

**FOR
INFORMATION**

EBS/21/46

May 27, 2021

To: Members of the Executive Board

From: The Secretary

Subject: **G20 Note on Boosting Productivity in the Aftermath of COVID-19 and Online Annex**

Board Action: Executive Directors' **information**

Publication: Yes, after Wednesday, June 2, 2021

Additional Information: The attached note has been prepared at the request of the G20 Framework Working Group.

Questions: Ms. Christiansen, RES (ext. 36975)
Ms. MacDonald, RES (ext. 38806)
Mr. Habib, RES (ext. 39486)



GROUP OF TWENTY

BOOSTING PRODUCTIVITY IN THE AFTERMATH OF COVID-19



Prepared by Staff of the
INTERNATIONAL MONETARY FUND*

*Does not necessarily reflect the views of the IMF Executive Board

May 2021

CONTENTS

EXECUTIVE SUMMARY	3
THE CRISIS HAS ACCELERATED DIGITALIZATION	4
WILL FASTER DIGITALIZATION LIFT PRODUCTIVITY?	8
WILL REALLOCATION HELP PRODUCTIVITY?	9
WILL HUMAN CAPITAL BE PERMANENTLY IMPACTED?	14
POLICY ACTION IS NEEDED TO BOOST PRODUCTIVITY	16
A. Support Investment in Intangible Capital	16
B. Boost Productivity-Enhancing Reallocation	19
C. Ease the Burden on Workers from Job Displacement and Reallocation	21
BOX	
1. Will COVID-19 Worsen Mismeasurement of Productivity?	23
FIGURES	
1. Automation and Digitalization	4
2. Digitalization of Labor	4
3. Tech's Equity Performance	5
4. Spending During COVID-19	5
5. New Remote-Work Technologies	5
6. Expectations for Digitalization	6
7. Mapping Aggregate TFP Growth	6
8. Trends in Intangible Capital	8
9. Investment and Productivity	8
10. Reallocation and Productivity	10
11. COVID-19 Business Churn	11
12. Rising Market Concentration	12
13. Changes in and Decomposition of Labor Productivity	13
14. Earnings Loss from Job Change	14
15. Employment Loss by Vulnerability to Automation and Skill Level	15
16. Structural Policies and Intangibles	18
17. Insolvency and Reallocation	19
18. Retention and Reallocation Policy	20
19. Skill Levels Across Countries	22
REFERENCES	24

Prepared under the supervision of Oya Celasun by a team led by Lone Christiansen and comprising Ashique Habib, Jaden Kim, Davide Malacrino, Margaux MacDonald (principal economist), Menexenia Tsaroucha, and Bryan Zou. Ilse Peirtsegaele provided administrative support. The paper does not necessarily reflect the views of G-20 members. G-20 notes by the IMF are available on [IMF.org](https://www.imf.org).

EXECUTIVE SUMMARY

The COVID-19 pandemic is changing the way we work and spend, including with highly uneven impact across people. This note discusses how the pandemic is influencing digitalization, resource allocation, and human capital accumulation, and how policies should be designed to enhance productivity and inclusiveness.

- *Digitalization has picked up, which could boost productivity.* Amid the need to reduce in-person interactions, the pandemic has propelled investment in intangibles, especially digital technologies, which has likely helped mitigate productivity losses stemming from measures to cope with the virus. In some cases, it may have made firms more productive. If it were to continue, faster digitalization may boost aggregate productivity. Yet, weakened balance sheets in the aftermath of the crisis can inhibit some firms from investing in intangible capital, which is particularly sensitive to credit conditions. Hence, any boost to digitalization and productivity could be short lived and uneven. Moreover, if such investments are concentrated in a few large firms, raising their market power, innovation and productivity may actually suffer over the longer run.
- *The crisis can also affect the allocation of capital and labor across firms and sectors, with ambiguous effects on productivity.* First, the flow of resources toward more productive firms normally lifts economy-wide productivity. In this respect, some reallocation of resources toward more digitized firms may occur. Yet, a prolonged crisis with extended need for policy support to help protect jobs and livelihoods could keep resources in less productive firms, holding back aggregate productivity growth. Second, the shift in demand away from in-person services (e.g., restaurants, tourism, brick-and-mortar retail) and toward digital solutions (e.g., e-commerce) suggests that some resource reallocation across sectors may take place. While some sectors could rebound (e.g., tourism), others may be permanently changed (e.g., retail), rendering lasting productivity impacts uncertain.
- *Skill gaps may present challenges.* Some jobs vulnerable to automation or in contact-intensive activities may never come back, potentially triggering large job losses and requiring people to search for work in different sectors where new skills may be needed. Many people may face prolonged unemployment, eroding their skills and future productivity, and new entrants may face long-term lower earnings. School closures during the pandemic may impact human capital.

A combination of policies can help support post-pandemic productivity growth. First, it will be important to support adequate access to financing for viable firms seeking to invest in productivity-boosting intangible capital. Second, once the constraints brought by the pandemic begin to ease durably, it is paramount that resources can flow to the most productive firms and those facing higher demand, including by gradually phasing out job retention schemes. Efficient bankruptcy procedures and well-designed employment protection laws will be key for freeing up resources in unviable firms and facilitating reallocation toward viable, productive firms, together with measures to promote competition and prevent increases in market power that can harm productivity in the longer run. Resolute efforts to reskill workers who have lost their jobs, including through on-the-job training, will help support inclusiveness as well as help boost human capital and strengthen potential growth. Ensuring broad-based access to digital technologies and internet connectivity for both firms and workers will help ensure that gains from digitalization can be leveraged everywhere.

THE CRISIS HAS ACCELERATED DIGITALIZATION

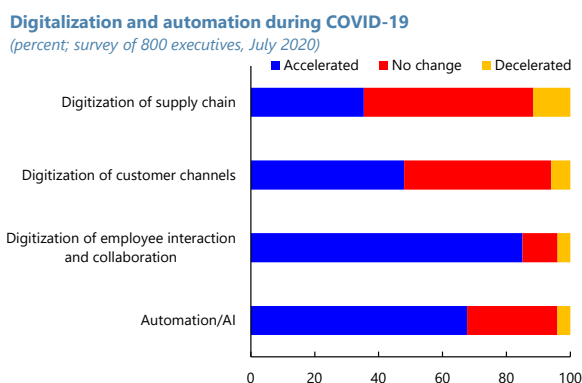
The COVID-19 pandemic is changing the way we work and spend. How will these changes affect productivity, which was sluggish in the decade leading up to the pandemic? While forecasting long-run productivity is particularly difficult in the current environment, this note examines how the pandemic might influence productivity through its impacts on digitalization and the allocation of labor and capital and discusses how policymakers can help boost productivity and ensure that gains are broadly shared.

1. The drive to reduce in-person interactions during the COVID-19 pandemic has put a premium on digitalization and automation. Already prior to the pandemic, broad adoption of information technology (IT) and labor saving automation rendered some jobs obsolete—particularly those involving low- and middle-skill routine tasks, as discussed in the G-20 Note on *The Future of Work*.¹ Since the onset of the pandemic—and even more than in other recessions—digitalization and automation have accelerated, in part because such adoption helped reduce the need for physical contact (Figure 1).² Moreover, the pandemic has prompted a shift toward working remotely—as much as half of firms in some sectors in the *United Kingdom* have seen an increase in remote work during the crisis (Figure 2). Demand for digital solutions, which are a subset of the broader intangible assets category, has risen (e.g., video and communications technologies; cloud-based transactions and service provision; interactive digital fitness; e-commerce; cloud-based identity verification technologies). The heightened demand for software and digital platforms that enable remote-work and the digital delivery of services is evident in the dramatic valuation gains during 2020 of major firms producing these products (Figure 3).

¹ IMF (2018a).

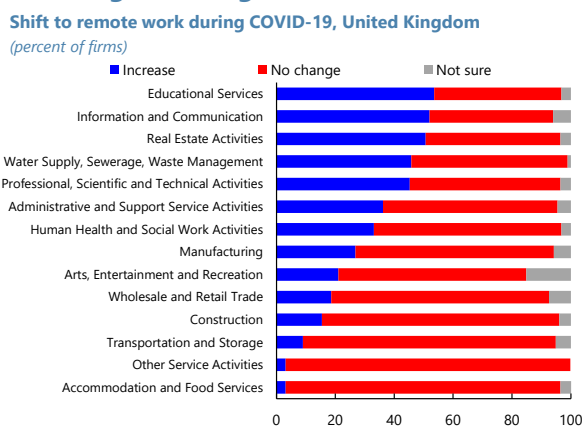
² Hershbein and Kahn (2018) show that recessions accelerate the restructuring of production toward routine-biased technologies and the skilled workers that complement them; Jaimovich and Siu (2020) show evidence that the majority of employment losses in routine occupations occur during economic downturns and, relatedly, jobless recoveries can be explained by a lack of job recovery in the routine occupations lost during the downturn.

Figure 1. Automation and Digitalization



Source: McKinsey Global Business Executive Survey, July 2020.

Figure 2. Digitalization of Labor



Sources: Office for National Statistics—Business Insights and Conditions Survey.

Note: Bi-weekly survey (January 4–18, 2021) of about 40,000 firms in the *United Kingdom*; response to the question “Has your business had more staff working from home as a result of the coronavirus (COVID-19) pandemic?”

2. Consumer spending patterns have also shifted—from in-person services toward digitally-delivered services and durable goods. During 2020, spending on services declined by almost 2 percent of GDP on average across the G-20, with especially large declines in spending on the arts, entertainment, tourism, and hospitality. In contrast, demand for durable goods rose by 0.4 percent of GDP in the second half of 2020 on average across G-20 economies (Figure 4) and spending on e-commerce (in percent of total retail sales) rose by over 5 percentage points in the *United States* and *China* and by over 10 percentage points in the *United Kingdom*.³ The substitution was not full, however, as evidenced by an 8 percentage points increase in household saving rates in 2020 on average across large G-20 advanced economies.⁴

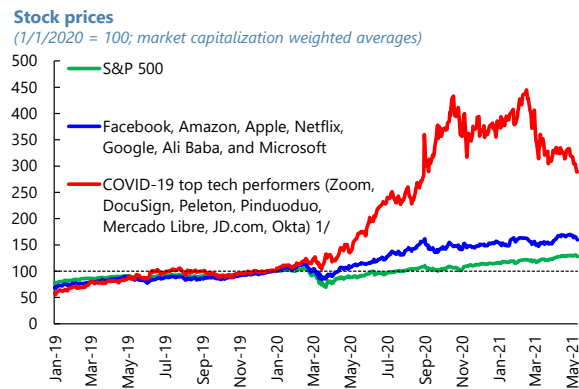
3. Forward-looking indicators suggest technology adoption will remain strong in the near term.⁵ Evidence to date points to a sharp rise in innovation to facilitate remote work and e-commerce, as measured by new patent applications for technologies that facilitate these activities (Figure 5). In fact, the average annualized monthly rise in patent applications related to work-from-home activities more than doubled to about ½ percent in 2020 from less than ¼ percent during 2015–19. For e-commerce technologies, growth in patent applications rose to a rate of 1 percent on average (monthly, annualized) in 2020. Survey results from the *United States* also suggest that many companies expect a further digitalization of sales to come (Figure 6).

³ OECD (2020).

⁴ Based on savings rates in *Australia, Canada, France, Germany, and the United States*.

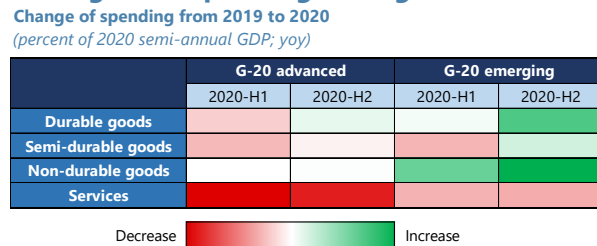
⁵ Bloom and others (2021).

Figure 3. Tech's Equity Performance



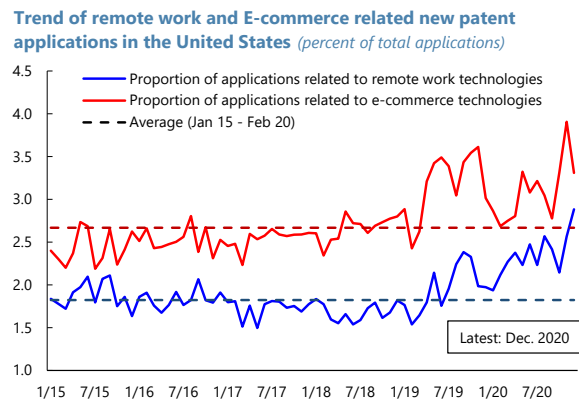
Sources: Bloomberg; and IMF staff calculations.
 1/ Highest performers on NASDAQ100 in 2020 related to work-from-home or remote commerce.

Figure 4. Spending During COVID-19



Sources: OECD; IMF, *World Economic Outlook*; IMF staff calc.

