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Bart van Ark, Klaas de Vries, Abdul Erumban
The Conference Board, University of Groningen,
University of Manchester & The Productivity Institute

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Economics Program
845 Third Avenue
New York, NY 10022-6679
Tel. 212-759-0900
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HOW TO NOT MISS A PRODUCTIVITY REVIVAL ONCE AGAIN?

Bart van Ark[1,2,3]
Klaas de Vries[1]
Abdul Erumban[2]

[1]The Conference Board, [2]University of Groningen
and [3]University of Manchester & The Productivity Institute

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Abstract

Over the past 15 years productivity growth in advanced economies has significantly slowed, giving rise to the productivity paradox of the New Digital Economy – that is, the notion of increased business spending on ICT assets and digital services without a noticeable increase in productivity. We argue that time lags are the most important reason for the slow emergence of the productivity effects from digital transformation. This paper provides evidence that underneath the slowing productivity growth rates at the macro level, signs of structural improvements can be detected. In the US most of the positive contribution to productivity growth is coming from the digital producing sector. The Euro Area and the UK show larger productivity contributions from the most intensive digital-using sectors, although the UK also had a fairly large number of less intensive digital-using industries which showed productivity declines. We also find that increases in innovation competencies of the workforce are concentrated in industries showing faster growth in labour productivity, even though more research is needed to identify causality. Finally, we speculate that as the recovery from the COVID-19 recession gets underway the potential for significant productivity gains in the medium term is larger than during the past fifteen years.

Note: This paper is based on an earlier working paper by the authors which was commissioned by the European Commission, DG ECFIN (van Ark et al., 2019). It also builds on the Inaugural Prais Lecture on Productivity which the first author delivered at the National Institute for Economic and Social Research on November 4th, 2019. The content is updated in light of the COVID-19 pandemic and considers the short- and long-term impacts of the crisis on productivity.

1. Introduction

As the global economy has entered recession in 2020, triggered by the COVID-19 pandemic, the human casualties and economic damage are perceived to be very large. Even as the health crisis will gradually get better managed, the impact on economic growth can be long- lasting and the recovery path can take several years. In particular, growth drivers such as the pace of job creation, income generation and investment may take several years to get back to pre-crisis trends. It seems that the productivity of those growth drivers may be of less concern as the mantra of "we'll do what it takes to avoid worse" is predominant in this phase of the crisis.

