Total Factor Productivity Growth



Source: IMF staff compilation.
Note: R&D = research and development, TFP = total factor productivity.

11. The slowing of global productivity growth caused by the global financial crisis and secular forces has occurred through the following mechanisms:

- **Legacies of the global financial crisis**. As in previous deep recessions and financial crises, financial market dislocation, policy uncertainty, and weak investment in the aftermath of the global financial crisis had visible implications for productivity growth, affecting within-firm productivity gains (through slower capital-embodied innovation and intangible investment) as well as resource allocation across firms.

- **Secular drivers**. The fading effects of the ICT revolution, population aging, and other demographics forces, as well as slowing global trade—some of which were in part already visible in the run-up to the global financial crisis—have exerted continuous downward pressure on global TFP. In emerging and

developing economies, the waning effects of earlier structural reforms and structural transformation have also been playing a role.[7]

These forces have affected TFP growth by weakening technological adoption or innovation by existing firms or by hampering the optimal allocation of resources between them. In some cases, the analysis in the note identifies which of these channel(s) have been at play—for example, when studying the role of weak balance sheets and credit constraints. In other cases, the note only provides evidence of the direct TFP growth impact of the driver of interest without investigating the precise transmission mechanism—for example, when analyzing the effect of ageing. The contributions of the legacies of the global financial crisis and the secular forces mentioned above are discussed next.

A. Legacies of the Global Financial Crisis

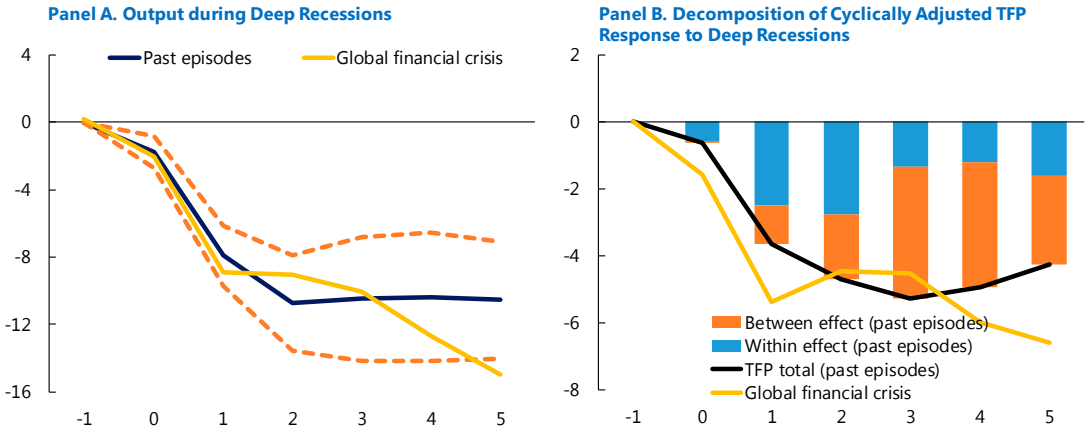
12. Lasting effects of deep recessions. Unlike normal growth slowdowns, deep recessions—often, albeit not always, associated with financial crises—have been shown to entail large and persistent output losses (Cerra and Saxena 2008; and Blanchard, Cerutti, and Summers 2015). New empirical analysis of past episodes of deep recessions in advanced economies—which, on average, displayed initial contractions comparable to those observed during the global financial crisis—shows that such output losses reflect not just persistent declines in employment—so-called employment hysteresis—or investment, but also significant and protracted losses in TFP (Figure 6, and Appendix I). This effect holds even when adjusting for factor utilization. Moreover, a sectoral decomposition indicates that these aggregate TFP losses are the result of both within-firm productivity losses and resource reallocation across industries (that is, disproportionately larger contractions of high-productivity sectors).[8] The negative reallocation (between) effect is small for regular recessions (see Appendix I), and initially during deep recessions. But in the latter case, the between component tends to increase over time, possibly reflecting greater market dislocation. Consistent with this evidence, and despite the deployment of extraordinary fiscal and monetary stimuli by major advanced economies, the global financial crisis displayed a fairly similar pattern in its aftermath, with both within and between effects driving down aggregate TFP. These crisis-related TFP losses appear to reflect a number of factors, including the effect of the tightening credit conditions for corporates with vulnerable balance sheets, weak investment, increased resource misallocation across sectors, and, more broadly, the effect of heightened economic and policy uncertainty. These are discussed in detail next.

[7] Earlier IMF work highlighted the fading role of structural transformation in advanced economies, reflecting secular reallocation of resources towards slow-growing services sectors (Dabla-Norris and others 2015). This mechanism is not studied in this note.

[8] While within-sector reallocation and firm-level innovation generally explain the bulk of aggregate productivity gains (Denis and others 2014; Dabla-Norris and others 2013a), the new analysis presented here suggests that cross-sectoral reallocation may play an important role during deep recessions. The latter are associated with a disproportionate contraction of manufacturing, wholesale and retail trade, and transportation sectors, in favor of service sectors (such as public administration, defense, education, health and social work, entertainment, recreation, and so on).

Figure 6. Lasting Effects of Deep Recessions on Total Factor Productivity

(Percent)



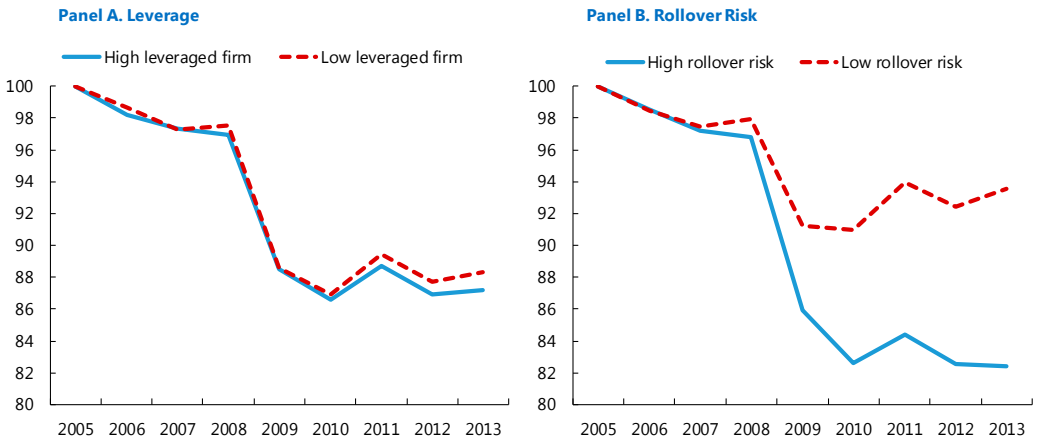
Sources: Penn World Table 9.0; EU KLEMS and WORLD KLEMS data; Blanchard, Cerutti, and Summers (2015); and IMF staff calculations.
Note: Years after the shock on the x-axis, t = 0 is the year of the shock. TFP = total factor productivity. The effect of past episodes is estimated using local projections method (Jordà 2005), controlling for past growth, lagged recessions and country-specific trends, and including a bias correction suggested by Teulings and Zubanov (2014). For the global financial crisis, output and unadjusted total factor productivity average deviation from precrisis trends are reported. Dashed lines denote 90-percent confidence bands. The TFP decomposition is based on McMillan and Rodrik (2011). *Within* effect refers to the contribution of sectoral productivity growth to aggregate productivity growth. *Between* effect refers to contribution of inter-sectoral reallocation of resources. See further details in Appendix I.

13. Tight credit conditions and corporate balance sheet vulnerability. Credit conditions tightened sharply after the collapse of Lehman Brothers in September 2008 and, despite the extraordinary monetary stimulus that followed, access to credit remained durably restricted for many small and medium-size enterprises, particularly in countries most affected by the euro area crisis. This partly reflected the persistence of asset legacy issues and capita shortfalls in the banking sector. Empirical analysis based on a large panel of advanced economies firms (Appendix II) indicates TFP growth fell more in companies with weaker balance sheets prior to the global financial crisis than their counterparts with stronger balance sheets (Figure 7).[9,10] Two distinct sources of firm vulnerability appear to have played a role, namely leverage (debt overhang) and, even more so, debt rollover risk (short-term financing). Neither of these is found to have affected TFP after the (milder) recession of the early 2000s, suggesting that the global financial crisis was different. Furthermore, since TFP gains for these two groups of firms were similar, on average, during the precrisis (2002–07) period, the post-crisis sub-par performance of more vulnerable firms was most likely a driver for the aggregate productivity slowdown—rather than reflecting a "cleansing" effect of less productive firms.

[9] Likewise, firms whose profits were lower relative to their interest payments experienced a sharper slowing of productivity See Duval, Hong and Timmer (forthcoming) for details.

[10] High- and low-leverage levels are defined as those corresponding to the 75th and 25th percentiles of the distribution of firm leverage across all countries and firms over the sample period.

Figure 7. Total Factor Productivity Level Path for Firms with Different Precrisis Balance Sheet Vulnerabilities
(Index, 2005 = 100)



Source: Duval, Hong, and Timmer (forthcoming).
Note: TFP = total factor productivity. High/low leverage and high/low rollover risk correspond to the 75th and 25th percentiles of the cross-country cross-firm distribution of leverage and rollover risk in the sample. Rollover risk is measured as debt maturing within a year in 2007, as a percent of total sales. Leverage is measured as total debt to total assets. For details, see Appendix II and Duval, Hong, and Timmer (forthcoming).