Figure 5. New Remote-Work Technologies



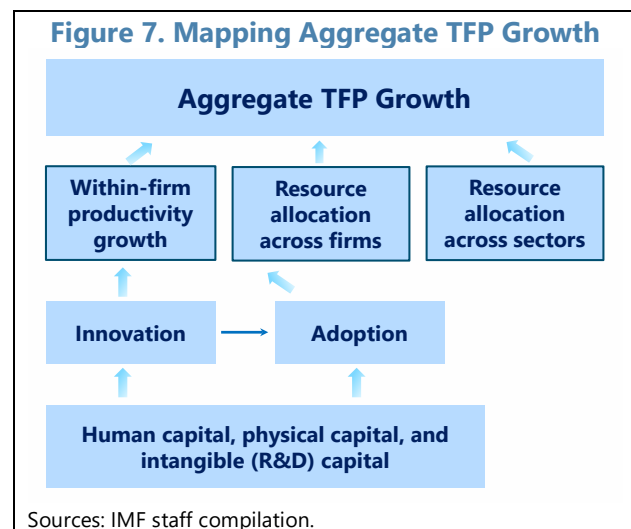
Sources: USPTO; and IMF staff calculations.
 Note: Non-provisional utility and plant patent applications only. Based on methodology in Bloom and others (2021).

4. The increase in technology adoption follows a slowdown in productivity growth prior to the pandemic in many economies. In G-20 advanced economies, average total factor productivity (TFP) growth fell from 0.7 percent before the global financial crisis to 0.3 percent afterwards.⁶ In G-20 emerging market economies, it declined from 1.8 percent to 0.6 percent.⁷ Though the full set of drivers of the slowdown are not yet fully understood, several factors likely played a role, including slow adoption of new technologies that may have led to missed opportunities;⁸ the possibility that new digital technologies may be less immediately productivity-enhancing than their tangible predecessors;⁹ difficulties in accurately measuring observed productivity growth (Box 1), along with other factors dampening investment since the global financial crisis (e.g., elevated policy uncertainty, weak corporate balance sheets in some market segments, declining firm dynamism, and limited access to credit).¹⁰



5. The pandemic could affect productivity through several channels (Figure 7).

- *Within-firm productivity growth through innovation and technology adoption.* Technology adoption, including to enable remote-work, and automation may help boost productivity for individual firms.¹¹ That said, negative impacts on productivity could occur from widespread remote work if digital communication tools prove less effective than in-person interactions or if peer learning suffers. Financing constraints or heightened uncertainty around the persistence of the crisis may also deter investments in innovation and technology adoption.



⁶ The report discusses at various points TFP and labor productivity depending on data availability.

⁷ Averages are for 2000–05 and 2011–18 (excluding crisis years) and using real PPP GDP weights.

⁸ Brynjolfsson and others (2018).

⁹ Gordon (2017, 2018).

¹⁰ IMF (2015); Adler and others (2017); Baker and others (2014); Aghion and others (2012).

¹¹ di Mauro and Syverson (2020).

- *Reallocation between firms.* In general, the output to be gained from adding an extra unit of labor and capital differs across firms; and the more capital and labor are reallocated to firms with the highest returns to additional inputs, the higher aggregate productivity will be. At the same time, recessions can affect the extent and efficiency of reallocation in various ways, and in this regard, the impact of the COVID-19 pandemic is not yet known. On the one hand, firms with an advantage in adopting and using digital technologies have likely enjoyed competitive advantages, attracting labor and capital, which may help lift economywide productivity if they are characterized by high marginal returns to capital and labor. On the other hand, financial lifelines to firms during the crisis, which helped avoid an even deeper recession, may have slowed the exit of unproductive firms and may hold back aggregate productivity growth going forward.¹²
- *Reallocation between sectors.* The COVID-19 crisis has seen a shift in demand, away from spending on services that require in-person interaction and toward digitally delivered goods and services. In this regard, a reduction in the size of sectors where output per worker tends to be relatively low will result in higher aggregate productivity in light of changes in the relative weights of sectors across the economy. Moreover, as output per worker tends to be higher in expanding sectors, and to the extent that shifts in the composition of demand persist, such shifts would tend to increase economywide output per worker.¹³
- *Human capital.* While adoption of new technology, increased automation, and a shift toward activities with higher output per worker may benefit productivity, they can also trigger job losses and prolonged, skill-eroding unemployment. In this respect, people taking up new jobs after an extended period of unemployment may initially be less productive, especially if they become employed in new occupations that require substantial reskilling. The pandemic has also prompted mass school closures and interruptions for children and has had potential adverse implications for health more broadly—factors that could weigh on productivity over the longer term.

6. This note discusses how the pandemic is influencing digitalization, resource allocation, and human capital accumulation, and how policies should be designed to enhance productivity and inclusiveness. The world still has much to learn about the implications of the crisis, including the extent to which pandemic-induced adaptations regarding how we live and work have mitigated productivity losses and potentially enhanced productivity. Nonetheless, evidence from the past, combined with what has been observed during the crisis so far, can provide valuable information for policymakers to support productivity and strengthen growth and inclusion.¹⁴ The first section of this note examines the growing importance of investment in intangible capital for productivity growth. The second section looks at how the crisis may impact the allocation of capital and labor across sectors and firms, and how productivity may be affected as a result. The third section discusses the likely impact of the crisis on human capital and skills. Finally, the fourth section discusses policies to help leverage opportunities for boosting productivity in the aftermath of COVID-19.

¹² The counterfactual of no lifelines would likely have led to widespread bankruptcies, including of viable firms. If these viable firms were also highly productive, aggregate productivity would have fallen also in this scenario.

¹³ Bannister and others (2020).

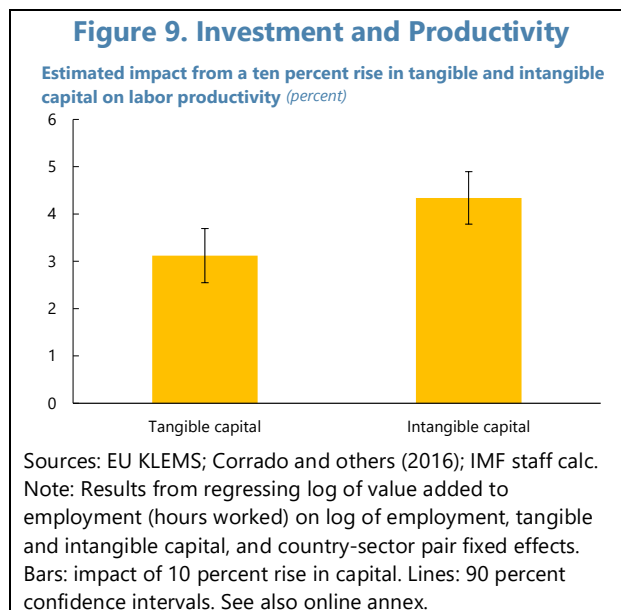
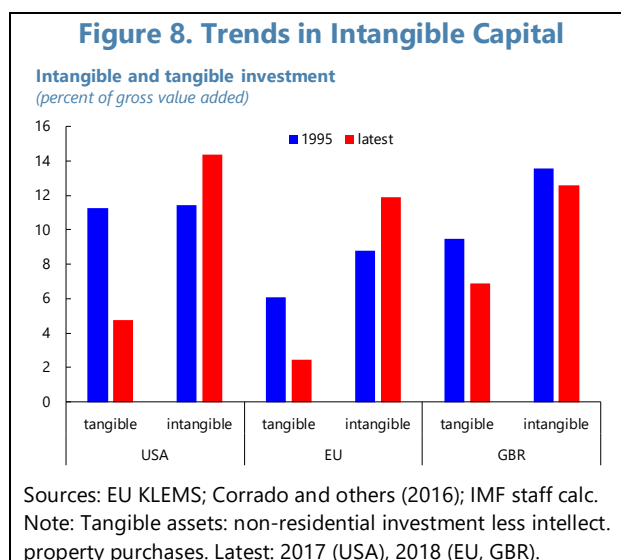
¹⁴ Due to data limitations, much of the empirical analysis relies on data for G-20 advanced economies.

WILL FASTER DIGITALIZATION LIFT PRODUCTIVITY?

Investment in intangible capital has been an important driver of productivity growth during the last two decades. The acceleration during the crisis of digital technologies, which are an important component of intangible capital, could thus help lift productivity growth if persistent. However, as investment in intangibles is sensitive to credit conditions, post-crisis balance sheet health and financial conditions can influence how strong and broad-based such a lift may be.

7. Investment in intangible capital has risen substantially in recent decades. Intangible capital assets are broad and cover (i) brand, organizational capital, and training (“economic competencies”); (ii) research and development, design, arts and mineral exploration, and financial innovation (“innovative property”); and (iii) software and databases (“computerized information,” including digital technologies).¹⁵ As digital technologies are categorized within intangible assets in the national accounts data, this note uses the broader category of intangible assets for the analysis. In addition to being directly beneficial to performance, some types of intangible capital can also indirectly support more effective use of tangible capital and workforce skill upgrades.¹⁶ For instance, organizational change and training are often needed to realize productivity gains from tangible information and communications technology (ICT) investment. In turn, intangible assets have been steadily increasing in importance (Figure 8). In some major G-20 advanced economies, investment in intangible capital now accounts for more than 10 percent of value added—a larger share than investment in tangible capital.

8. Intangibles have also become an important contributor to productivity growth. Investment in intangible capital is significantly associated with higher labor productivity (Figure 9). Estimates from a regression of 15 countries over 1995–2016



¹⁵ Classification as in Corrado and others (2016).

¹⁶ These may occur with a lag (Bresnahan and others, 2002; Corrado and others, 2017; Brynjolfsson and others, 2021).

suggest that a ten percent rise in intangible investment is associated with about a 4½ percent rise in labor productivity, while a boost in tangible capital is associated with a rise in productivity of about 3½ percent.¹⁷ The strong positive impact of intangible investment on productivity likely reflects the role of intangible capital in improving efficiency and competencies or enhancing other characteristics that increase firms' output or valuation without the need for investment in new physical capital.¹⁸

9. Yet, investment in intangibles is highly sensitive to financing conditions and typically suffers during recessions involving tight credit conditions. Financing conditions are critically important for firms' intangible investment, since intangible capital is generally non-pledgeable as collateral, rendering its financing more costly than that of tangible investment. Moreover, this difference tends to widen during recessions that are characterized by tight credit conditions as creditors become more risk averse, and, hence, investment in intangible capital declines relative to its pre-recession level—and more so for firms that are more financially constrained.¹⁹

10. Moreover, there are other factors that may hold back a broad-based increase in investments in intangibles after the pandemic. While a financial crisis has been avoided so far during the pandemic, to the extent the downturn is prolonged, uncertainty stays high, and some degree of social distancing remains necessary for an extended period, individual firms' balance sheets may nonetheless become increasingly strained, holding back investments in intangibles and digital technologies and weighing on productivity of those firms.²⁰ Higher corporate tax rates could potentially also hold back some intangible investment through their impact on the cost of investment. As many firms may be constrained in their ability to invest, potential implications also include increased market concentration, with potential adverse effects on innovation as discussed below. As such, while digitalization offers upside potential for productivity after the pandemic, it is also possible that its overall impact on economywide productivity will disappoint amid factors holding back a broad-based, sustained increase in investment in intangible capital.

WILL REALLOCATION HELP PRODUCTIVITY?

The pandemic will likely entail some degree of reallocation across firms and sectors, as the most efficient firms likely attract additional resources and pandemic-induced shifts in demand entail changes in the relative composition of output across sectors. While some of these sectoral shifts in demand could prove temporary, lasting impacts on economywide productivity could still arise from the reallocation of resources between firms. Relatedly, the impact on economywide productivity will also depend on the fate of low-performing firms that were kept alive by policy support during the crisis and on whether market power will rise after the pandemic, potentially putting a damper on innovation down the road.

¹⁷ Given that TFP is in the error term but also potentially correlated with investment in tangible and intangible capital, these estimates may be biased. However, they are broadly consistent (if slightly larger) with contributions of intangible capital to productivity found in the literature (e.g., van Ark and others, 2009; Roth and Thum, 2013).

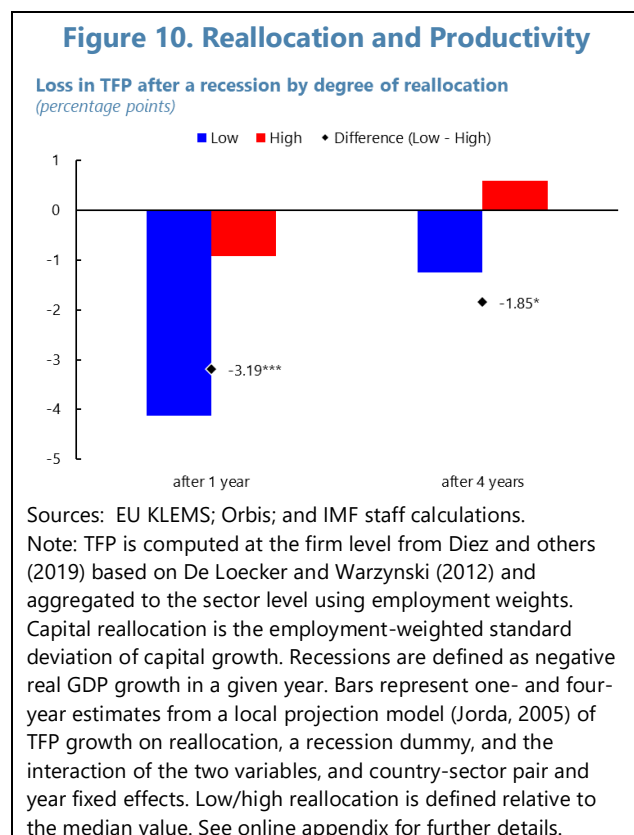
¹⁸ Crouzet and Eberly (2018).