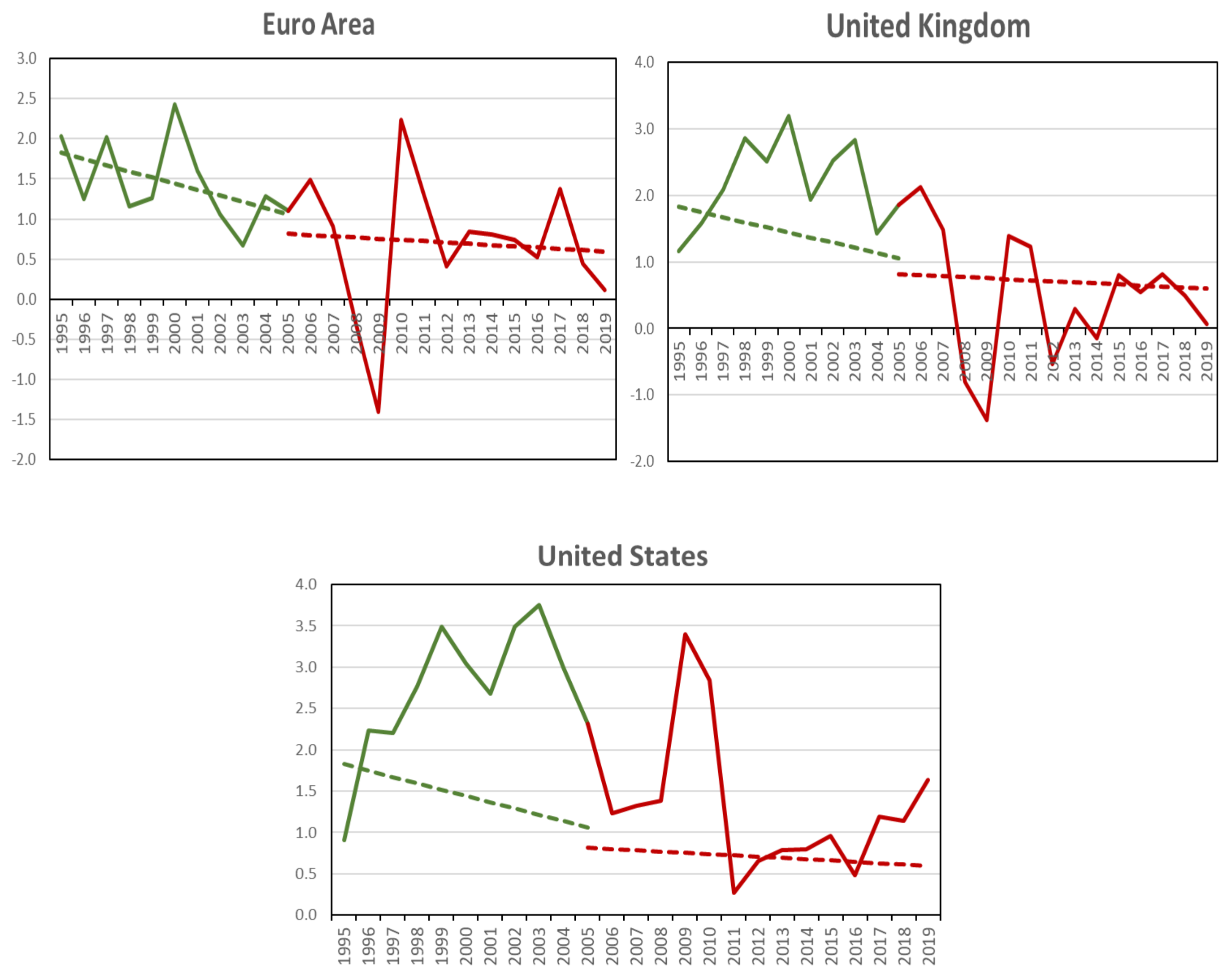
However, once the recovery gets underway the productive use of resources is key to sustained growth. While we do not ignore the short-term challenges of the economic recovery, our primary focus in this paper is on the productivity puzzle from a long-term perspective. Productivity is driven by technological change and innovation which, in turn, depends on investment in human, physical or natural capital as well as in other "missing capitals" often referred to as intangible assets. Indeed, those investments create a positive feedback effect, as the productivity it generates also helps to make more efficient usage of scarce resources in the future. When properly measured and valued, productivity also provides a critical yardstick to realise a fairer distribution of the gains from economic growth to those who bring the resources to bear. It thereby creates the incentives for people to produce and business to invest helping to drive economic progress and raise living standards.

Unfortunately, in the aftermath of the global financial crisis of 2008/09, many economies around the world, especially advanced economies, have failed to recharge the economy by powering productivity as the key source of growth in the long term. Indeed the latest update of The Conference Board Total Economy Database (July 2020) points at significant weakening in labour productivity growth in Europe up to 2019 (Charts 1a-1c). While the United States experienced somewhat faster productivity growth from 2017-2019 than the Euro Area and the United Kingdom, it still has not recovered to the rates of productivity growth from before the global financial crisis either.

The slowdown in productivity growth over the past 15 years has been well documented. There are multiple causes including an exhaustion of catch-up potential in emerging markets impacting economies along entire global value chains, and the drag from the global financial crisis because of low demand and weak investment, too low interest rates causing misallocations an overreliance on cheap labour, and failing fiscal policies. (Cette et al., 2016; Syverson, 2016, Fernald et al., 2017, Crafts, 2018; Dieppe, 2020; Bauer et al, 2020). [1] Technical measurement issues regarding inputs and outputs may have played a role as well.,

[1] In the United Kingdom the productivity puzzle is further complicated as chronic underinvestment was combined with large regional differences in terms of investment and productivity gains across the nation. See, for example, McCann and Vorley (2020); Carrascal-Incera et al. (2020).

Charts 1a,b,c: GDP per hour worked, Euro Area, United Kingdom and United States, 1995-2019 (% change)



Source: The Conference Board Total Economy Database (adjusted version) July 2020.