14. Credit conditions and investment in intangible assets. One key feature that sets the global financial crisis apart from past recessions was the sharp tightening of credit conditions, despite extraordinarily loose monetary policy, after the Lehman Brothers failure, and later during the euro area crisis. The evidence indicates that the interaction of vulnerable balance sheets and tightening credit conditions has a visible impact on TFP. Indeed, the effect discussed above—firms with weaker balance sheets experiencing a larger post-global financial crisis TFP slowdown—was particularly acute in countries whose banking sectors were more affected by the global financial turbulence. On average across countries, the post-crisis decline in advanced economies' annual TFP growth was about 1.01 percentage points greater for high-leverage than for low-leverage firms, while the gap was over 1.31 percentage point in countries where bank credit default swap spreads rose more sharply (Figure 8, Panel A). One channel through which the global financial crisis may have persistently weakened TFP growth is lower investment in intangible capital, such as R&D, in vulnerable firms. Aghion and others (2012) show that when firms face credit constraints after severe downturns, R&D expenditure becomes pro-cyclical, impairing future productivity growth. The post-global financial crisis evidence analyzed here is consistent with this finding.[11] Firms with weaker balance sheets are found to have reduced their investment rate in intangible assets—measured as a share of total value added—by 0.5 percentage points more than their less vulnerable counterparts (Figure 8, Panel B). This difference increases to 0.81 percentage points in countries where credit conditions tightened more. Compared with high leverage, high *ex-ante* rollover risk seems to have led to even greater declines in TFP growth; the sudden liquidity squeeze and the associated difficulty in

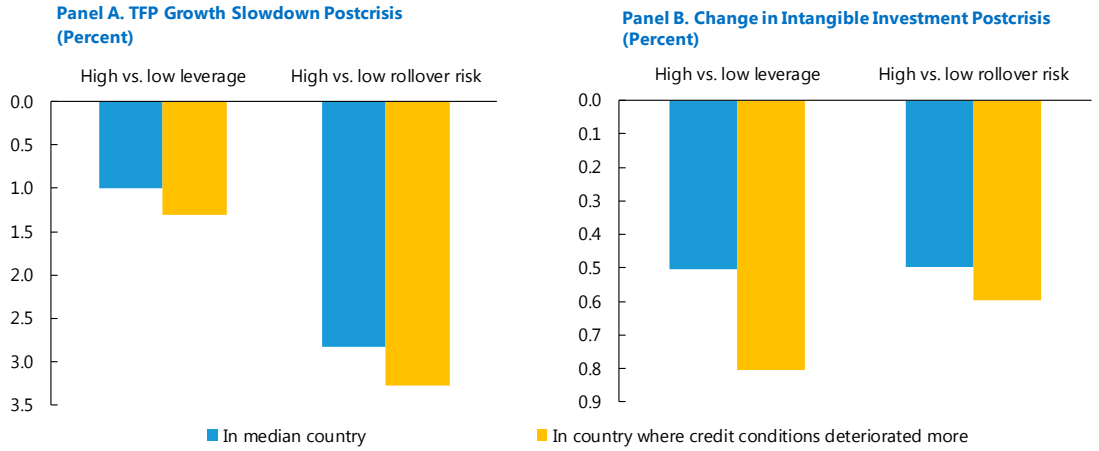
[11] See also recent related work by Garcia-Macia (2015) and de Ridder (2016).

(continued)

financing working capital may have forced distressed firms into asset fire sales, layoffs and cuts in intangible investment, with persistent adverse effects on productivity.[12]

Figure 8. Estimated Impact of Balance Sheet Vulnerabilities and Credit Conditions on Postcrisis Total Factor Productivity Growth and Intangible Investment

(Difference between 2002–07 and 2008–13 average TFP growth rates, percent)



Source: Duval, Hong, and Timmer (forthcoming).
Note: TFP = total factor productivity. High/low leverage and high/low rollover risk correspond to the 75th and 25th percentiles of the cross-country cross-firm distribution of leverage and rollover risk in the sample. The illustrative country where credit conditions deteriorated more corresponds to 75th percentile of the cross-country distribution of changes in average bank credit default swap spreads between the first and the second halves of 2008. Estimates are obtained from firm-level regressions of the change in average TFP growth between pre and postcrisis periods on firm-level leverage and rollover risk as well as their interactions with the country-level change in credit conditions—as measured by the average bank credit default swap spreads between the first and the second halves of 2008—controlling for various firm characteristics and country-sector fixed effects. For details, see Appendix II and Duval, Hong, and Timmer (forthcoming).

15. Misallocation of capital across firms. The financial crisis, and the credit boom that preceded, it may have not only undermined TFP growth within firms, but also the efficiency of capital allocation across firms, further weakening aggregate productivity growth. Misallocation of capital and labor can be measured as the dispersion of their marginal revenue product across firms within each sector in each advanced country, following the framework proposed by Hsieh and Klenow (2009). On average across business sectors in advanced economies, measured capital misallocation seems to have increased both before and after the global financial crisis (Figure 9). This, along with stable labor misallocation, point to a greater increase in frictions in capital than in labor markets.[13] Growing misallocation during the pre-global-financial-crisis financial boom is consistent with results for the Spanish manufacturing sector in Gopinath and others (2015), who link the increased misallocation of capital in Southern Europe to the sharp rise in poorly intermediated capital inflows following the inception of the euro (see also Reis 2013; Borio and others 2016; and Dias, Marques, and Richmond 2016). The global financial crisis might have worsened capital allocation further by impeding the growth of financially constrained firms relative to their less constrained counterparts. Indeed, the divergence in TFP paths between both types of firms shown in Figure 7 was accompanied by a growing gap in their marginal revenue product of capital, as factors of production were adjusted and reallocated across firms only slowly. Possibly slowing this reallocation further has been

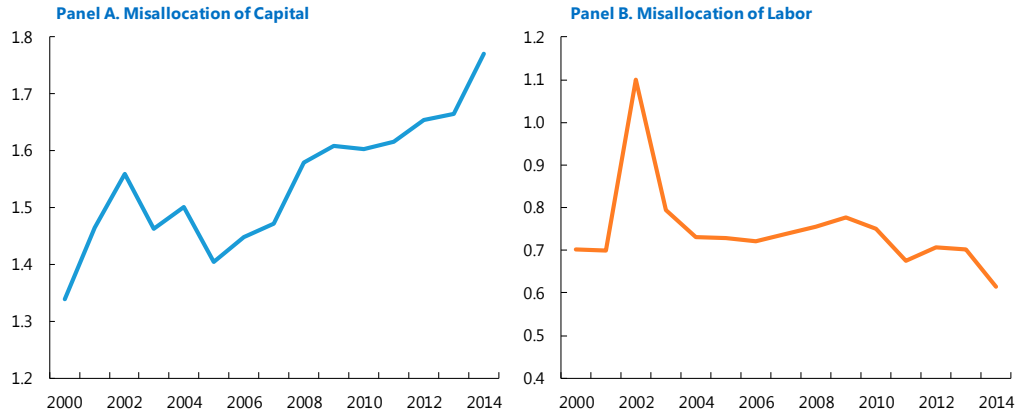
[12] Distressed firms may also have exited altogether. Due to the rather poor quality of exit data that can be derived from Orbis, the analysis focuses only on surviving firms.

[13] Consistent with the findings in Gopinath and others (2015), stable labor misallocation indicates that, conditional on the observed allocation of capital, labor was allocated as efficiently as historically.

(continued)

that banks may have "evergreened" loans to weak firms to delay loan-loss recognition and the need to raise capital—particularly in continental Europe where progress toward addressing banking sector problems has been slower than in some other advanced economies such as the United States. Together, these forces may have fostered the emergence of some "zombie firms" and thereby further increased misallocation of capital.[14]

Figure 9. Rising Capital Misallocation in Advanced Economies
(Standard deviation of factor return, median across countries and industries)



Source: Duval, Hong, and Timmer (forthcoming).
Note: The calculation of marginal returns to capital and labor and their dispersion follows the approach proposed by Hsieh and Klenow (2009). For details, see Duval, Hong, and Timmer (forthcoming).

16. Feedback loop between weak investment in physical capital and productivity. Private fixed investment fell sharply in advanced economies in the aftermath of the global financial crisis—and weakened more gradually in emerging market economies and low-income countries—largely as a result of weak aggregate demand (IMF 2015a).[15] This drop is likely to have contributed to subdued labor productivity growth not only by weakening the contribution of capital deepening, but also by affecting TFP growth itself through a slower adoption of capital-embodied new technologies.[16] Indeed, new empirical estimates of this effect at the country level, based on data for 112 countries over 1970–2014 (see Appendix III) suggests that falling investment may be responsible for lowering TFP growth by nearly 0.2 percent points per year in advanced economies over the post-crisis period (Figure 10). Bleak prospects for TFP growth, in turn, appear to have fed back into weak demand and investment.[17] In emerging market economies, this effect has arguably materialized more gradually, following a less abrupt weakening in the pace of capital

[14] Adalet McGowan and others (2017) indeed document a rise in zombie firms in the post-global-financial-crisis period and find an adverse effect on the growth of healthy firms. The implied impact on TFP is not found to be large, however. Assuming all weak firms to be zombies, and reducing their share to the minimum level observed in each industry, would yield a one-off TFP level gain of about 0.6 percent on average across a sample of (mostly European) advanced economies.