¹⁹ Ahn and others (2020); Manaresi and Pierri (2018).

²⁰ Ahn and others (2020).

11. With well-functioning capital markets, the reallocation of resources toward more efficient firms, such as within a sector, helps raise aggregate productivity. Such reallocation may occur within a sector either between incumbent firms or through the entry and exit of firms. The essential mechanism is that firms with relatively high marginal product of labor and capital expand and those with a low marginal product of labor and capital shrink or exit, creating selection-driven aggregate productivity increases.²¹ This is often characterized by the exit of existing small firms—as larger firms tend to be more productive—and the entry of new firms, as young fast-growing firms often are highly efficient and, thus, help boost aggregate productivity growth.²² However, business dynamism—the pace of entry and exit of new firms—in advanced economies has declined since the 1990s alongside a decline in productivity growth, suggesting that the churn of resources across firms may have become a less important source of productivity growth.²³

12. Reallocation of labor and capital across firms tends to cushion the hit to productivity during recessions. Recessions typically entail some decline in TFP, but the loss is smaller during recessions that entail greater reallocation within sectors. An analysis based on firm-level data covering 19 countries over 20 years shows that sectors in which capital and labor reallocate to a greater extent experience a significantly smaller decline in TFP during a recession. Four years after the recession, TFP recovers above its pre-recession level in sectors with above-average reallocation during the recession, while it remains below its pre-pandemic level in sectors with below-average reallocation (Figure 10). While causality is hard to pin down, this inverse relationship between reallocation and TFP losses is suggestive of a reallocation during recessions that favors a shift of labor and capital to firms where their marginal product is relatively higher.



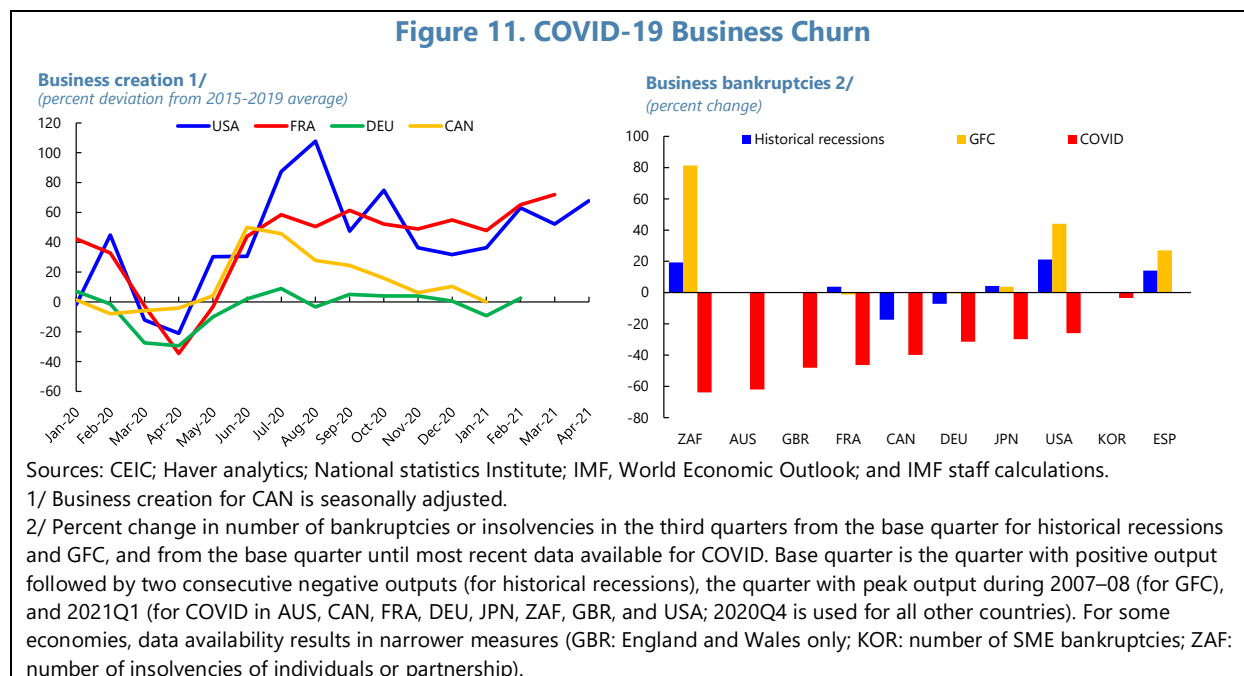
13. Going forward, the productivity impact of the crisis will depend in large part on the extent to which labor and capital will flow to firms where their marginal product is the highest. So far during the crisis, evidence from some large economies points to a measurable rise in new firm creation in 2020, which may indicate some ongoing reallocation of labor and capital towards firms

²¹ Foster and others (2008) and references therein.

²² Fort and others (2013).

²³ Decker and others (2016).

with high growth potential (Figure 11, left panel).²⁴ Recent surveys also indicate reallocation towards more digitalized and highly-productive incumbent firms.²⁵ That said, evidence on reallocation patterns and efficiency remains lacking for most G-20 economies and in all economies much is still to be learned about the extent of reallocation. For example, if reallocation between firms is held back, either because of rigidities in shifting resources between incumbent firms or because of the presence of financing constraints or other obstacles that prevent the entry of new firms, potential gains for aggregate productivity may not be realized. Moreover, labor market rigidities in some economies may slow reallocation in these economies, with smaller resulting productivity gains.



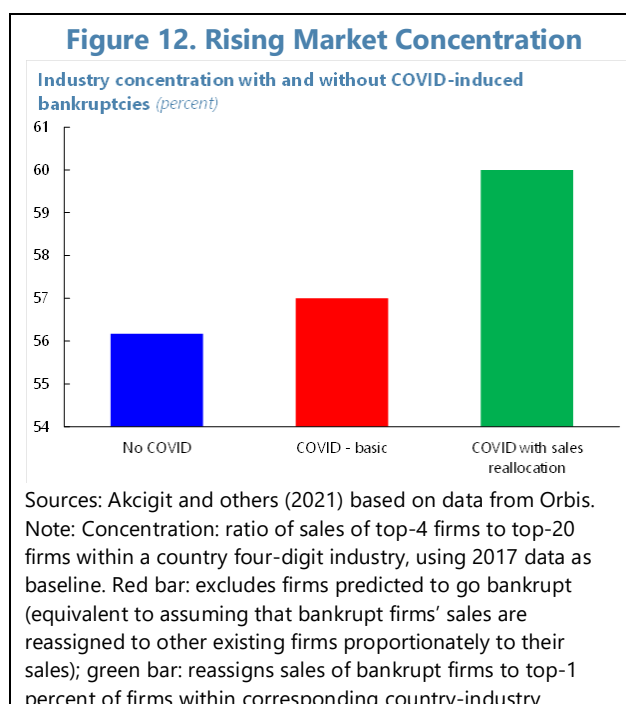
14. Productivity growth in the aftermath of the crisis may also be held back by the possible presence of weak firms that have been kept alive with policy support. To avoid mass bankruptcies during the crisis, which would have resulted in an even deeper crisis, vital policy support for firms were provided across the G-20. In turn, insolvency rates have so far been lower during the pandemic than during previous recessions (Figure 11, right panel). However, partly as a result of difficulties in optimal targeting of the support and amid a crisis that is still ongoing, prolonged undifferentiated financial support to firms (as opposed to targeted support to viable but insolvent firms) may inhibit the shift of labor and capital to firms where their marginal product is relatively higher, which often happens during recessions—with the permanence of such effect depending on whether the bankruptcies that ensue once policy support is withdrawn are of the most inefficient firms. Alongside, weak debt

²⁴ Prior research indicates that small young firms often have high job creation rates and, hence, support the recovery (Ayyagari and others, 2011). Data on the growth potential of new businesses created during the pandemic is very limited, though preliminary data suggest some cross-country variation: *French* data show few new businesses hiring employees (Insee Premiere No. 1837, “A New Record for Business Births in 2020 Despite Health Crisis”) while *US* data point to a large share of new firms having a high propensity to turning into businesses with payroll (US Census Bureau, Business Formation Statistics Monthly Reports).

²⁵ See for example Bloom and others (2020) for the *United Kingdom*.

restructuring mechanisms that slow down the reallocation of capital toward firms with a higher marginal product of capital may also hold back reallocation and dampen potential productivity gains.

15. Another concern is the risk of a rise in market concentration in the aftermath of the pandemic, potentially holding back innovation and productivity growth over time. Key indicators of market power (e.g., markup of prices over marginal costs; revenue concentration) are rising across many industries, continuing the trends seen in advanced economies in recent decades. In those sectors that have benefited most from the crisis, like digital services, already-dominant firms have performed better. Recent estimates suggest that, as a result of COVID-19, concentration could increase by at least as much as it did during 2000–15 in advanced economies (Figure 12).²⁶ While strong profits have historically been the result of firms displacing incumbents through innovation and efficiency, an entrenched increase in market power could hurt innovation and, over time, productivity.^{27 28}



16. Shifts in the share of labor and capital employed in different sectors resulting from shifts in demand can also impact aggregate productivity. In general, shifts in resources across sectors occur slowly over time (e.g., an expansion of the service sector in advanced economies over time while the manufacturing sector shrunk) as well as cyclically (e.g., demand for durable goods has often dipped temporarily during past recessions). As output per worker varies across sectors (with highly capital-intensive sectors exhibiting a high level of output per worker), the expansion and decline in the shares of labor and capital in different sectors can thus affect aggregate output per worker. Notably, a decline in sectors with relatively lower levels of output per worker will result in higher economywide productivity, while a shift in resources from one sector to another will lift productivity to the extent that the marginal product of labor is relatively larger in the expanding sector.

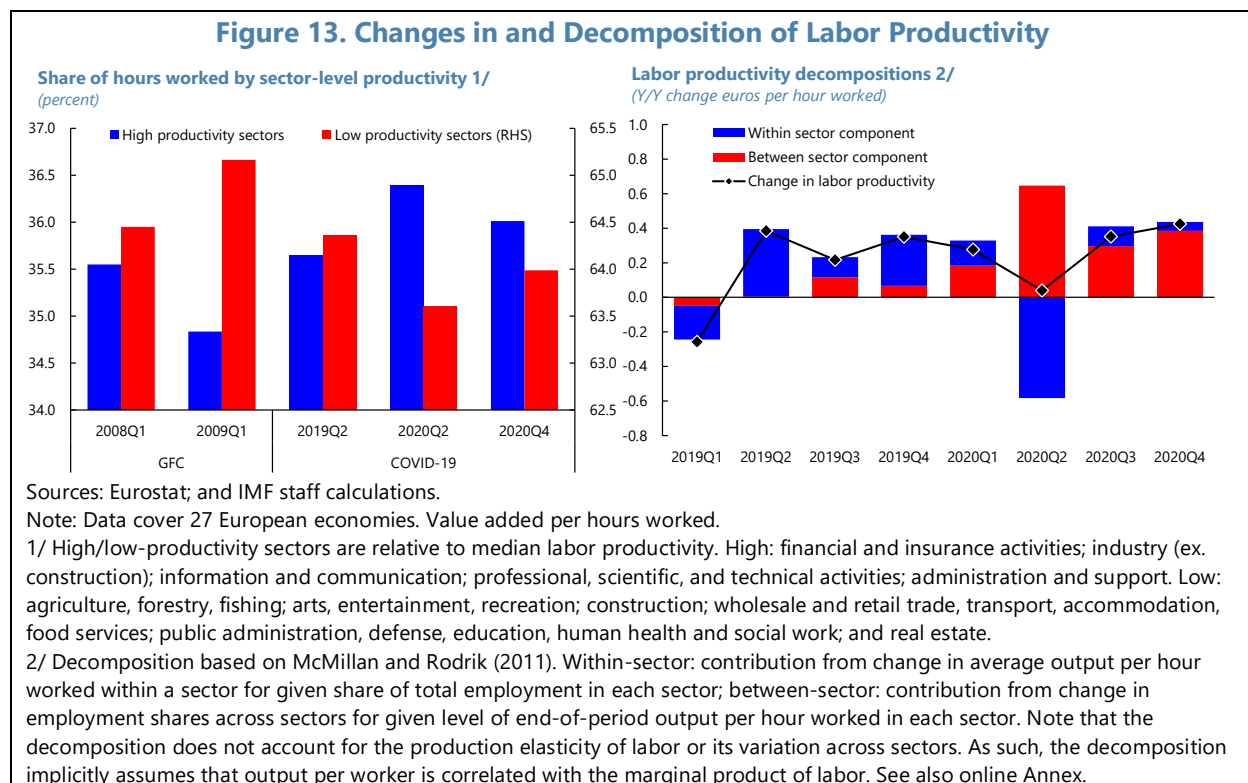
17. In this respect, aggregate labor productivity increased during the pandemic as employment losses were concentrated in sectors where output per worker were relatively low, but at the cost of very high unemployment in many countries. While in 2020Q4, output per worker

²⁶ Akcigit and others (2021).

²⁷ IMF (2019),

²⁸ The causal link between rising market power and declining productivity is not always direct, as lower competition may blunt incentives to innovate, while higher profits and economies of scale may make it easier to do so. Andrews and others (2016) find productivity divergence between frontier and lagging firms remains after controlling for markup behavior and suggest that rising productivity gaps reflect technological divergence. Ahn and others (2020) show monopoly rents can boost intangible investment. See also Liu and others (2020); Dabla-Norris and others (2015).

in the average sector stood barely above its level a year ago, the relative composition of economywide employment shifted away from sectors with relatively low levels of output per worker and toward sectors with relatively high output per worker—owing to a decline in employment in contact-intensive sectors, in particular the arts, entertainment, and recreation (Figure 13). For instance, In the *United States* during 2020, personal consumption expenditure in the service sector fell by over 7 percent and the number of persons employed fell by over 20 percent in a subset of the hardest hit service sectors; in contrast, the manufacturing sector saw personal consumption expenditure rise by almost 4 percent and the number of persons employed fall by about 4½ percent. This change in composition contrasts with what happens in a typical recession, when sectors with relatively high levels of output per worker (e.g., durable goods manufacturing or construction) lose more jobs than services where output per worker tends to be lower on average.²⁹ However, such compositional shifts do not signify a large change in the productivity of workers—rather, the improvement in aggregate output per worker during 2020 has come with a very large unemployment cost. Moreover, some portion of these shifts are likely to prove temporary, as many service industries will likely rebound once the need for social distancing subsides. The degree to which these forces offset one another is not yet known.



18. In sum, the impact of reallocation so far looks beneficial for productivity, but much remains to be learned and it is associated with several concerns. Preliminary evidence points to

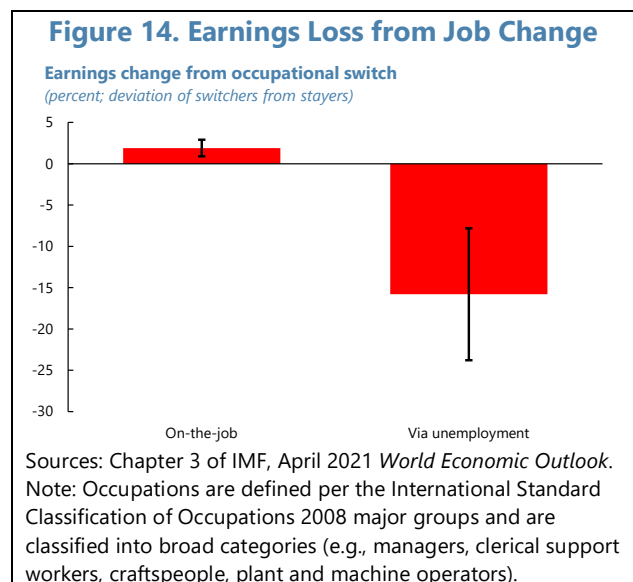
²⁹ For instance, during 2007–10 (during and after the global financial crisis) in the *United States*, the manufacturing sector saw personal consumption expenditure and employment fall by over 5 and 18 percent, respectively, while in the service-providing sectors, personal consumption expenditure rose by 0.6 percent and employment fell by only 2½ percent (U.S Bureau of Labor Statistics).

some degree of firm creation in several economies and there are indications that firms with relatively high levels of productivity are attracting resources. Moreover, the change in relative employment shares across sectors has benefitted sectors, which tend to have higher levels of output per worker—though this shift may be partly temporary and has come at the expense of large job losses. Nonetheless, concerns and open questions remain: evidence and details on the extent and lasting effect of reallocation, both within and across countries, remains sparse; policy support may have held back the typical shift of resources to firms where their marginal product is relatively higher usually observed during recessions; once failures do occur, capital may in some economies be “locked in” for a long period by lengthy bankruptcy procedures; and market concentration may increase, with potential impact on innovation and investment in intangibles and, hence, productivity going forward.

WILL HUMAN CAPITAL BE PERMANENTLY IMPACTED?

The COVID-19 shock has led to a sharp decline in employment in sectors and occupations vulnerable to automation. To the extent that these jobs do not come back, workers will need to find new work and acquire new skills. Prolonged unemployment, combined with extended disruptions to schooling for the next generation of workers, can come at a high cost to human capital and longer-term productivity.

19. Workers suffer a lasting negative impact on earnings after spells of unemployment, likely reflecting a decline in their productivity. Analysis in the IMF’s April 2021 *World Economic Outlook* shows that, relative to workers who stay in an occupation, a worker’s earnings decline if he/she joins a new occupation after a period of inactivity or unemployment, in contrast to a gain in case of an on-the-job switch (Figure 14). Transitions through unemployment tend to be more common for lower-skilled workers and increase the likelihood of needing to switch occupations—which may require new skills. All in all, the evidence is consistent with a lack of skills needed for the job, following spells of unemployment.³⁰

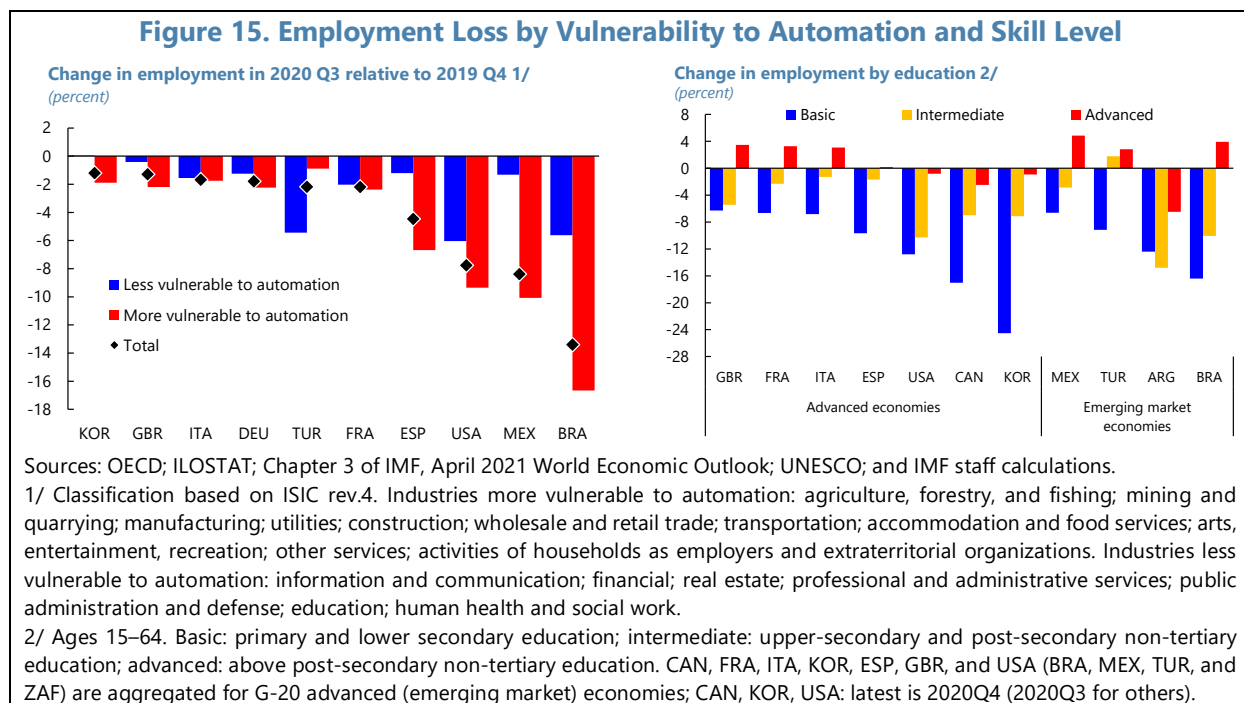


20. So far, the crisis appears to be accelerating automation. Historically, employment losses in middle-skill routine occupations accelerated during downturns.³¹ For instance, the so called “jobless recoveries” from previous US recessions were driven by contractions in routine occupations, which

³⁰ IMF (2021b).

³¹ Jaimovich and Siu (2020).

account for about 50 percent of total employment, that are never recovered.³² More recently, the COVID-19 shock has also hit sectors that are more vulnerable to automation much harder and lowered the share of low-skilled and low-wage workers in the workforce (Figure 15).³³ As we look ahead, the productivity and earnings of low-skilled workers that have lost their jobs in sectors vulnerable to automation are therefore at risk, and averting a further polarization of labor market outcomes would thus take determined and comprehensive measures to reskill and reemploy the affected workers.³⁴



21. In addition to the adverse impact on vulnerable workers today, the current crisis has harmed the next generation of workers. School closures affected 1.6 billion learners globally at the peak of the pandemic and continue to disrupt learning for millions. These disruptions had disproportionately adverse impacts on schooling in economies with preexisting gaps in infrastructure (such as access to electricity and internet), which constrained their ability to implement remote learning.³⁵ Girls and learners in low-income households faced disproportionately greater risk of learning losses as they lost a boost from peer-effects that occur in school and may have been less likely to have parental support for remote learning. Women may also have needed to take on additional caregiving and teaching responsibilities while at home, putting them at a disadvantage in the labor market.³⁶ These interruptions to learning and work will likely set back human capital accumulation—with such effects spread unevenly across generations, genders, and income levels, and with adverse implications for longer-run productivity.

³² Autor and Dorn (2013); Jaimovich and Siu (2020). Jobless recoveries are defined by periods following recessions in which rebounds in aggregate output are accompanied by much slower recoveries in aggregate employment.

³³ Chernoff and Warman (2020); Cajner and others (2020); IMF (2021b).

³⁴ IMF (2018a).

³⁵ IMF (2021a).

³⁶ Agostinelli and others (2020); Azevedo and others (2020).

POLICY ACTION IS NEEDED TO BOOST PRODUCTIVITY

To bolster productivity, policies must support digitalization, facilitate the reallocation of resources to the most productive activities, and help workers transition to the post-pandemic world.

22. The crisis has generated opportunities for boosting productivity but also led to immense challenges related to higher poverty and inequality; policies should be designed to help firms reap the opportunities and redress any adverse impacts on vulnerable workers. The COVID-19 pandemic could potentially lead to higher productivity by accelerating change, including by speeding up digitalization and improvements to the way we live and work. In this respect, any benefits are likely to be greatest to the extent that an efficient reallocation of labor and capital ensues across firms and sectors. However, there are also risks, obstacles, and challenges, which must be overcome. For example, necessary emergency lifelines to firms during the crisis have likely also halted the reallocation process, and as economies recover from the pandemic, it will be necessary to gradually transition to support schemes that are compatible with a reallocation of resources. A potential increase in market power will also require careful attention as reduced competition can be a barrier to progress and innovation. Alongside, the pandemic has had devastating implications for the low-skilled and minorities as well as the education of the next generation of workers, adding risks to the accumulation of human and social capital. All these opportunities, challenges, and risks must be addressed to put the world on a stronger and more inclusive path. At the same time, structural characteristics, rigidities, and the degree of fiscal space vary across G-20 economies, including across advanced and emerging market economies. As such, policy actions will need to be tailored to individual circumstances.

A. Support Investment in Intangible Capital

Accelerated digitalization has been a silver lining of the pandemic but determined efforts will be needed to ensure that it is sustained and broad-based.

23. To ensure adequate access to credit, policymakers should maintain accommodative policy settings through the crisis and support a cleaning up of balance sheets after the crisis.

- *Continue monetary and fiscal accommodation.* Given that financing constraints can be a significant barrier to investment in intangible capital, counter-cyclical policies may play a particularly beneficial role during downturns. Particularly, as accommodative policies help to support demand and ease financing conditions, firms may be better able to invest when faced with a liquidity shock. In this way, monetary and fiscal policies can help boost productivity through the accumulation of intangible assets. More generally, policymakers should remain vigilant in a context of asynchronous and divergent recoveries, which could heighten the risk of a sudden tightening of financial conditions, particularly in emerging market economies. Continuing monetary and fiscal support to the extent policy space allows will be critical in helping support intangible investments and protecting productivity growth in the aftermath of the pandemic (while carefully monitoring any potential buildup of vulnerabilities from accommodative monetary policy).³⁷

³⁷ Ahn and others (2020); Aghion and others (2019).