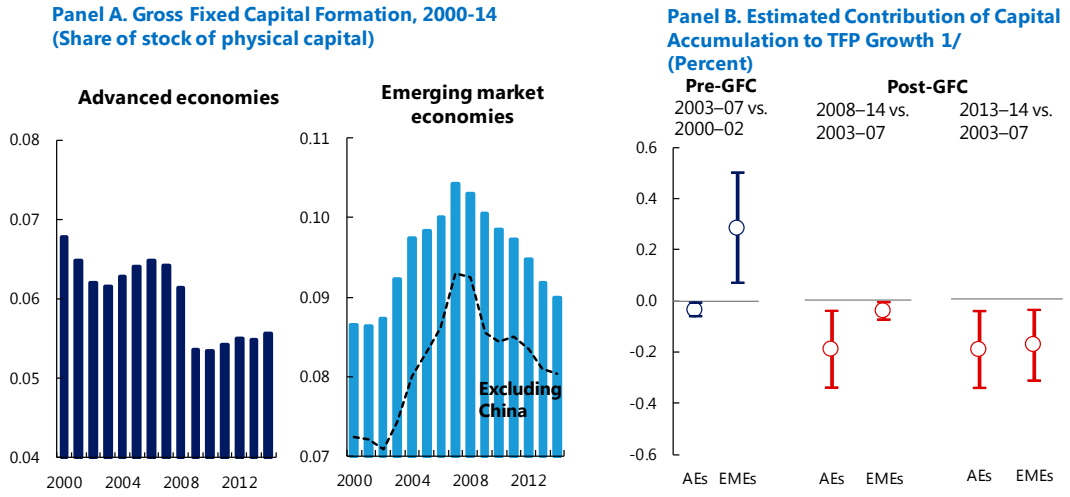
[15] Re-running the analysis underpinning Panel B of Figure 8 for investment in physical capital rather than in intangible assets also points to some—albeit only weakly significant statistically—role of the interplay of tighter credit conditions and weak corporate balance sheets in the investment slowdown.

[16] New capital equipment enables some innovations to find their way into actual production (Solow 1959). For example, in the late 1990s and early 2000s technological change such as internet use was "embodied" in new and increasingly powerful computers. New investment may also facilitate TFP-enhancing organizational innovations—for instance, just-in-time manufacturing and supply chain management emerged during the 1980s–1990s thanks to new information technology equipment and software. See further discussions in Wolff (1991) and Greenwood, Hercowitz, and Krusell (1997).

[17] See Blanchard, Lorenzoni, and L'Huillier (2017).

accumulation. For commodity exporting emerging and developing economies, the large fluctuations in commodity prices have also been a key factor in the fall in investment (Box 2) (See IMF (2015a and 2015c).

Figure 10. Investment and Its Impact on Capital-Embodied Technological Innovation



Sources: Penn World Table 9.0; IMF, *World Economic Outlook*; and IMF staff estimates.
Note: AEs = advanced economies, EMEs = emerging market economies, TFP = total factor productivity, and GFC = global financial crisis. Purchasing power parity GDP weighted average of largest 20 economies in each income group is reported.
1/ Estimated contribution of capital accumulation to the change in TFP growth between stated periods. 90-percent confidence bands are reported. See details in Appendix III.

Box 2. Productivity Growth in Commodity-Exporting Countries*

Since the global financial crisis, productivity growth in emerging market economies, and especially commodity-exporting ones, has slowed sharply. Can some of this be attributed to the post-crisis drop in commodity prices, or are there other factors at play? Economic theory suggests the process of productivity growth in commodity extracting sectors may be distinctly different from other sectors, with structural and cyclical factors playing a role.

Structural drivers. Higher quality commodity deposits are generally the first to be developed, with subsequent development targeting lower quality deposits—this is particularly true in the mining sector. Over time, commodities become harder to extract, and are of lower grade, so the inputs required to extract the same amount of output (volume) increases, resulting in weaker total factor productivity (TFP) (Aguirregabiria and Luengo 2015; Parham 2012). This sector-specific phenomenon would tend to exert downward pressure on aggregate TFP growth in commodity-producing countries.

Cyclical shifts. High commodity prices may affect TFP in conflicting ways. Elevated prices can induce increased capital investment to extract more of the commodity (or more rapidly) to take advantage of high prices. This process takes time to complete, implying that capital is not fully utilized during the initial investment phase, thereby driving down (measured) productivity growth (Parham 2012). Higher commodity prices can also induce capital investment in new, less productive mines, as they become profitable with higher prices, also pushing down TFP. At the same time, higher income associated with rising commodity prices may help relax budget and credit constraints, facilitating investment in technology and human capital, potentially boosting TFP growth in the medium term. Finally, for oil exporters, production can be driven by "non-technical" factors, such as production quotas—such an output change would be attributed to a shift in measured productivity in these countries.

Empirical evidence is consistent with a secular decline in mining-sector TFP growth—a sectoral breakdown for 11 advanced economies indicates that TFP growth in mining has been about half the rate of other industries during 1990–2007 (Figure 2.1). In addition, Blagrave and Santoro (2016) show that mining sector TFP growth has been persistently negative in Chile over the past decade or more.

Looking at the evidence on cyclical forces in Chile's mining sector, Blagrave and Santoro (2016) find suggestive evidence that during the recent copper-price boom, capital accumulation in the mining sector picked up during 2005–12, with limited changes in mining output, resulting in falling TFP growth. Taking a broader look at the economy, Aslam and others (2016) provide evidence that TFP growth in commodity-exporting countries tends to co-move positively with commodity prices. This is also visible when comparing pre- and post-global-financial-crisis TFP growth between commodity-exporting and other economies—especially across emerging market economies (Figure 2.2). Overall, the evidence suggests that the dynamics of commodity prices in recent years may have been a driving force of the recent TFP slowdown.

Figure 2.1. Average TFP Growth by Sector, 1990-2007 1/
(Annual average, percent)

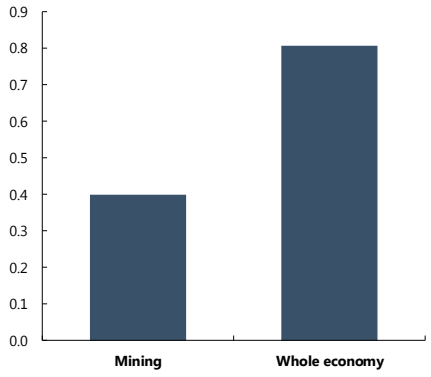
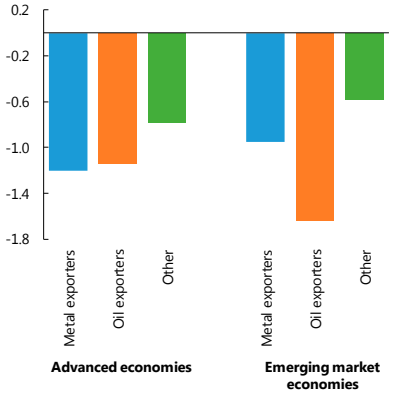


Figure 2.2. Pre- to Post-GFC TFP Slowdown 2/
(GDP-weighted average, percent)



Sources: EU KLEMS and WORLD KLEMS data; Penn World Table 9.0; IMF, *World Economic Outlook*; and IMF staff calculations.
1/ Average for a sample of 11 advanced economies (for which sectoral total factor productivity data is available)
2/ 2008–15 versus 1990–2007 average aggregate total factor productivity growth.

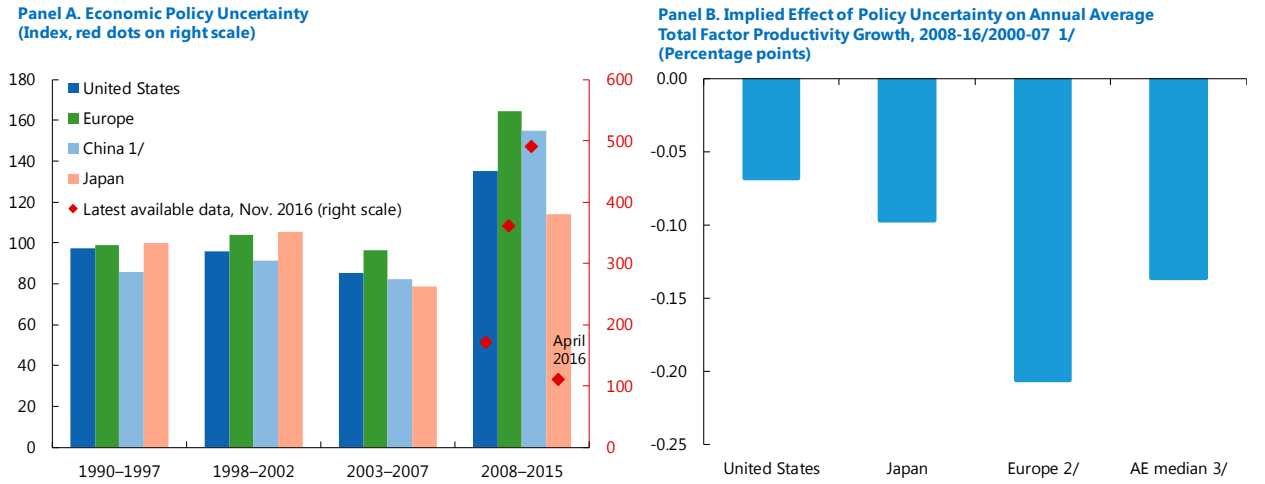
* Prepared by Patrick Blagrave.

17. Protracted uncertainty. Elevated economic and policy uncertainty in the post-global-financial-crisis environment, more generally, appears to have played a significant role in driving down investment and productivity. While conventional measures of market uncertainty, such as stock market volatility, largely returned to precrisis levels after a temporary spike during the global financial crisis, indicators of policy-

related economic uncertainty (Baker, Bloom, and Davis 2016) have remained high in key systemic economies—such as the euro area or Japan, and more recently the United States (Figure 11). Higher uncertainty induces firms to "wait and see", slowing the expansion of more productive firms at the expense of less productive ones, and leading firms to cut investment and shift its composition toward shorter-term, lower-risk/lower-return projects (Bloom and others 2014).