- *Ensure crisis support is sufficiently targeted.* Policy support to firms at risk of insolvency owing to the crisis will have the most benefits for aggregate productivity when it is targeted at viable firms (and not the firms that are not likely to be viable after the crisis). In fact, there is substantial heterogeneity within the group of insolvent firms. Estimates suggest that in advanced economies, those small and medium-sized enterprises (SMEs) that became insolvent solely because of the crisis are on average 25 percent more productive than those that would be insolvent even in the absence of the crisis.³⁸ Well-targeted equity injections can also be helpful insofar as they help prevent viable firms from becoming insolvent. Furlough schemes may be particularly beneficial to labor-intensive firms, while financial policy measures, such as loan restructuring or repayment moratoria, may help more credit-reliant or capital-intensive businesses. In all cases, these measures will need to be well-targeted to viable firms and temporary to limit the risk of creating zombie firms. Targeting the support well would also help reduce risks from debt overhang—which, if they were to materialize, would hold back investment in R&D and other intangible capital and weigh on productivity. A decision tree framework, as proposed in the recent *Global Financial Stability Report*, can be useful in determining which firms to target with support.³⁹ One aspect of the design is that well-functioning capital markets can help ensure capital is allocated to viable firms, particularly when viability has to be determined for many firms in a short period of time or where insolvency frameworks are weak.
- *Support balance sheet cleanup.* Firms that were hit especially hard by the COVID-19 shock are likely to emerge from the crisis with weakened balance sheets, which may become more apparent as government support is withdrawn.⁴⁰ Such firms may then be unable to increase investment, be more likely to use future profits to repay debt rather than to finance new capital, and may face increased borrowing costs.⁴¹ Thus, actions to help repair balance sheets by strengthening management of nonperforming loans, including market-based solutions to swiftly dispose of distressed debts or problem assets, will help investments recover more quickly and thereby support productivity growth.

24. Fiscal incentives for innovation also have a role to play. Past IMF research has found substantial scope for fiscal policy to boost R&D and, thus, productivity. In the context of the current crisis, the boost to vaccine development from government subsidies is a case in point. In general, well-targeted subsidies for R&D are particularly beneficial for sectors with high external financing needs or with high positive spillovers. Appropriately designed tax incentives could also help boost R&D, especially if targeted to new firms and high-potential but long-term investments.⁴² Tax incentives for R&D may also be a way to target support to viable firms, as non-viable ones are less likely to make such investments. Moreover, public sector infrastructure investment that are focused on digital and green projects, as well as fiscal incentives, can bolster private sector productivity-enhancing

³⁸ Diez and others (2021).

³⁹ IMF (2021c).

⁴⁰ IMF (2020a; 2020b).

⁴¹ Borensztein and Ye (2018); Meyers (1977).

⁴² IMF (2016a).

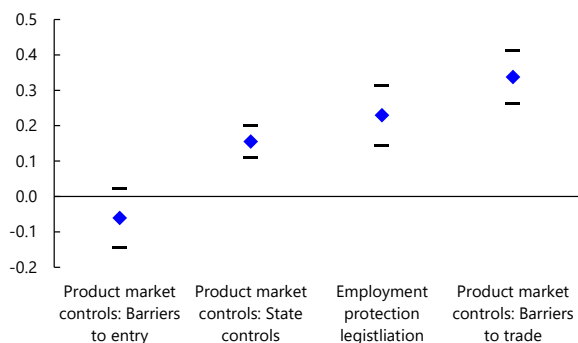
investments in the digital economy and investments to help tackle climate change.⁴³ In addition, fiscal spending on public R&D and the associated creation of a skilled workforce can help boost private R&D by supplying critical complements.

25. Product market reforms and less restrictive employment protection regulations can help support investment in intangible capital.

- Reduce state control (such as public ownership and government involvement in business operations) and barriers to trade to enhance access to financing and facilitate knowledge spillovers.* For instance, promoting competition in the banking sector may help boost financing for intangible assets by increasing the efficiency of services, lowering the cost of finance, and improving the access of funding to new entrants.⁴⁴ An analysis based on the underlying distribution of state control legislation among G-20 economies point to a statistically important positive impact. Moving from the 25th percentile of restrictiveness (more restrictive) to the 75th percentile (less restrictive) would be associated with higher relative intangible investment (to tangible) of 1.2 percentage points, supporting a rise in productivity (Figure 16). Private sector financing will be particularly important once the recovery takes hold and government support is unwound. Moreover, policies to facilitate international trade can help generate opportunities for firms to learn from imports and allow countries to specialize according to their comparative advantages while arranging production across border in the most efficient manner.⁴⁵ In light of the broad resilience of global supply chains during the pandemic this may be a particularly fruitful avenue for boosting productivity growth.
- Combine product market reforms that enhance competition with macro policies to facilitate investment.* While an easing of barriers to entry may not directly spur investment in intangible capital where competition is strong and low rents may prevent self-financing (as suggested by an insignificant association between easing barriers to entry and investment in intangible capital in Figure 16), if such reforms are combined with policies to alleviate financing constraints (e.g., counter-cyclical macroeconomic policies), constraints on investment can be eased, thereby helping to increase the supply of new ideas and enhance knowledge diffusion.⁴⁶ A higher degree

Figure 16. Structural Policies and Intangibles

Estimated impact of product and labor market policies on intangible investment (coefficient estimates and 90% confidence intervals)



Sources: OECD; WDI; Corrado and others (2016); IMF staff calc. Note: Blue dots are the negative of coefficient estimates from regressing the log-ratio of intangible to tangible investment on the specified policy strictness variables. Controls for the ratio of tangible to intangible capital investment and the share of employment in manufacturing. Includes country and time fixed effects. Black lines are 90 percent confidence intervals.

⁴³ IMF (2019).

⁴⁴ OECD (2019).

⁴⁵ OECD (2020b); Mendoza (2010); Bloom and others (2016).

⁴⁶ Duval and others (2020).

of competition is also generally thought to spur innovation and investment in intangibles such as R&D in sectors (or firms) close to the technology frontier, thereby supporting productivity.⁴⁷ Moreover, positive spillovers to up- and downstream industries can provide additional benefits.⁴⁸

- *Where employment protections for regular workers have created an inflexible labor market, ease protections, while maintaining adequate safety nets, to enable a more efficient adjustment to technological advances.* Where appropriate social safety nets exist, including well-designed unemployment insurance, a phased easing of dismissal regulations would help firms be able to react more quickly to changes in technology or product demand that require reallocation of staff or downsizing. This could help ease constraints related to investment in new (intangible) capital, and should be combined with labor market reforms such as worker training and other support for individuals, as needed.⁴⁹

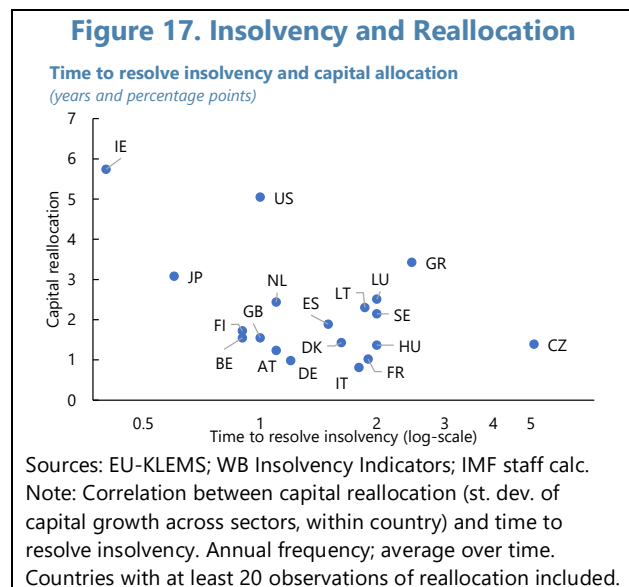
B. Boost Productivity-Enhancing Reallocation

During the crisis, necessary emergency lifelines may have halted the reallocation process. To support a strong recovery, policies should ensure that capital in failed firms can be quickly put to more efficient use and that displaced workers are supported so they can move from shrinking to expanding firms and sectors. It will also be important to remain vigilant in monitoring mergers and dominant positions.

26. Efficient insolvency regimes, pro-competition reforms, and labor reallocation policies can enhance the allocative efficiency of markets and the resilience of employment.

- *Ensure efficient insolvency and restructuring procedures to avoid a prolonged reallocation process.*

Improving the efficiency of insolvency regimes and the flexibility of restructuring and enhancing the predictability of judicial processes help support efficient capital reallocation.⁵⁰ For instance, regimes that promote reorganization rather than liquidation can prevent capital from remaining idle or underutilized for long periods, which is especially important when access to finance is tight.⁵¹ In fact, in some economies where the time to resolve insolvencies is shorter, capital reallocation has been larger (Figure 17). More efficient insolvency regimes have also been shown to support economic resilience more broadly,



⁴⁷ IMF (2016b) and Aghion and others (2005).

⁴⁸ Duval and Furceri (2016); Bouis and others (2016); Dabla-Norris and others (2015); OECD (2016).

⁴⁹ Bassanini and others (2009). See also section C below regarding support for workers.

⁵⁰ Aiyar and others (2019).

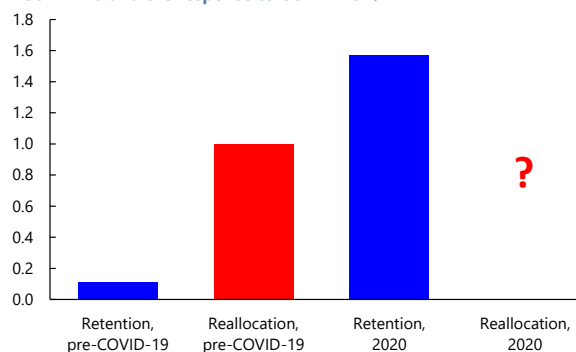
⁵¹ Bernstein and others (2019).

as reflected in smaller output losses and quicker recoveries associated with contractionary episodes.⁵²

- *Promote competition to enable the exit and entry of firms, while removing distortions in tax systems that may foster misallocation.* Greater competition by reducing barriers to entry, constraints to business operations, and administrative burdens can facilitate the entry of new firms and exit of inefficient firms, and thus help speed up capital and labor reallocation toward more productive uses.^{53 54} Moreover, amid risks of increased market concentration arising from the current crisis, competition authorities will need to remain vigilant regarding mergers and acquisitions to ensure they do not harm competition.⁵⁵ In this respect, active reviews of competition policy frameworks underway in major economies (e.g., *European Union, United States*) provide welcome opportunities to prevent a further rise in market power. Reviewing tax systems for potential barriers to efficient allocation (e.g., tax treatments that discriminate by asset type, financing source, or firm characteristics) could provide a boost to productivity through more efficient factor allocation.⁵⁶
- *Closing the digital divide for firms and individuals.* Ensuring widespread access to broadband connectivity, especially in rural areas, is critical to ensure equitable access to new markets for firms and—through such access and new investments—be able to gain from reallocation. For individuals, access to broadband connectivity and digital skills has become critical for work, education, healthcare, and access to social services in many economies. Policies should thus focus on broadband investment (complemented with universal access to electricity where not already available) along with a digital-friendly business and regulatory environment for the private sector.⁵⁷
- *Gradually adjust crisis policies from retention to reallocation support to facilitate the adjustment to the new normal (Figure 18).*

Figure 18. Retention and Reallocation Policy

Public spending on retention and reallocation policies: Before COVID-19 and the response to COVID-19 (percent of GDP)



Sources: IMF World Economic Outlook 2021; OECD Labor Market Programmes database; and IMF staff calculations.

Note: Bars indicate the average spending on the indicated area as a share of GDP. Pre-COVID-19 period is from 2014 – 2018, COVID-19 period is from March 2020 – February 2021. Sample includes AUS, CAN, FRA, DEU, ITA, JPN, KOR, ESP, and USA for pre-COVID-19 data, and G-19 countries and ESP for COVID-19 data. COVID-19 retention policies include any policies related to preserving employment linkages and may be broader than pre-COVID-19 retention policies which include wage subsidies, short-term work schemes, and partial unemployment benefits. Reallocation policies include hiring and start-up incentives, job search and matching assistance, and retraining programs.

⁵² Aiyar and others (2019).

⁵³ Aiyar and others (2019),

⁵⁴ As noted above, such policies should also be combined with support for firm’s investment in intangible goods.

⁵⁵ Akcigit and others (2021).

⁵⁶ IMF (2017).

⁵⁷ See IMF Blog (2020) on “[Low Internet Access Driving Inequality](#)” and IMF Blog (2020) on “[Bridging the Digital Divide to Scale Up the COVID-19 Recovery](#).”

After a period when the goal was to retain jobs and avoid mass bankruptcies, policies will gradually need to pivot to reallocation support as growth strengthens. For example, worker reallocation policies (e.g., well-designed job search and matching assistance and hiring subsidies) can raise the likelihood of both job finding and on-the-job occupational switches. These policies can be particularly beneficial to more vulnerable workers, like youth and women.⁵⁸ Care should be taken, however, to ensure that policies targeted at job placement of specific groups do not simply displace other employed workers, rather than create new jobs.⁵⁹ Less stringent job protection for regular workers and greater homogeneity in protection between regular and temporary workers could also encourage reallocation of all workers when necessary, reduce labor market dualism, and strengthen resilience.

- *Address data access challenges.* Alongside capital and labor, data have become a key input in modern production, and many of the world's largest firms have data at the core of their business models. However, access to data is also a specific source of corporate market power. Hence, a number of policy actions are needed to mitigate adverse impacts on concentration. These may include enforcement of laws that preclude abuse of dominance as well as support for data portability to enable consumers to transfer their data across suppliers. In addition, an integrated approach is needed to harness growth opportunities from data and amid complex trade-offs between privacy, competition, and stability. Global cooperation is also essential to ward off the risk that the digital economy becomes fragmented, with data access limited by national borders.⁶⁰

C. Ease the Burden on Workers from Job Displacement and Reallocation

COVID-19 disproportionately harmed the least advantaged and minorities, exacerbating inequality and risks to the accumulation of human capital. In addition to general reallocation policies, actions are needed to cushion the earnings loss from unemployment and to help the unemployed gain the necessary skills for the demands of post-pandemic jobs.

27. While crisis conditions continue and to the extent possible, to lessen the burden from the crisis, efforts to support worker-firm linkages should be maintained. Where fiscal space exists, possible support measures include (i) wage support or short-term work schemes, which help maintain worker-firm attachments in otherwise viable firms and help avoid costly temporary transitions through unemployment⁶¹ and (ii) liquidity and solvency support for viable firms, possibly with conditionality attached to preserving jobs. Overall, such support—if well targeted and timed—may also be less costly than the labor market fallout from excessive business failures.

28. As economies adapt to legacies from the crisis and the recovery strengthens, focus should increasingly be on training and reskilling, while supporting the most vulnerable people.

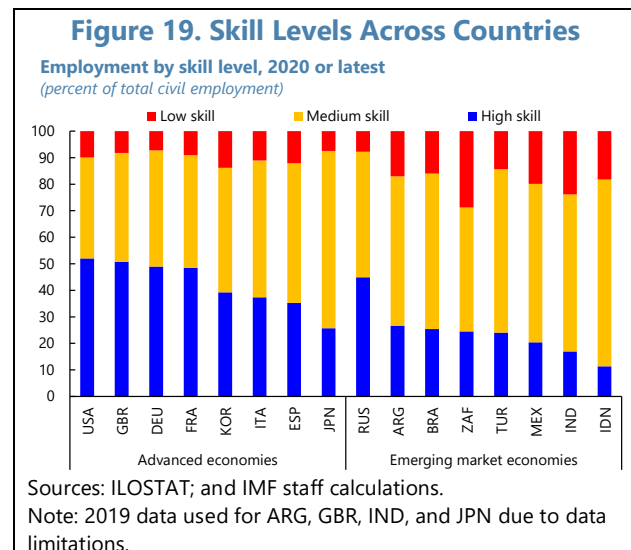
⁵⁸ IMF (2021b).

⁵⁹ Aiyar and others (2019).

⁶⁰ Carriere-Swallow and Haksar (2019) and Akcigit and others (2021).

⁶¹ IMF (2021a).

- *Support people suffering from job losses to cushion the shock.* Ensuring sufficient unemployment insurance may be particularly important during and after the pandemic as it is a more robust instrument for protecting workers facing changes in the nature of work (e.g., in the context of a rise in more flexible forms of labor in the so-called gig economy) than providing them with stronger job protections. That said, care should be taken to avoid an increase in workers' reservation wages, which could weaken the recovery.
- *Boost workers' skills to facilitate job finding.* Support for human capital investments, such as training and reskilling of workers, can help people regain employment, including by finding jobs in new occupations. Doing so effectively will require strengthening existing training measures to improve on past weaknesses, as well as new approaches and initiatives. In this respect, learning accounts are being explored in the *European Union* to tie training support to individuals rather than jobs.⁶² Moreover, as training can help ensure workers' skills match the needs of firms, it will also facilitate the efficient allocation of labor and support productivity within individual firms. Facilitating retraining and re-skilling while workers remain on job retention schemes would help to minimize the negative effects of unemployment. However, challenges will differ markedly across countries, not least amid the different natures of their labor markets and general skill levels (Figure 19). Alongside, ensuring access to school and learning for children and students will help minimize interruptions in human capital accumulation, while remedial efforts will be needed to offset losses incurred from school closures (e.g., complementary tutoring).⁶³ The jobs created by automation, and those that survive it, will be more demanding in terms of technical skills and cognitive and social abilities than the jobs they replace.⁶⁴ As such, education is a key component of meeting demands for a more flexible skill set and lifelong learning, and will ultimately help boost long-term productivity.



⁶² European Commission (2021)

⁶³ World Bank (2020).

⁶⁴ IMF (2018a).

Box 1. Will COVID-19 Worsen Mismeasurement of Productivity?

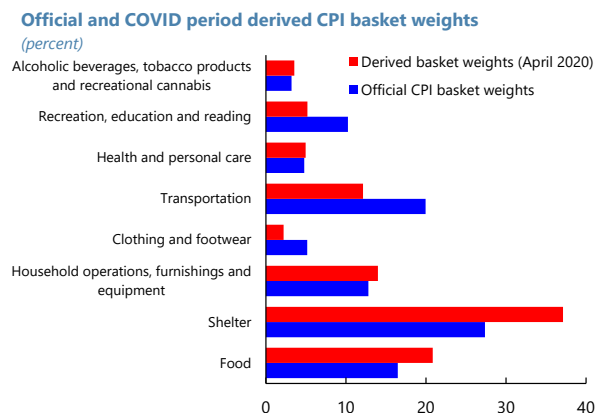
Mismeasurement of the digital economy has been an often-cited contributor to the prolonged slowdown in measured productivity growth prior to the COVID-19 pandemic. As the productivity slowdown occurred alongside a fast pace of innovation in the hard-to-measure digital economy, a commonly mentioned contributor to the measured slowdown is the inability to capture well in price statistics and deflators the increases in convenience, varieties, free online products, and lower quality-adjusted prices that arises from the digital economy. For example, standard methods for bringing new products into the measurement of inflation and deflators assume the quality-adjusted price for a new product is the same as for existing competitors. Yet, if digital services (e.g., Uber) have lower quality-adjusted prices, then such an assumption would lead to an overestimation of inflation and deflators. The result would be an underestimation of the new product’s contribution to growth and, hence, to productivity growth. Moreover, the plethora of free services now available (e.g., social media, search engines), while enhancing welfare, does not fit into the conceptual framework for productivity measurement due to their zero price.

Nonetheless, such mismeasurement issues can only explain a small portion of the productivity slowdown. For example, Byrne and others (2016) documented for the *United States* that mismeasurement from various sources (including from the digital economy) explains very little of the observed productivity slowdown. In fact, for mismeasurement to be a key contributor to the measured productivity slowdown, it would have had to get worse over time; and when the various sources of mismeasurement are tallied, this does not seem to be the case. While mismeasurement owing to the digital economy does tend to become worse over time, such digital services account for only a small portion of output in the *United States*. In most economies, the digital sector is still less than 10 percent of all activity, irrespective of whether it is measured in terms of value added, income, or employment (IMF, 2018b). Furthermore, these specific measurement problems are partly offset by other sources of mismeasurement. For example, prices of ICT hardware were overestimated throughout the period (though the impact of this mismeasurement became progressively less important as a result of offshoring of ICT hardware production).

Looking forward, if the pandemic accelerates growth in the digital economy, its contribution to mismeasurement may become more salient. For example, greater prevalence of remote work and online interactions across borders may reduce travel costs, which, if not properly captured, may lead to an underestimation of productivity growth. A shift to digital and peer-to-peer platforms could also bring added convenience, making it feasible to access an increasing number of varieties and lower prices, which, if not properly accounted for, would also result in mismeasurement. Yet, the size of the error remains unknown.

In addition, the pandemic has shifted weights across other items in the baskets used to measure inflation, with potential impact on measurement accuracy. For Canada, a preliminary COVID-adjusted CPI basket points to significant shifts in consumption patterns in 2020 as the pandemic took hold, with declines in spending on items such as transportation and increases in household items (Mitchell and others, 2020; Box Figure). An updated basket, combined with higher prices for in-demand goods and services, suggests a higher actual inflation rate than the pre-existing basket would imply—highlighting the importance of updating the weights as soon as the flux from the pandemic settles.

Canada: Shift in Spending Patterns During COVID-19



Source: Statistics Canada and Mitchell and others (2020).

References

- Adler, Gustavo, Romain Duval, Davide Furceri, Sinem Kiliç Çelik, Ksenia Koloskova, and Marcos Poplawski-Ribeiro. 2017. "Gone with the Headwinds: Global Productivity." IMF Staff Discussion Note 17/04. Washington D.C.
- Aghion, Philippe, Philippe Askenazy, Nicolas Berman, Gilbert Cette, and Laurent Eymard. 2012. "Credit constraints and the cyclicalities of R&D investment: Evidence from France." *Journal of the European Economic Association* 10, no. 5: 1001–24.
- Aghion, Philippe, Nicholas Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt. 2005. "Competition and innovation: An inverted-U relationship." *The Quarterly Journal of Economics*, 120(2): 701–728.
- Aghion, Philippe, Emmanuel Farhi, and Enisse Kharroubi. 2019. "Monetary policy, product market competition and growth." *Economica* 86(343): 431–470.
- Agostinelli, Francesco, Matthias Doepke, Giuseppe Sorrenti, and Fabrizio Zilibotti. 2020. "When the Great Equalizer Shuts Down: Schools, Peers, and Parents in Pandemic Times." National Bureau of Economic Research, No. w28264.
- Ahn, JeaBin, R. Duval, and C. Sever. 2020. Macroeconomic policy, product market competition, and growth: the intangible investment channel. IMF Working Paper 20/25. Washington D.C.
- Aiyar, Shekhar, John Bluedorn, Romain Duval, Davide Furceri, Daniel Garcia-Macia, Yi Ji, Davide Malacrino, Haonan Qu, Jesse Siminitz, and Aleksandra Zdzienicka. 2019. "Strengthening the Euro Area: The Role of National Structural Policies in Building Resilience." IMF Staff Discussion Note No. 19/05
- Akcigit, Ufuk, Wenjie Chen, Federico J. Diez, Romain Duval, Philipp Engler, Jiayue Fan, Chiara Maggi, Marina M. Tavares, Daniel Schwarz, Ippei Shibata, and Carolina Villegas-Sanchez. 2021. "Rising Corporate Market Power: Emerging Policy Issues" IMF Staff Discussion Note, Washington D.C.
- Andrews, Dan, Chiara Criscuolo, and Peter Gal. 2016. "The Best versus the rest: the global productivity slowdown, divergence across firms and the role of public policy." OECD Productivity Work Paper No. 5.
- Autor, David, and David Dorn. 2013. "The growth of low-skill service jobs and the polarization of the US labor market." *American Economic Review*, 103(5): 1553–97.
- Ayyagari, Meghana, Asli Demirgüç-Kunt, and Vojislav Maksimovic. 2011. "Small vs. young firms across the world: contribution to employment, job creation, and growth." World Bank Policy Research Working Paper 5631.
- Azevedo, João Pedro, Amer Hasan, Diana Goldemberg, Syedah Aroob Iqbal, and Koen Geven. 2020. "Simulating the potential impacts of COVID-19 school closures on schooling and learning outcomes: A set of global estimates". The World Bank.
- Baker, Scott, Nicholas Bloom, Brandice Canes-Wrone, Steven Davis, and Jonathan Rodden. 2014. "What has US Policy Uncertainty risen since 1960?" *American Economic Review: Papers & Proceedings*, 104(5): 56–60.