18. New IMF work (Choi and others 2016) for a panel of 25 industries and 18 countries over 1985–2010 finds that the adverse productivity impact of higher economic and policy uncertainty has been significantly larger in industries that face tighter credit constraints, due to their greater dependence on external finance for capital expenditure.[18] Further empirical analysis based on Choi and others (2016) points to a change in the investment mix as a possible channel through which higher uncertainty may have affected productivity. Indeed, higher uncertainty is found to lower the *share* of ICT in total capital in industries that depend more on external finance.[19] Under conservative assumptions (such as that only financially-dependent industries have been affected by the rise in policy-related uncertainty), these estimates imply a contribution of increased policy uncertainty to the TFP slowdown between the precrisis and 2012–14 periods of about 0.2 percent per year on average for Europe, 0.1 for Japan, and 0.07 for the United States.[20]

Figure 11. Policy-Related Economic Uncertainty and Estimated Impact on Total Factor Productivity Growth



Sources: Baker, Bloom, and Davis (2016); IMF staff calculations.
Note: Index for each country/region normalized to a mean of 100 corresponding to different time periods: the United States from January 1985 through December 2009, Europe from January 1985 through December 2010, China from January 1995 through December 2011, Japan from June 1988 through December 2013.
1/ Data starts from 1995.

Sources: Baker, Bloom, and Davis (2016); EU KLEMS and WORLD KLEMS data; Organisation for Economic Co-operation and Development; and IMF staff estimations.
1/ 2016 is an average of January – November monthly data, except Japan, which is an average of January – April.
2/ Includes France, Germany, Italy, Spain, and the United Kingdom.
3/ 10 advanced economies included in the sample: Canada, France, Germany, Italy, Japan, Korea, the Netherlands, Spain, the United Kingdom, and the United States.

B. Long-Term Forces

Crisis legacies have dragged on productivity growth since the late 2000s. But this has occurred on the back of a secular slowdown already in train before the crisis—especially in advanced economies—driven in part

[18] Macroeconomic shocks such as higher uncertainty induce credit-constrained firms to prioritize investment projects that contribute to output and liquidity quickly but may not deliver the highest returns (Aghion and others 2010, Aghion, Hemous, and Kharroubi 2014).

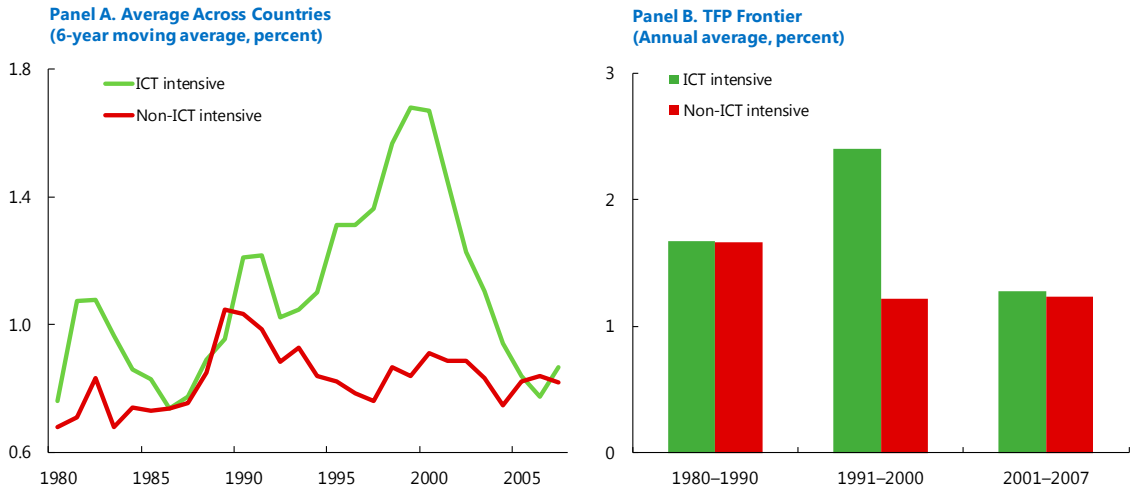
[19] This analysis is not reported in the technical appendix, but is available upon request.

[20] See also Arbatli and others (forthcoming) for an exploration of the effect of uncertainty on investment in Japan.

by the waning of the ICT revolution and slower innovation, population aging, and slowing global trade. In emerging and developing economies, the fading effects of earlier structural reforms and structural transformation may have also played a role. These forces are discussed next.

19. Waning gains from ICT and the slowing pace of innovation at the technological frontier. A fading ICT-related boom and slowing TFP growth at the technological frontier had been a significant driving force of the TFP slowdown in advanced economies even before the global financial crisis. Indeed, after a temporary boom associated with the ICT revolution in the late 1990s-early 2000s, TFP in ICT-intensive sectors slowed significantly starting in the early 2000s (Figure 12, Panel A). This process was also visible at the ICT frontier (Figure 12, Panel B). Meanwhile, while still a subject of much debate,[21] the pace of innovation at the frontier in other sectors may have slowed earlier, and remained more stable (although significantly lower than ICT) more recently. This is consistent with the aggregate pattern of frontier slowdown found in Dabla-Norris and others (2015). For the United States, which remains the technological leader in several industries, including ICT, the ICT slowdown partly reflects the well-documented loss of business dynamism, which also extends to other sectors, since the early 2000s (Cardarelli and Lusinyan 2015; Decker and others 2016; Haltiwanger, Hathaway and Miranda 2014).

Figure 12. Total Factor Productivity Growth in ICT- and Non-ICT-Intensive Sectors in Advanced Economies



Sources: Furceri, Çelik, and Schnucker (2016); Dabla-Norris and others (2015); EU KLEMS and WORLD KLEMS data; and IMF staff estimations.
Note: ICT = information and communications technologies, TFP = total factor productivity. Top and bottom 5th percentiles of the distribution across country-industries are excluded as outlier treatment for Panel A. Total factor productivity frontier in Panel B is defined as the average of the three highest total factor productivity levels across countries, for each industry and year. See further details in Appendix IV.

20. Adverse productivity spillovers from a slowing frontier. While the true extent, causes, and future persistence of slower innovation remain the subject of intense research,[22] the TFP slowdown at the

[21] See Andrews, Criscuolo, and Gal (2015), and Decker and others (2016).

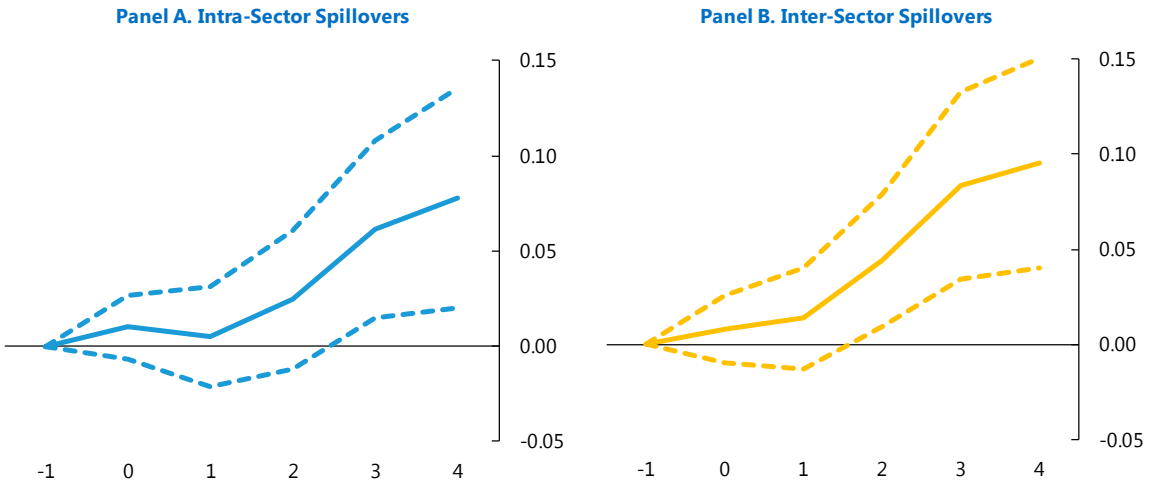
[22] Leaving aside the possible measurement issues discussed in Box 1, a few recent papers using firm-level data suggest that TFP growth may actually have remained steady within global frontier firms, with slowing TFP at the sector level reflecting primarily weaker diffusion to lagging firms—including within countries that host global frontier firms in a particular sector (see in particular Andrews, Criscuolo, and Gal 2015). Some argue that the slowdown in innovation is likely to be permanent (Gordon 2016) while others foresee a productivity revival connected to advances in artificial intelligence (Brynjolfsson and McAfee 2014).

(continued)

frontier observed thus far has spilled over across advanced economies industries, helping to explain the global TFP slowdown. New analysis using cyclically adjusted TFP growth rates at country-industry-level for a group of 17 advanced economies over 1970–2010 (see Appendix IV) shows that spillovers from TFP shocks in the United States—and more broadly at the technological frontier—are significant, both through intra-sector (such as competition and learning in the same sector) and inter-sector (such as improvement in the quality and variety of inputs available to other sector) spillovers. A 1 percent positive TFP level shock in an average U.S. sector leads, on average, to a TFP level increase of about 0.1 percent in other economies in that same sector over the medium term (Figure 13, Panel A).[23] Such a shock leads to a further 0.1 percent average TFP increase in other industries of foreign countries through their use of imported inputs from the United States (Figure 13, Panel B). Taken together, the two effects indicate that a 1 percent drop in TFP at the technological frontier in each industry lowers TFP by about 0.2 percent on average across all advanced economies over the medium term. These magnitudes are significantly larger for countries with relatively high exposure to the frontier through trade linkages.[24]

Figure 13. Spillovers from a One Percent U.S. Total Factor Productivity Shock

(Percent)



Sources: EU KLEMS and WORLD KLEMS data; IMF staff estimations.
Note: Years after the shock on the x-axis, t = 0 is the year of the shock. Estimates based on local projections method. Dashed lines denote 90-percent confidence intervals. See details in Appendix IV.