- Bannister, Geoffrey, Harald Finger, Yosuke Kido, Siddharth Kothari, and Elena Loukoianova. 2020. "Addressing the Pandemic's Medium-Term Fallout in Australia and New Zealand." IMF Working Paper No. 20/272, Washington D.C.
- Bassanini, Andrea, Luca Nunziata, and Danielle Venn. 2009. "Job protection legislation and productivity growth in OECD countries." *Economic Policy*, 24(58): 349–402.
- Bernstein, Shai, Emanuele Colonnelli, and Benjamin Iverson, 2019. Asset allocation in bankruptcy. 2019. *The Journal of Finance*, 74(1), pp. 5–53.
- Bloom, Nicholas, Philip Bunn, Paul Mizen, Pawel Smietanka, Gregory Thwaites. 2020. "The impact of COVID-19 on Productivity." National Bureau of Economic Research, No. w28233.
- Bloom, Nicholas, Steven J. Davis and Yulia Zhestkova. 2021. "COVID-19 Shifted Patent Applications towards Technologies that Supported Working from Home". Becker Friedman Institute Working Paper No. 2020–133.
- Bloom, Nicholas, Mirko Draca and John Van Reenen. 2016. "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity." *The Review of Economic Studies*, 83(1): 87–117.
- Borensztein, Eduardo, and Lei Sandy Ye. 2018. "Corporate debt overhang and investment: firm-level evidence." The World Bank.
- Bouis, Romain, Romain Duval, and Johannes Eugster. 2016. "Product Market Deregulation and Growth: New Country Industry-Level Evidence." IMF Working Paper 16/114, International Monetary Fund, Washington, DC.
- Bresnahan, Timothy, Erik Brynjolfsson, and Lorin Hitt. 2002. "Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence." *Quarterly Journal of Economics*, 117 (1): 339–376.
- Brynjolfsson, Erik, Daniel Rock, and Chad Syverson. 2018. "Artificial intelligence and the modern productivity paradox: A clash of expectations and statistics." In *The economics of artificial intelligence: An agenda*: 23 – 57. University of Chicago Press.
- Brynjolfsson, Erik, Daniel Rock, and Chad Syverson. 2021. "The productivity J-curve: How intangibles complement general purpose technologies." *American Economic Journal: Macroeconomics* 13(1): 333–72.
- Byrne, David, John Fernald, and Marshall Reinsdorf. 2016. "Does the United States have a productivity slowdown or a measurement problem?" *Brookings Papers on Economic Activity*, 2016.1: 109–182.
- Cajner, Tomaz, Leland D. Crane, Ryan A. Decker, John Grigsby, Adrian Hamins-Puertolas, Erik Hurst, Christopher Kurz, and Ahu Yildirmaz. 2020. "The US labor market during the beginning of the pandemic recession." National Bureau of Economic Research, No. w27159.
- Carriere-Swallow, Yan and Vikram Haksar. 2019. "The Economics and Implications of Data: An Integrated Perspective." IMF Departmental Paper No. 19/16. Strategy, Policy, and Review Department.
- Chernoff, Alex W., and Casey Warman. *COVID-19 and Implications for Automation*. 2020. No. w27249. National Bureau of Economic Research.

- Corrado, Carol, Jonathan Haskel, Cecilia Jona-Lasinio, and Massimiliano Iommi. 2016. "Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth." EIB Working Papers, No. 2016/08.
- Corrado, Carol, Jonathan Haskel, and Cecilia Jona-Lasinio. 2017. "Knowledge spillovers, ICT and productivity growth." *Oxford Bulletin of Economics and Statistics*, 79(4): 592–618.
- Crouzet, Nicolas, and Janice Eberly. 2018. "Intangibles, investment, and efficiency." In *AEA Papers and Proceedings*, vol. 108: 426–31.
- Dabla-Norris, Ms Era, Mr Si Guo, Mr Vikram Haksar, Minsuk Kim, Ms Kalpana Kochhar, Kevin Wiseman, and Aleksandra Zdzienicka. 2015. "The new normal: A sector-level perspective on productivity trends in advanced economies." IMF Staff Discussion Note No 15/03, Washington D.C.
- De Loecker, Jan, and Frederic Warzynski. 2012. "Markups and firm-level export status." *American Economic Review*, 102.6, 2437–71.
- Decker, Ryan A., John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2016. "Where has all the skewness gone? The decline in high-growth (young) firms in the US." *European Economic Review* 86: 4–23.
- Di Mauro, Filippo and Chad Syverson. 2020. "The COVID Crisis and Productivity Growth. White Paper." Becker Friedman Institute for Economics at the University of Chicago.
- Diez, Federico, Jiayue Fan, and Carolina Villegas-Sanchez. 2019. "Global declining competition." IMF Working Paper No. 19/82, Washington D.C.
- Diez, Federico J., Romain A. Duval, Jiayue Fan, José Garrido, Sebnem Kalemli-Ozcan, Chiara Maggi, Maria Soledad Martinez Peria, and Nicola Pierri. 2021. "Insolvency Prospects Among Small-and-Medium-Sized Enterprises in Advanced Economies; Assessment and Policy Options." International Working Paper No. 2021/002, Washington D.C.
- Duval, Romain, and Davide Furceri. 2016. "The Effects of Labor and Product Market Reforms: The Role of Macroeconomic Conditions and Policies." Paper presented at the 17th Jacques Polak Annual Research Conference, International Monetary Fund, Washington D.C.
- European Commission. 2021. Individual Learning Accounts Initiative https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12876-Adult-skills-Individual-Learning-Accounts-a-tool-to-improve-access-to-training_en.
- Fort, Teresa C., John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2013. "How firms respond to business cycles: The role of firm age and firm size." *IMF Economic Review* 61(3): 520–559.
- Foster, Lucia, John Haltiwanger, and Chad Syverson. 2008. "Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?" *American Economic Review* 98(1): 394–425.
- Gordon, Robert J. 2017. "The rise and fall of American growth: The US standard of living since the civil war." Princeton University Press.
- Gordon, Robert J. 2018. "Why has economic growth slowed when innovation appears to be accelerating?" National Bureau of Economic Research, No. w24554.

- Hershbein, Brad, and Lisa B. Kahn. 2018. "Do recessions accelerate routine-biased technological change? Evidence from vacancy postings." *American Economic Review*, 108(7): 1737–72.
- International Monetary Fund. 2015. "Private investment: what's the holdup?" *World Economic Outlook*, Chapter 4, April.
- International Monetary Fund. 2016a. "Fiscal policies for innovation and growth." *Fiscal Monitor*, Chapter 2, April.
- International Monetary Fund. 2016b. "Time for a supply-side boost? Macroeconomic effects of labor and product market reforms in advanced economies." *World Economic Outlook*, Chapter 3, April.
- International Monetary Fund. 2017. "Upgrading the tax system to boost productivity." *Fiscal Monitor*, Chapter 2, April.
- International Monetary Fund. 2018a. "G-20 background note: The future of work: measurement and policy challenges"
- International Monetary Fund. 2018b. "Measuring the digital economy"
- International Monetary Fund. 2019. "Mitigating climate change." *Fiscal Monitor*, October.
- International Monetary Fund. 2019. "The rise of corporate market power and its macroeconomic effects." *World Economic Outlook*, Chapter 2, April.
- International Monetary Fund. 2020a. "Corporate funding: liquidity strains cushioned by a powerful set of policies." *Global Financial Stability Report*, Chapter 3, October.
- International Monetary Fund. 2020b. "Fiscal policies to address the COVID-19 pandemic." *Fiscal Monitor*, Chapter 1, October.
- International Monetary Fund. 2021a. "After-effects of the COVID-19 pandemic: prospects for medium-term economic damage." *World Economic Outlook*, Chapter 2, April.
- International Monetary Fund. 2021b. "Recessions and recoveries in labor markets: patterns, policies, and responses to the COVID-19 shock." *World Economic Outlook*, Chapter 3, April.
- International Monetary Fund. 2021c. "Global financial stability review: an asynchronous and divergent recovery may put financial stability at risk." *Global Financial Stability Report*, Chapter 1, April.
- Jaimovich, Nir, and Henry E. Siu. 2020. "Job polarization and jobless recoveries." *Review of Economics and Statistics* 102(1): 129–147.
- Jorda, Oscar. 2005. "Estimation and inference of impulse responses by local projections." *American Economic Review*. 95(1), 161–182.
- Liu, Ernest, Atif Mian, and Amir Sufi. 2020. "Low interest rates, market power, and productivity growth." National Bureau of Economic Research, No. w25505.
- McMillan, Margaret S., and Dani Rodrik. 2011. "Globalization, structural change and productivity growth." National Bureau of Economic Research, No. w17143.
- Mitchell, Taylor, Gerry O'Donnell, Rebecca Taves, Zachary Weselake-George, and Alice Xu. 2020. "Consumer expenditures during COVID-19: An exploratory analysis of the effects of changing consumption patterns on consumer price indices.", Statistics Canada.

- Myers, Stewart C. 1977. "Determinants of corporate borrowing." *Journal of financial economics* 5, no. 2: 147–175.
- Organization for Economic Co-operation and Development. 2016. "Technological slowdown, technological divergence and public policy: A firm level perspective."
- Organization for Economic Co-operation and Development. 2019. "Productivity growth and finance: The role of intangible assets A sector level analysis."
- Organization for Economic Co-operation and Development. 2020b. "Returns to intangible capital in global value chains: New evidence on trends and policy determinants."
- Roth, Felix, and Anna-Elisabeth Thum. 2013. "Intangible capital and labor productivity growth: panel evidence for the EU from 1998–2005." *Review of Income and Wealth* 59(3): 486–508.
- Van Ark, Bart, Janet X. Hao, Carol Corrado, and Charles Hulten. 2009. "Measuring intangible capital and its contribution to economic growth in Europe." *EIB papers* 14(1): 62–93.
- World Bank. 2020. "The COVID-19 Pandemic: Shocks to Education and Policy Responses." World Bank Report 148198, Washington D.C.



GROUP OF TWENTY

BOOSTING PRODUCTIVITY IN THE AFTERMATH OF COVID-19—ANNEX



Prepared by Staff of the
INTERNATIONAL MONETARY FUND*

*Does not necessarily reflect the views of the IMF Executive Board

May 2021

ONLINE ANNEX

This Annex provides underlying details on the empirical exercises in the 2021 G-20 Background Note on Boosting Productivity in the Aftermath of COVID19.¹ The Annex is structured in four sections, providing background analysis for (i) Figure 9 on intangible investment and productivity; (ii) Figure 10 on reallocation and productivity; (iii) Figure 13 on labor productivity decompositions; and (iv) Figure 16 on structural policies and investment in intangible capital.

A. Intangible Investment and Productivity

This section describes the analysis shown in Figure 9 of the main text.

Empirical specification

1. The analysis builds on Corrado and others (2009) who estimate the role of intangible capital in US economic growth. Treating intangible capital symmetrically to tangible capital, a production function consistent with the growth equations in Corrado and others (2009) is established:

$$Y_{ijt} = A_{ijt} K_{ijt}^{\alpha} R_{ijt}^{\beta} L_{ijt}^{\gamma}$$

Here, Y_{ijt} is output at the country (i), sector (j), and year (t) level. A_{ijt} is total factor productivity, K_{ijt} is tangible capital, R_{ijt} is intangible capital, and L_{ijt} labor. Baseline regressions are based on value added output, which allows to ignore intermediate inputs in the production function (gross output is used as an alternative measure in robustness analysis). Labor is measured as hours worked (number of persons employed in robustness analysis).

2. The production function is transformed to consider labor productivity in log terms:

$$\frac{\ln(Y_{ijt})}{\ln(L_{ijt})} = \ln(A_{ijt}) + \alpha \ln(K_{ijt}) + \beta \ln(R_{ijt}) + \delta \ln(L_{ijt}) + \varepsilon_{ijt}$$

Here, $\gamma = \delta + 1$. As total factor productivity is not directly observed, it is assumed to be in the error term. Hence, the coefficients of interest are α and β . The model is augmented to include country-sector fixed effects, which control for sector-specific characteristics of labor productivity within each country. The results are robust to also including time fixed effects.

¹ This annex, and the G20 Background Note it supports, was prepared under the supervision of Oya Celasun by a team led by Lone Christiansen and comprising Ashique Habib, Jaden Kim, Davide Malacrino, Margaux MacDonald (principal economist), Menexenia Tsaroucha, and Bryan Zou. Ilse Peirtsegaele provided administrative support. This annex and the paper do not necessarily reflect the views of G-20 members. G-20 notes by the IMF are available on IMF.org.

Data

3. Data on intangible capital are from the INTAN database of Corrado and others (2016).

Data on tangible capital, value added output, and labor are from EU KLEMS. The sample includes 17 countries (*Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, United States*) from 1995 to 2017. The industry classification is from EU KLEMS, aligned with the NACE Rev 2, and covering 13 industries (excluding all non-market sectors and sectors for which data on intangible assets are missing). All variables are in real terms after deflating with the nominal GDP deflator from the World Economic Outlook database.

Results

4. Results are reported in Appendix Table A1. Both tangible and intangible capital are positively and significantly associated with higher labor productivity growth. The baseline specification (column one) is presented in the main text.

Table A1. Association Between intangible investment and productivity

<i>Dependent variable:</i>	(1) ln(Value added)	(2) ln(Value added)	(3) ln(Value added)	(4) ln(Gross output)
ln(hours worked)	-0.715*** (0.0692)	-0.642*** (0.0649)		-0.797*** (0.0666)
ln(tangible capital)	0.312*** (0.0350)	0.202*** (0.0346)	0.305*** (0.0339)	0.331*** (0.0406)
ln(intangible capita)	0.434*** (0.0338)	0.378*** (0.0330)	0.434*** (0.0334)	0.484*** (0.0351)
ln(employed persons)			-0.725*** (0.0671)	
N	4301	4301	4319	4301
R-sq	0.974	0.978	0.972	0.980
Country-sector FE	YES	YES	YES	YES
Year FE	NO	YES	NO	NO

Clustered standard errors (country-sector) in parentheses

* p<0.1 ** p<0.05 *** p<0.01

B. Reallocation and Productivity

This section describes the analysis of the impact of recessions and reallocation on total factor productivity (TFP) growth shown in Figure 10 of the main text.