21. Population aging. Workforce aging is another secular force that seems to have weakened productivity growth since the late 1990s in advanced economies, and more recently in emerging and developing economies (Figure 14).[25] A worker's productivity varies over her working life, for reasons such as

[23] See also previous analysis in Dabla-Norris and others (2015).

[24] In the input channel, for example, the medium-term TFP impact of a one percentage point shock to U.S. TFP rises from 0.1 (the average effect across the sample) to 0.3 in a country-sector with relatively strong links to the United States (at the 75th percentile of the distribution across all country-sectors of the intensity of input imports from the United States), and declines to 0.05 in a country-sector with low input trade with the United States (25th percentile of the distribution). It should also be noted that an average 0.2 percentage point effect of a 1 percentage point TFP shock at the frontier after five years implies that about 4 percent of the gap between the frontier and lagging countries is closed this year. This is about twice as much as the typical speed of resorption of GDP per capita gaps found in the empirical growth literature (such as Barro and Sala-i-Martin 2004).

[25] While difficult to separate from aging, the overall slowing of population growth could also have an independent adverse effect on TFP, for example by lowering investment needs and slowing embodiments of technological progress (Greenwood

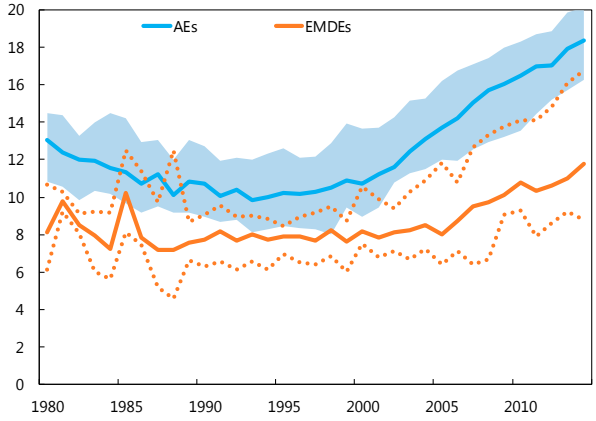
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the accumulation of experience over time, depreciation of knowledge, and age-related trends in physical and mental capabilities. A mature labor force will have higher average levels of work experience, with positive effects on productivity (Disney 1996). On the other hand, workforce skills also depend on the stock of knowledge acquired through formal education before entering the labor market and on the job in the early stages of individuals' careers. As such, skills are likely to peak and start declining later in the career, leading to a decline in innovation and productivity (Aksoy and others 2015; Dixon 2003; Feyrer 2008; Jones 2010; Liu and Westelius forthcoming; Maestas, Mullen, and Powell 2016).[26] Building on previous work,[27] new analysis explores the relationship between changes in the age structure of the working population and TFP growth using a new panel dataset composed of selected advanced economies and emerging and developing economies over 1985–2014 (see Appendix V). The estimates suggest that aging (that is, changes in the age structure) can indeed affect TFP growth and, all else equal, may have played a role in slowing TFP gains—perhaps by as much as 0.2–0.5 percentage point per year on average across advanced economies, and about 0.1 percentage point on average across emerging and developing economies, from the 1990s through the 2000s.

Figure 14. Population Aging and Its Impact on Total Factor Productivity

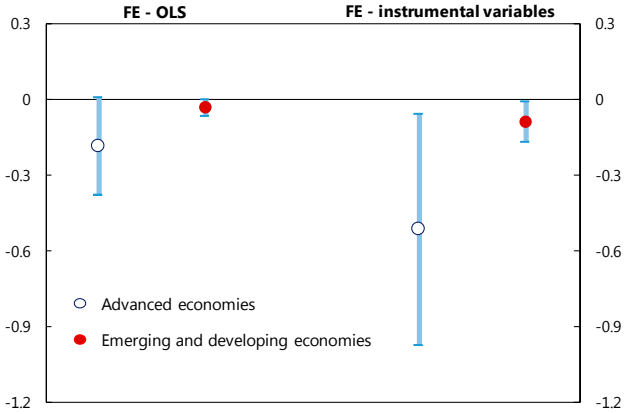
(Percent)

Panel A. Share of Old (ages 55–64) to Total Labor Force Participation
(Percent)



Sources: International Labour Organization Labour Statistics; IMF staff estimations.
Note: Medians and interquartile ranges are reported.

Panel B. Effect on TFP Growth of Change in Share of Old Employed Workers (Ages 55–64) to Total Labor Force, 2000s
(Annual average, percent)



Sources: International Labour Organization Labour Statistics; IMF staff estimations.
Note: TFP = total factor productivity, FE= fixed effects, and OLS = ordinary least squares. Vertical lines indicate the 90-percent confidence bands. Average effects for each income group are based on observed changes in the share of old employed workers, and the estimated effects on TFP growth. See details in Appendix V.

22. Global trade slowdown. Anemic global productivity growth has coincided with a global trade slowdown. International trade barely kept pace with global GDP after 2012, while it grew twice as fast in the two decades preceding the global financial crisis. While the trade slowdown is first and foremost the result

Hercowitz, and Krusell 1997). Another mechanism might be the disincentive of incurring sunk costs of innovation when markets grow more slowly.

[26] Furthermore, increased penetration of information technologies might place older workers at a disadvantage (Dixon 2003). Also, younger managers tend to lead firms towards greater innovation as they are more open to product destruction (Acemoglu, Akcigitz, and Celik 2014).

[27] See Aiyar, Ebeke and Shao (2016), Feyrer (2007), Jaimovich and Siu (2009), and Wong (2007) for previous findings on the link between aging and productivity. A recent paper by Acemoglu and Restrepo (2017) casts doubts about the theoretical and empirical impact of aging on productivity, highlighting the faster adoption of labor-saving technologies in rapidly ageing societies. See further details in Appendix V.

of weak economic activity, waning trade liberalization efforts and the maturation of global supply chains have also contributed (IMF 2016a). These supply-side forces can have strong implications for productivity growth through two broad channels: (1) *Import penetration*—greater foreign competition increases pressure on domestic firms to produce more efficiently or to innovate; and imported inputs expand the variety, and enhance the quality of intermediate goods to which firms have access (such as Romer 1994); (2) *Export penetration* can improve firm-level productivity through learning from foreign markets both directly (through buyer-seller relationships) and indirectly (through exposure to competition). These channels can operate both at the firm level— by inducing firms to adopt more efficient production processes, improve product quality, or undertake specific investments—and at the sectoral level, by inducing a reallocation of resources towards more productive firms within a sector (such as Criscuolo, Timmis, and Johnstone 2016). All else equal, slowing import and export penetration should reduce productivity growth.

23. China's integration into world trade. New analysis quantifies the impact of both the import and export channels in a panel setting of 18 advanced economies and 18 sectors spanning over one decade before the global financial crisis (see Appendix VI). The focus is on the effects of growing trade exposure to China and using instrumental variable techniques to address measurement issues and concerns of reverse causality running from growth to trade liberalization. The estimated effects on TFP in advanced economies from China's integration into world trade in the 1990s and 2000s are sizeable, although they also coincide with adverse effects on domestic employment in sectors with greater exposure to China (see Ahn and Duval forthcoming). Results imply that the trend increase in trade with China alone may have accounted for as much as 10 percent of the overall TFP increase in the median advanced economies country-sector over 1995–2007. More broadly, these findings suggest that stagnating trade intensity because of China's maturing integration into world trade will imply lower productivity gains going forward, while outright trade restrictions in advanced economies would mean reversing some of the earlier sizable gains.

24. Slowing human capital accumulation. A fourth global headwind for productivity growth has been slowing human capital accumulation. Individuals reap high returns from schooling in the form of increased productivity and wages (Mincer 1974), and returns to society may be even higher (Cohen and Soto 2007; De la Fuente and Domenech 2006). Reflecting this, the secular improvement in educational attainment in advanced economies and emerging and developing economies alike made an important contribution to aggregate labor productivity growth in past decades. However, such human capital accumulation has slowed across both country income groups during the 2000s (Barro and Lee 2013; Morrisson and Murtin 2013). An illustrative calculation based on the approach of Hall and Jones (1999) and broadly accepted estimates of social returns to education suggests that about a 0.3 percentage point per year of the slowing labor productivity in the average advanced economy and emerging market economy during the 2000s can be attributed to the falling pace of human capital accumulation (Figure 15).[28,29] Part of this slowdown may

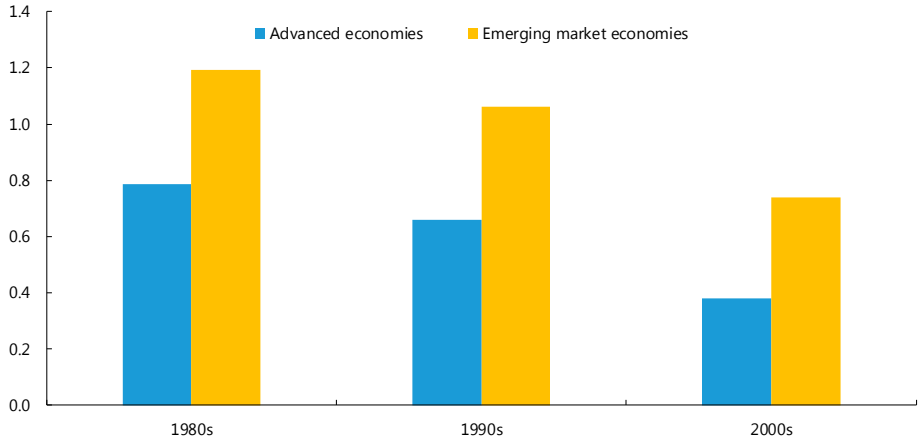
[28] Estimates presented here assume declining marginal returns from educational attainment, with highest (lowest) returns primary (tertiary) education, as specified in Morrisson and Murtin (2013) based on Psacharopoulos and Patrinos (2002). Recent papers provide new evidence in favor of non-decreasing, and perhaps increasing, returns (such as Montenegro and Patrinos 2014). Under constant returns—a conservative assumption—the slowdown in human capital stock growth between the 2000s and the 1990s would be about 0.25 instead of 0.3 percentage points for advanced economies, while the estimates for emerging market economies would be essentially unchanged.

[29] There is wide dispersion across countries within each group, in the level and the change of the contribution of human capital to labor productivity growth. For example, the United States enjoyed stable but very low human capital accumulation—0.1–0.2 percent per year—during the 2000s, reflecting the previous levelling off of secondary schooling in the 1970s and slow progress on tertiary education attainment. China, on the other hand, experienced a slowdown but still fast

(continued)

show up in weaker measured TFP growth depending on how human capital is accounted for when calculating TFP, and whether human capital entails positive externalities.

Figure 15. Contribution of Human Capital to Labor Productivity Growth
(Simple average by decade for both country income groups, percent)

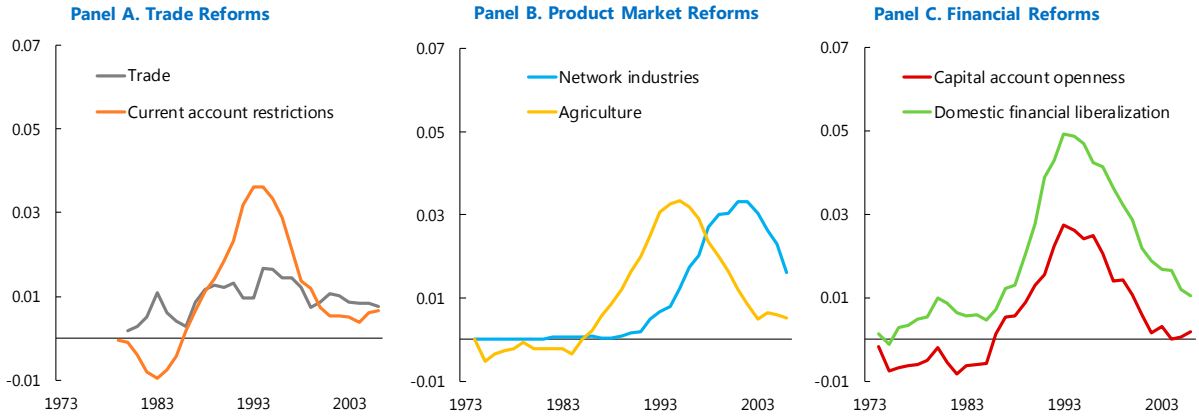


Sources: Murtin and Morrisson (2013); Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: The calculation follows the approach of Hall and Jones (1999), only departing from them by allowing for diminishing rather than constant returns to schooling as estimated by Morrisson and Murtin (2013), and consistent with Psacharopoulos and Patrinos (2002). Advanced economies include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Emerging market economies include Argentina, Brazil, Chile, China, Hungary, India, Indonesia, Mexico, Poland, Saudi Arabia, South Africa, and Turkey.

25. Fading structural reform efforts in emerging and developing economies. TFP growth in emerging and developing economies may have also been affected by a slowing pace of structural reform. Significant progress on both real and financial sector reforms was achieved during the late 1980s and the 1990s—partly in the aftermath of financial crises—paving the way for fast emerging and developing economies growth during the 2000s. Indeed, past research has found positive TFP and growth impacts of these reforms, while also highlighting that these effects vary across types of reforms and depends on the overall institutional environment (Christiansen, Schindler, and Tressel 2013; Prati, Onorato, and Papageorgiou 2013). However, with a few exceptions, reform efforts faded across a broad range of areas over the decade (Figure 16). In advanced economies, the pace of product market reform also appears to have slowed after the wave of liberalization of network industries during the 1990s and early 2000s, while progress on labor market reform has been uneven (Duval and others forthcoming; IMF 2016d).

average growth—about 0.9 percent per year—over that decade, mainly reflecting cohort effects (as older, less educated cohorts were replaced by younger, more educated ones)—and continued increases in tertiary education attainment among new generations.

Figure 16. Fading Structural Reform Efforts in Emerging and Developing Economies
(Average annual index change, 5-year moving average)



Sources: Prati, Onorato, and Papageorgiou (2013); IMF staff calculations.
Note: The average annual index change uses reform indices data from Prati, Onorato, and Papageorgiou (2013). All indices are rescaled to range between 0 and 1, with higher values corresponding to higher degree of liberalization. Indices are comparable across countries and time for each sector, but are not directly comparable across sectors because different methodologies are used to construct each index.

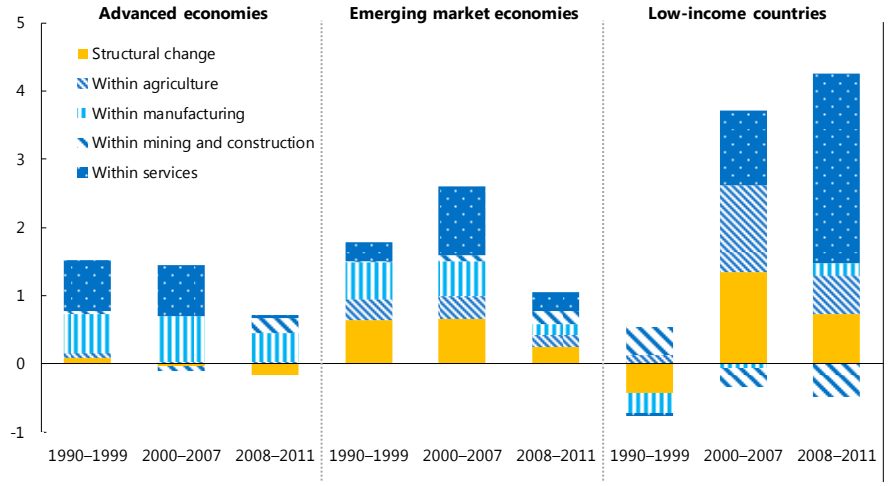
26. Structural transformation. Reallocation of resources away from low-productivity and toward high-productivity industries can also be an important driving force of aggregate productivity (labor productivity and TFP), especially in developing countries transitioning from agriculture to manufacturing. Sector-level analysis of labor productivity growth updating earlier IMF work (Dabla-Norris and others 2013b and 2015) indeed indicates that resource reallocation has been an important driver of productivity in emerging market economies and low-income countries over the last two decades, and especially before the global financial crisis (Figure 17). However, post-crisis evidence—although limited to 2008–11 due to lack of more recent data—suggests that benefits from structural transformation have declined for emerging market and low-income countries alike, partly as some of them, especially emerging market economies, have increasingly moved toward services.[30,31]

[30] China is not included in the sample for this analysis due to lack of manufacturing value-added data at the beginning of the sample.

[31] A decline in labor productivity growth *within* both manufacturing and services has also contributed significantly to the post-global-financial-crisis productivity slowdown in advanced economies and emerging market economies. In low-income countries labor productivity growth has picked up within both sectors, offsetting the drag from the declining contribution of structural transformation. These patterns, however, should be interpreted cautiously, given the heavy weight of the global financial crisis during the short time span (2008–11) for which data are available.

Figure 17. Structural Transformation, 1990–2011

(Contribution to annual labor productivity growth, percent)



Sources. Groningen Growth and Development Centre; World Bank, World Development Indicators; United Nations National Accounts database; Penn World Table 9.0; Dabla-Norris and others (2013); and IMF staff calculations.
Note: The decomposition is based on McMillan and Rodrik (2011). *Within* effect refers to the contribution of sectoral productivity growth to aggregate productivity growth, weighted by the initial value-added share of each sector. *Structural change* refers to the contribution of inter-sectoral reallocation of resources, measured by the change in the sector's employment share weighted by its relative productivity level at the end of the period. Countries are weighted by their purchasing power parity GDP at the beginning of each period.

REMEDIES

It is conceivable that innovation will gain pace in the future (see introduction), but, meanwhile, trend productivity growth remains sluggish. Ensuring that productivity continues to play its role in boosting living standards will require immediate policy action to address the legacies of the global financial crisis, along with a gradual implementation of structural policies to address secular drivers of slowing TFP growth.