Empirical specification

5. The analysis is based on a sequence of OLS regressions. They are considered at various horizons (i.e., “local projections”, see Jorda, 2005):

$$y_{sc,t+k} - y_{sc,t-1} = \beta_k D_{c,t} + \gamma_k R_{sc,t}^D + \delta_k D_{c,t} * R_{sc,t}^D + \sum_{j \in \{-1,-2\} \cup \{1..k\}} \zeta_k D_{c,t+j} + \phi_{k,cs} + \phi_{k,t} + \varepsilon_{sct}^k$$

Here, k is the forward time horizon and takes values from 0 to 4; s is the sector and c country; and t is quarter. The variables are as follows:

- $y_{sc,t}$ is the log of TFP computed at the firm level and aggregate to the country-sector level. The firm-level TFP measure is from Diez and others (2019), which is based on the De Loecker and Warzynski (2012) definition of firm-level TFP. The measure uses turnover revenue and, as a measure of inputs, materials. Where data on materials is unavailable, cost of goods sold is used. The firm level measure of TFP is then aggregated at the sector level (Nace 2 level) by taking employment weighted averages.
- $D_{c,t}$ is a dummy that takes the value of one in year t if country c experienced a recession (defined as negative real GDP growth) in year t . Following the literature, the regression controls for 2 lags and k forwards of the recession dummy to capture the effect of the recession on impact (such controls are represented by the sum in the equation).
- $R_{sc,t}^D$ is a dummy that takes the value of one if the measure of reallocation in sector-country pair sc (R_{sc}) is above the median of the reallocation distribution in the sample in the year of the shock. Here, we compute R_{sc} across firms and within sector-country pairs as the employment-weighted standard deviation of capital growth:

$$R_{sc} = \sqrt{\sum_{f \in sc} Emp_f * (g_f^k - \bar{g}_{sc})^2}$$

Here, g_f^k is the log change in capital (computed as the sum of tangible and intangible fixed assets), \bar{g}_{sc} is the average growth of capital within each sector-country pair, and Emp_f is the number of employees in the firm.

- $\phi_{k,cs}$ and $\phi_{k,t}$ are country-sector pair and country-year fixed effects, respectively, and ε_{sct}^k is an error term.

6. The coefficients of interest are β_k and δ_k . The sequence of β_k (for k in 0 to 4) captures the local projection of TFP from a recession (on impact and up to 4 years after the event for country-sector pairs with reallocation index below the median). The sequence of sums $\{\beta_k + \delta_k\}$ represents the same object for pairs with reallocation index above the median.

Data

7. The data combine sector and firm level data.

- *Sector level data are from EU KLEMS.* The sample covers 19 advanced economies (*Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Lithuania, Luxembourg, Netherlands, Spain, Sweden, United Kingdom, and United States*) from 1995 to 2017.
- *Firm level data are from Orbis.* The baseline sample includes data from 13 countries for which it is possible to compute TFP based on De Loecker and Warzynski (2012) using materials as an instrument. Those are *Austria, Belgium, Czech Republic, Finland, France, Germany, Spain, Hungary, Italy, Norway, Poland, Portugal, Slovakia*. In robustness checks, 5 additional countries (*United Kingdom, Greece, Ireland, Japan, and United States*), for which it is possible to use only “cost of goods sold” as an instrument to build TFP, are added. The time dimension varies from country to country: most countries have data from 1995 or 1997 to 2015 except for *Japan* (2001–2015) and the *United States* (2007–2015).

Results

8. Results are reported in Figure A1. As highlighted in the main text, the baseline specification shows that TFP falls by more in country-sector pairs with low degree of reallocation. The difference vanishes over time and it is not statistically significant 3 to 4 years after the recession event. Over the analyzed horizon, the cumulative loss in TFP in country-sector pairs with low reallocation stays consistently below country-sector pairs with high degree of reallocation.

9. To check the robustness of the result, the baseline is modified in three ways:

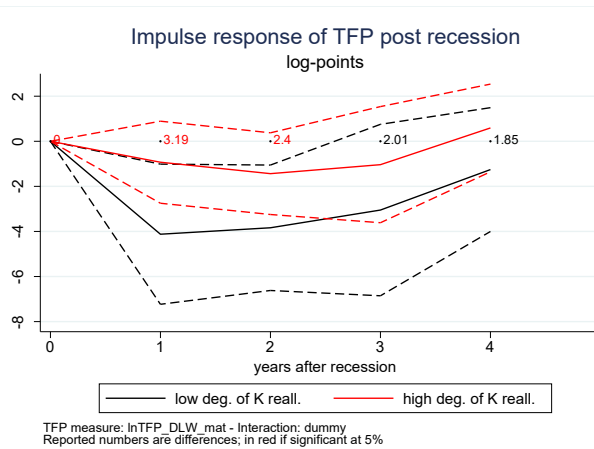
1. *Expanding the sample.* The sample is extended to include those countries for which it is only possible to compute TFP using cost of goods sold as an instrument (panel b).
2. *Alternative reallocation measures.* The specification is altered by using a reallocation measure that enters continuously rather than as a dummy (panel c). In this case the “high” and “low” reallocation IRFs are computed by picking values of the reallocation index at the 90th and 10th percentiles of the distribution respectively.
3. *Combining modifications in 1 and 2.* The results are shown in panel d.

10. Results from the robustness check are in line with the baseline results. The results from robustness check 1 confirm those in the baseline although the difference between the two groups is

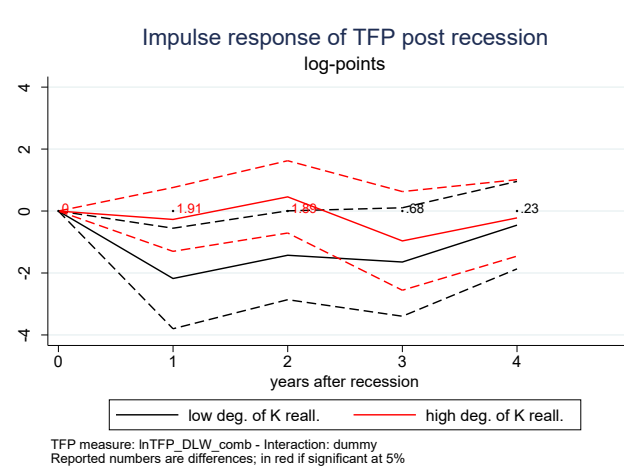
now smaller. The results from robustness checks 2 and 3 confirm qualitatively the baseline findings insofar as the local projects among country-sector pairs with high degree of reallocation lie systematically above those computed for pairs with low degree of reallocation—though responses are statistically indistinguishable.

Figure A1. Impulse Responses of TFP to Recessions for given levels of Capital Reallocation

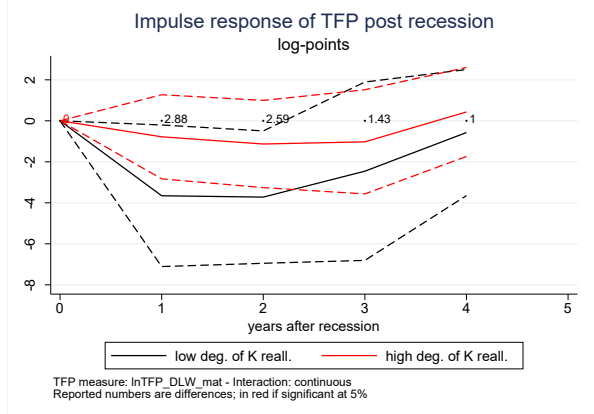
1. Baseline



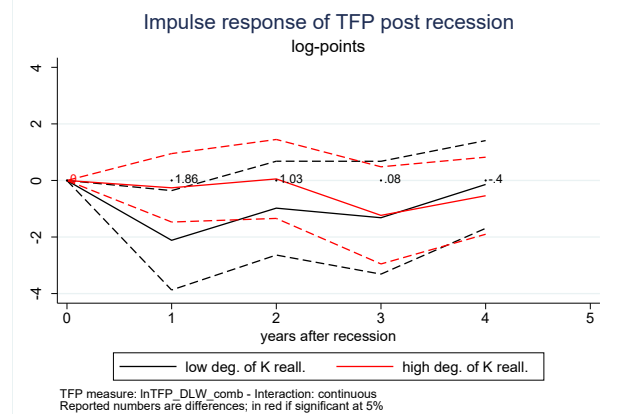
2. Robustness: extended sample



3. Robustness: continuous specification



4. Robustness: continuous specification and extended sample



Source: Orbis; EU KLEMS; and IMF staff estimates.

C. Decomposition of Labor Productivity

This section describes the analysis shown in Figure 13 of the main text.

Empirical specification

11. The labor productivity decomposition is based on McMillan and Rodrik (2011). This method decomposes labor productivity growth in an economy into two sources:

- *With sectors.* Labor productivity growth *within* sectors through capital accumulation, technological change, or reduction of misallocation across firms.
- *Between sectors.* Labor can move *across* sectors, from sectors with low output per worker to those with high output per worker, increasing overall labor productivity in the economy.

12. This is expressed, for each individual country i , as:

$$\Delta Y_{it} = \sum_{s=n} \theta_{si,t-k} \Delta y_{sit} + \sum_{s=n} y_{sit} \Delta \theta_{sit}$$

Here, Y_{it} and y_{sit} are economy-wide and sectoral labor productivity levels, and θ_{sit} is the share of employment in sector s . The data is quarterly and $k=4$, and Δ denotes the year-on-year change in labor productivity or employment shares. The first term $\sum_{s=n} \theta_{sit-k} \Delta y_{sit}$ (the “within” component) is the employment-weighted sum of labor productivity growth within sectors. The second term $\sum_{s=n} y_{sit} \Delta \theta_{sit}$ (the “between” component) captures the productivity effect of labor reallocation across different sectors. The within and between components of changes in aggregate labor productivity (measured as total value added over hours worked) are then calculated in each country in the sample. To reach at an overall measure, the aggregate value-added weighted average across countries is then computed for each within and between sector component.

Data

13. The data are from Eurostat. The data cover 28 countries (*Austria, Belgium, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, and Sweden*) from 2018Q1 to 2020Q4.

D. Structural Policies and Intangible Investment

This section describes the analysis shown in Figure 16 of the main text.

Empirical specification

14. The analysis of policy determinants of intangible investment follows the methodology in Corrado and others (2016). This approach uses the ratio of intangible to tangible investment, rather than intangible investment in levels, in order to control for any common effects affecting investment that are difficult to model (e.g., the observation that investment tends to be cyclical in ways that are difficult to capture with prices or adjustment costs). In addition, the specification controls for the relative price level of intangible to tangible capital and the share of employment in the manufacturing sector (since countries with more services might be more intensive in intangible capital). The specification also includes country-specific fixed effects, which control for country-specific characteristics that do not vary over time.

15. In addition, the specification includes reform indices. The method in Corrado and others (2016) is augmented to include reform indices for the strictness of policies related to competition (state control, barriers to entry, and barriers to trade) and labor market flexibility (strictness of employment protection legislation)—with reform indices entering the regressions one at a time. As the underlying reform indices are interpreted as being stricter for a larger value of the index, the regressions are run using the negative of the indices in order to reach the reverse interpretation: a higher value of the indices in the specification here is associated with less strictness of the policy.

16. The following regression specification is estimated:

$$\ln\left(\frac{K_{it}^{intangible}}{K_{it}^{tangible}}\right) = \alpha_i + \gamma_t + \beta_1 \ln\left(\frac{P_{it}^{intangible}}{P_{it}^{tangible}}\right) + \beta_2 Emp_{it}^{manuf} + \beta_3 Policy_{it} + e_{it}$$

Here, $K_{it}^{intangible}$ is intangible capital in country i and year t , $K_{it}^{tangible}$ is tangible capital, P_{it} variables are price levels, Emp_{it}^{manuf} is the share of manufacturing in the economy, α_i and γ_t are country and time fixed effects, and $Policy_{it}$ is the policy variable of interest. Results are reported in Table A2.

Data

17. Data on intangible capital are from the INTAN database of Corrado and others (2016). Data on tangible capital, price levels, and employment shares are from EU KLEMS. Data on policy restrictiveness is from the OECD.

Table A2. Policy Stringency and Intangible Investment

	(1)	(2)	(3)	(4)
<i>Dependent variable: ln(Intangible/Tangible)</i>				
ln(P ^{intan} /P ^{tan})	-0.364*** (0.123)	-0.318*** (0.103)	-0.114 (0.106)	-0.245** (0.0959)
Employment in manuf	0.00275 (0.00771)	-0.00244 (0.00775)	-0.00277 (0.00811)	-0.0165** (0.00772)
Employment protection legislation	0.229*** (0.0512)			
State controls		0.155*** (0.0281)		
Barriers to entry			-0.0612 (0.0507)	
Barriers to trade				0.337*** (0.0461)
Constant	5.390*** (0.220)	5.113*** (0.220)	4.611*** (0.248)	5.306*** (0.217)
N	276	359	359	359
R-sq	0.928	0.921	0.914	0.926
Country FE	Yes	Yes	Yes	Yes

Clustered standard errors (country level) in parentheses

* p<0.1, ** p<0.05 *** p<0.01