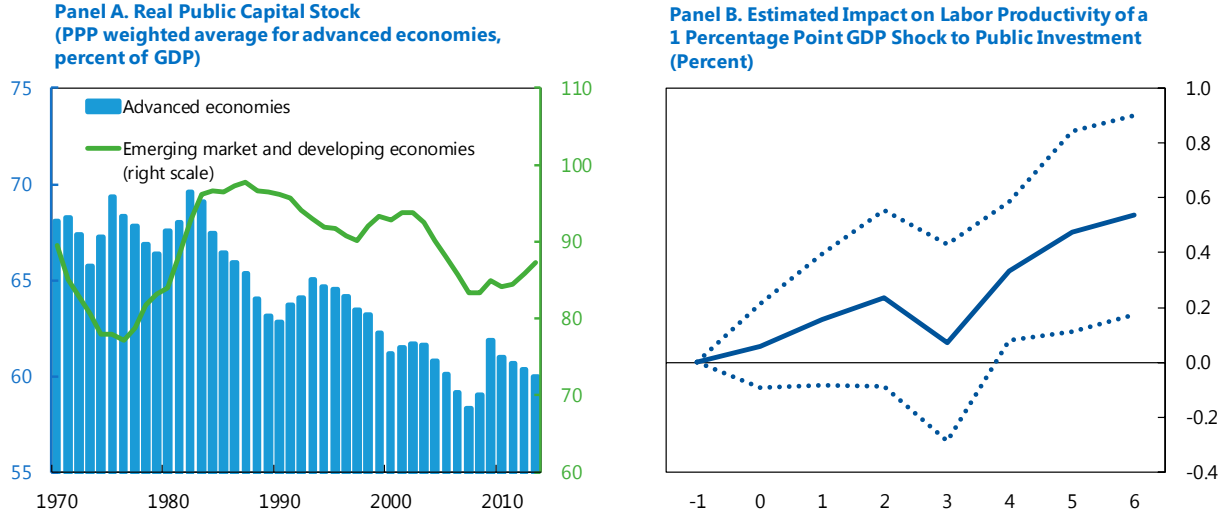
A. Short-Term Remedies

27. Boosting demand—primarily private investment—where it remains too weak. Demand support would not only help close output gaps but, especially if geared towards stronger investment, would also support capital deepening and further adoption of technologies embodied in new physical capital, helping to reverse the adverse feedback loop between weak investment and productivity. Recent IMF work discusses policy options to boost demand when macroeconomic policy space is constrained, as it now is in many advanced economies. Crucial under such circumstances is to exploit all existing synergies between monetary, fiscal, and structural policies (Gaspar and others 2016).

28. Efficient spending on infrastructure. Over the last two decades, the stock of public capital has fallen continuously relative to GDP in many advanced and emerging and developing economies (Figure 18, Panel A). In countries facing very low long-term borrowing costs and, in many cases, significant infrastructure needs, the social benefits of carefully selected public investment projects—including maintaining existing infrastructure—are likely to be high (see IMF 2016b). An efficient public infrastructure spending boost would raise labor productivity directly through higher infrastructure capital, and possibly TFP as well, by making existing private capital more productive—so-called spillover externalities. As an illustration, Figure 18, Panel B, estimates the dynamic impact on labor productivity of an increase in public investment equivalent to one percentage point of GDP across a panel of 17 advanced economies over

1985–2013. Following IMF (2014), infrastructure spending shocks are computed as the forecast error of public investment relative to GDP, using *OECD Economic Outlook* forecasts.[32] On average, labor productivity rises by 0.5 percent over the medium term, although primarily through higher physical capital intensity. Ensuring efficient spending can deliver larger effects than this historical average. IMF (2015b) finds that public investment in countries with the most efficient public spending leads to twice the growth impact as that seen in the least efficient. By contrast, infrastructure development designed to support particular sectors with chronic and growing excess capacity may delay necessary long-term adjustments and boost output only in the short term.

Figure 18. Stock of Public Capital and Productivity Effect of Infrastructure Spending



Sources: IMF, Investment and Capital Stock database; IMF staff calculations.
Note: PPP = purchasing power parity. For Panel B, years after the shock on the x-axis, t = 0 is the year of the shock. The methodology follows that used in the October 2014 IMF, *World Economic Outlook* to identify reform shocks and estimate their dynamic impact on output.

29. Strengthening balance sheets. Weak balance sheets still constrain access to credit, investment in intangibles, and productivity growth in some countries. Speeding up balance sheet repair—especially in Europe—would help boost labor productivity through both higher capital deepening and TFP growth, the latter by facilitating the implementation of innovations embodied in, or complementary to, new capital vintages. Facilitating corporate restructuring, including by lifting legal impediments, and strengthening banking sector supervision, could help in some cases to improve capital allocation across firms by inducing the exit of low-productivity/loss-making firms.

30. Reducing economic policy uncertainty. Providing greater certainty about future economic policy would also support investment and its shift toward higher-risk/higher-return projects, such as in Europe, where economic policy uncertainty remains substantially above precrisis levels. Particularly important is adopting a consistent dynamic framework to guide economic policies (Gaspar and others 2016). In fiscal policy, sound medium-term fiscal frameworks to manage public sector balance sheet risks can be

[32] This approach identifies plausibly exogenous shocks, whose dynamic impact is then traced out using the local projection method described in IMF (2014).

particularly helpful. Similarly, greater clarity about prospects for regulatory and trade policies would lower uncertainty and support investment decisions across the board.

B. Longer-Term Remedies

31. Innovation policies to boost technological progress. Slower advancement at the technological frontier in some industries suggests there may be scope for policies to further stimulate R&D, entrepreneurship, and technology transfer. Recent IMF analysis indicates that, given its positive externalities, current global R&D spending remains suboptimal by a significant margin (IMF 2016c). In advanced economies, a socially desirable level of R&D that accounts for positive knowledge spillovers would entail a 40 percent increase from current levels—which in turn could have a large positive effect on the long-term level of GDP in those countries. Well-designed R&D tax incentives, policy reforms aimed at limiting legal and market impediments to venture capital financing, and a strong framework for intellectual property rights that incentivizes investment in innovation while facilitating technological diffusion and follow-on research, can all play an instrumental role in this regard. R&D incentives targeted to young firms may be particularly effective in countries where these firms still face tight credit constraints, such as in a number of continental European countries. In emerging and developing economies, R&D can also support productivity growth, provided a sufficiently strong human capital base is available. In these countries, investment in education and infrastructure can strengthen capacity to absorb technologies from abroad. Simplifying tax regimes for small businesses could facilitate firm entry and reduce informality, also raising productivity.

32. Policies to mitigate the effects of aging. Continuing current trends, workforce aging will drag on productivity growth in advanced economies over the next three decades—roughly comparable in magnitude to that seen since over the past three decades—and will increasingly affect emerging market economies as well, albeit to varying degrees. This negative effect could be dampened by improving health support and affordability for mature workers, who are disproportionately affected by health risk, and facilitating human capital upgrading and retraining (Aiyar, Ebeke, and Shao 2016). Active labor-market policies and pension reforms that eliminate disincentives to continue work at older ages, can give older workers the means and incentives to acquire new skills.

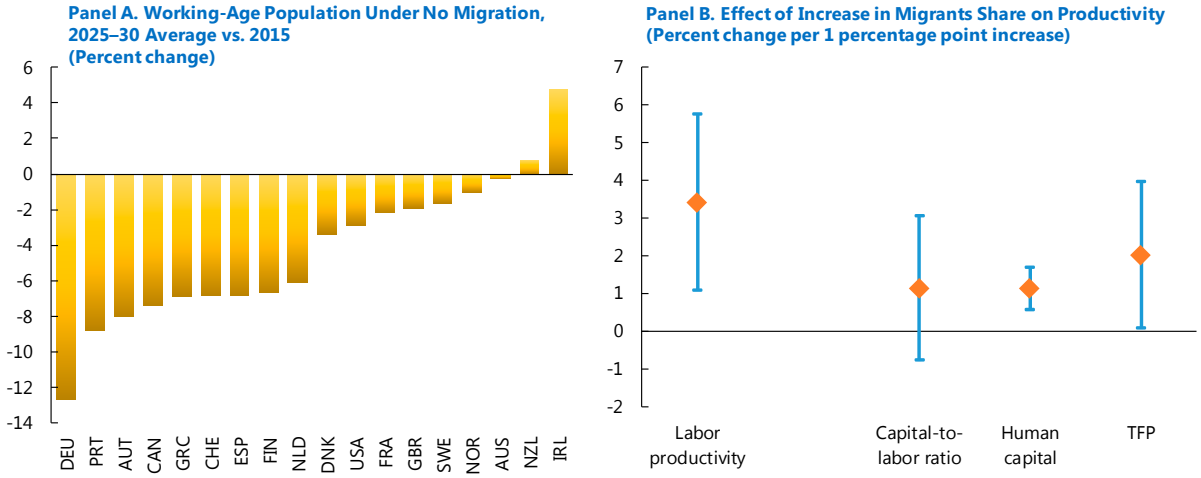
33. Migration policies. Workforce aging itself can be mitigated by higher fertility and, importantly, immigration. Between 1990 and 2010, immigrants contributed about half of total working-age population growth in many advanced economies, and may continue to play an important role in counteracting declining labor forces in advanced economies in the coming years. Immigrants are typically younger than natives, and can bring further productivity gains to the host economy through other channels. New analysis of the effects of immigration on the host country indicates that the gains from immigration may be sizeable (see Appendix VII).[33] A 1 percentage point increase in the share of migrants in adult population is found to raise labor productivity in the host economy by up to 3 percent in the long term through both higher human capital and improved TFP (Figure 19).[34] These effects do not come solely from high-skilled migrants,

[33] The analysis builds on Jaumotte, Koloskova, and Saxena (2016). It controls for the age structure of the working-age population, and thereby recognizes that migrants may increase productivity simply because they are younger than natives. As a result, the productivity gains discussed in this paragraph operate through channels different than age.

[34] The effect is not driven by the increase in the capital-to-labor ratio, because, in the long term, the level of capital adjusts to the larger labor force.

who bring diverse skills and innovation to their new home countries. Low-skilled migrants appear to contribute as well, likely reflecting their skill complementarity with higher-skilled natives (for example, Peri 2016). Moreover, the long-term benefits of migration appear to be broadly shared. The average per capita incomes of both the top 10 and of the bottom 90 percent of earners increase as a result of immigration, although high-skilled immigration benefits top incomes more strongly (possibly due to stronger synergies among high-skilled migrants and high-skilled natives). Key to harnessing these long-term gains, however, is preventing social and political disruptions associated with sizable immigration. Clear and widely accepted immigration policies are essential, as are labor market institutions and active policies that facilitate immigrants' labor market integration. This includes language training and assistance in job search, better recognition of migrants' skills through credential recognition, and lower barriers to entrepreneurship. Challenges in integrating refugees can be particularly acute, as uncertainty about their legal status can delay their employment, potentially resulting in worse labor market outcomes (IMF 2016f).

Figure 19. Projected Working-Age Population and Productivity Gains from Immigration



Sources: United Nations, World Population Prospects, 2015 Revision; Jaumotte, Koloskova, and Saxena (2016); and IMF staff calculations.
Note: Data labels in Panel A use International Organization for Standardization (ISO) country codes. Estimated effect of migration is based on a two-stage least squares approach, where the migration share is instrumented using a gravity-type model of bilateral migration flows. See further details in Appendix VII and Jaumotte, Koloskova, and Saxena (2015).

34. Advancing an open global trade system. Multilateral trade liberalization could provide a productivity boost for all through the same channels that have made the global trade slowdown harmful. IMF research using a historical database of effective tariffs in 18 sectors across 18 advanced economies finds significant productivity gains from liberalization—a 1 percent reduction in input tariffs is found to raise TFP levels by about 2 percent (see Ahn and others 2016; and Dabla-Norris and Duval 2016). Consequently, the increase in TFP from eliminating existing tariffs could be in the order of 1 percent, on average, across advanced economies and significantly larger in emerging and developing economies, where remaining tariffs are higher.[35] Eliminating nontariff barriers would add more sizable additional gains. Trade liberalization would also help boost spillover effects to other countries from innovation at the technological frontier.

[35] These calculations are likely to underestimate the potential gains from trade liberalization because they do not account for the gains that would arise from reallocation of resources across industries.

35. Exploiting synergies between trade, FDI, and other policies. Complementary policies can magnify the gains from trade liberalization. Productivity gains from tariff reductions tend to be higher in countries with less restrictive FDI regimes (Ahn and others 2016). More foreign firms facilitates knowledge diffusion across countries, while also magnifying the benefits of lower trade barriers (as foreign companies tend to use more and better imported inputs—see Halpern and others 2015). This is particularly relevant for the many emerging and developing economies that maintain comparatively strict barriers to foreign direct investment. Likewise, the effect of trade liberalization can be larger if domestic, "behind-the-border" product market regulations are reduced, and if labor market institutions are (re)designed in ways that facilitate swift reallocation of workers across jobs—reforms that, as shown above, would also lift productivity in and of themselves. Such reallocation often entails costs for certain categories of workers, however. Thus, pushing through an ambitious liberalization agenda will require forcefully addressing these adverse labor market and distributive impacts upfront. Tax-benefit systems and active labor market policies—such as job search support and (re)training—have a key role to play in this regard.

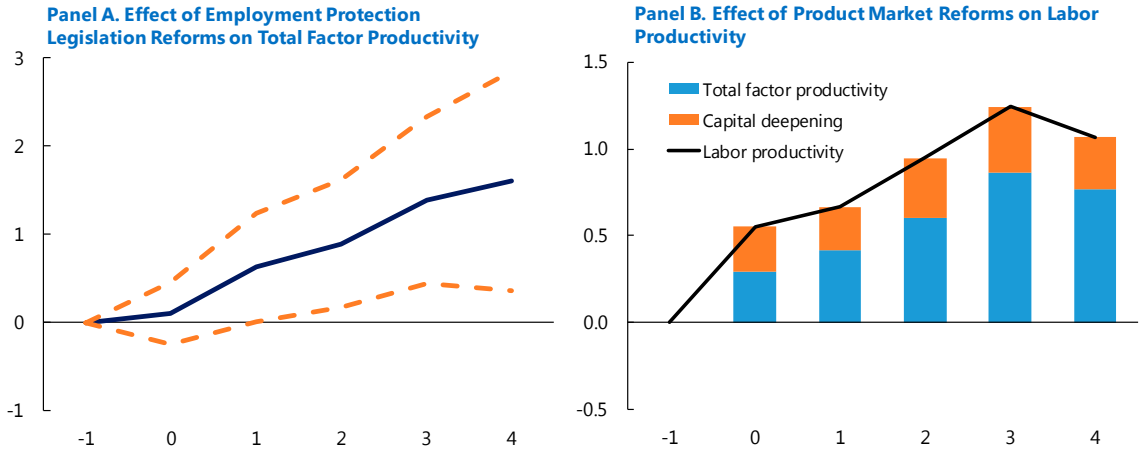
36. Structural reforms. More broadly, advanced economies and emerging and developing economies have considerable scope for pressing ahead with structural reforms. While priorities vary widely across and even within country-income groups, product and labor market reforms often rank high, for example across many European advanced economies and Asian and Latin American emerging markets. Building on the reform database and methodology developed in IMF (2016d), new analysis (see Appendix VIII) indicates that market deregulation in non-tradable sectors can meaningfully enhance labor productivity in the medium term through both higher TFP and capital intensity, with the former accounting for about two thirds of the total effect (Figure 20). Long-term effects are typically larger (see Duval and Furceri 2016). Such reforms do not only facilitate new firms' entry but can also stimulate employment and investment by incumbents (see Bouis, Duval, and Eugster 2016; Gal and Hijzen 2016), while exerting positive spillovers on downstream and upstream industries, including in manufacturing (see Duval and Furceri 2016; IMF 2016d). Services deregulation is even more important for emerging and developing economies, where services account for a growing share of resources and GDP (Dabla-Norris and others 2013b; Rodrik 2015) and regulation remains much stricter than in advanced economies.[36] Likewise, easing employment protection legislation for regular workers can lift TFP by improving allocation of labor across firms and sectors (Figure 20).[37] In addition, product and labor market reforms can help restore external competitiveness through internal devaluation, which might in itself enhance productivity in the presence of economies of scale. Fiscal structural reforms, aimed at improving efficiency in tax system, can also boost firm-level productivity by reducing resource misallocation (IMF 2017; and Banerji and others 2017).

[36] For a recent and broader discussion of the potential gains from structural reforms in Central and Eastern European emerging economies see IMF (2016e).

[37] Employment protection legislation reforms appear to be associated with a fall in the capital-to-labor ratio, however, reflecting lower labor costs and the consequent substitution of labor for capital.

Figure 20. Effect of Product and Labor Market Reforms

(Percent)



Sources: Penn World Table 9.0; Duval and others (forthcoming); and IMF staff calculations.
Note: Years after the shock on the x-axis, t = 0 is the year of the shock. Dashed lines denote 90 percent confidence bands. Capital deepening is defined as the difference between log labor productivity and log total factor productivity. The effects are estimated using local projections method (Jordà 2005), controlling for lagged growth, past reforms, crisis dummies and using a bias correction suggested by Teulings and Zubanov (2014). See further details in Appendix VIII.

37. Raising the quantity and quality of human capital. Finally, scope exists for mitigating or reversing the slowdown in human capital accumulation. In many emerging and developing economies, tax and public spending reforms could free up space for higher investment in education and health, adding to another form of capital and source of productivity growth (IMF 2015b). In advanced economies, still-high private returns to tertiary education (Boarini and Strauss 2010) continue to incentivize investment in human capital. Nonetheless, enrollment has slowed and access remains unequal in most countries, with high and rising tuition costs in a number of cases. Raising enrollment, including by maintaining moderate access costs, would benefit productivity and equity. In both advanced and emerging and developing economies, improving the quality of education is at least equally important. This calls for education policy reforms to enhance service delivery and policy actions to reduce the skills mismatch in the labor market (OECD 2016; World Bank, forthcoming).

FINAL REMARKS

38. As the key source of progress in living standards over the long term, persistently sluggish TFP growth is an obvious source of concern. While the debate about future productivity remains unsettled, and underlying forces in emerging market economies and low-income countries need to be better understood, our analysis indicates that the global slowing of productivity growth reflects not only structural factors, but also scars from the global financial crisis. The latter—weak corporate and bank balance sheets that are tilting investment away from high-return but high-risk projects, elevated economic policy uncertainty, persistently sluggish demand feeding into slower capital-embodied technological change—afflict many advanced economies, particularly in Europe. Some of these factors, such as policy uncertainty and weaker investment, may have also been at play more recently in some emerging market economies and low-income countries. It is conceivable that a new leap in innovation, driven by major breakthroughs in artificial intelligence or other general purpose technologies, will raise TFP growth in the medium term. If not, or until then, however, a return to a healthy pace of productivity growth appears difficult to achieve without policy action. Thus, renewed efforts to tackle the legacies of the global financial

crisis, especially in continental Europe, while simultaneously addressing the secular forces behind the longer trend of slowing productivity growth, are paramount to reviving growth.

39. Policies addressing crisis legacies and more secular headwinds can be mutually supportive. For example, lifting future potential growth—through R&D tax incentives, infrastructure spending, or migration and trade policies—would raise expectations of demand and investment returns, helping support current investment and capital-embodied technological innovation. Conversely, policies geared towards boosting domestic demand and investment in the short term—including through balance sheet repair—would create economic and political conditions more conducive to implementing structural reforms with high long-term productivity payoffs. A comprehensive approach is best suited for breaking the adverse feedback loops and addressing the current cycle of low output and productivity growth.

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