In much of our own earlier work we have stressed the importance of time lags in the adoption of new technologies, and in particular the complexity in generating productivity growth from the latest round of new digital technologies since the early 2010s, including the move towards mobile, ubiquitous access to broadband, the rise of cloud storage and advances in artificial intelligence and robotics (van Ark, 2016a 2016b; van Ark et al. 2016; van Ark and O'Mahony, 2016).

While the first priority for economic recovery from the COVID-19 crisis is to restore jobs, it is important that any employment intensive growth path does go together with a productivity revival. In this paper we argue that it is possible to avoid another productivity slowdown. Underneath the aggregate figures, there is evidence pointing towards a possible tipping point at which many advanced economies may expect to see more widespread impacts from the adoption and absorption of digital technology on productivity and GDP growth.

In **Section 2** we review the latest literature on the productivity impacts of general purpose technologies (GPTs), including the notion of time lapses through which digital technologies result in faster productivity growth. We also look at patterns by which innovation and productivity effects GPTs emerge across industries and disperse across the economy. We explain why the New Digital Economy is especially characterized by long lag effects.

In **Section 3** we provide an empirical analysis of productivity growth by industry data to observe whether we can detect a distinct pattern across groups of industries pointing to a structural improvement in recent years. We use a taxonomy on digital intensity by industry which was recently developed by the OECD (Calvino et al., 2018), showing that the most digital-intensive industries have experienced a relatively strong performance in terms of labour productivity growth since 2007 and especially since 2013.

In **Section 4** of the paper we discuss the connection between labour and skills in the digital economy, which we believe provides the key to a productivity revival. We developed a new metric on innovation competencies by occupation on the basis of data from the O*Net database on occupation-specific descriptors in the United States (Hao et al. 2018). When applied to the United Kingdom, we find that innovation competencies point at stronger productivity effects by industry.

In the final section, **Section 5**, we will review our hypothesis that a productivity revival could be imminent in the light of the recovery from the COVID-19 crisis. In order not to miss this opportunity again, as happened a decade ago, we argue that a coordinated effort from business and policy is needed, and has to be delivered in a such a way that the gains from productivity will be more widespread and such that those who provide the resources for growth are incentivized to deliver them in an efficient way.

2. The Productivity Paradox of the New Digital Economy

It is well known that general purpose technologies (GPTs), defined as new methods of producing and inventing new goods and services which are important enough to have a long-term aggregate impact on the economy, can take a significant amount of time to translate to faster productivity growth at the aggregate level of the economy. This is inherent to the three critical characteristics of a GPT as identified by Bresnahan and Trajtenberg (1996):[2]

1) Pervasiveness – The GPT should spread to most sectors.
2) Improvement – The GPT should get better over time and, hence, should keep lowering the costs of its users.
3) Innovation spawning – The GPT should make it easier to invent and produce new products or processes.

Historical analysis has focused on productivity trends in previous technology phases (Crafts, 2004; Bakker et al., 2019). Recent literature has shown that the information and communication technology

[2] See also Jovanovic and Rousseau (2005).

(ICT) revolution of the past 50 years can be characterized as a general purpose technology and doesn't pale with previous GPTs such as steam technology, electricity and the combustion engine. For example, Hempell (2006) concludes that "investment in information and communication technologies (ICT) are closely linked to complementary innovations and are most productive in firms with experience from earlier innovations.". In a more recent analysis of the evolution of the Internet, Simcoe (2015) argues that the modularity of the internet has prevented a fall in return to investments in innovation by "facilitating low-cost adaptation of a shared general-purpose technology to the demands of heterogeneous applications." In a review of the data, Liao et al (2016) conclude that:

> *"… ICT investment does contribute to productivity but not in the usual manner – we find a positive (but lagged) ICT effect on technological progress. We argue that for a positive ICT role on growth to actually take place, a period of negative relationship between productivity and ICT investment together with ICT-using sectors' capacity to learn from the embodied new technology was crucial. In addition, it took a learning period with appropriate complementary co-inventions for the new ICT-capital to become effective and its gains to be realized. Our findings provide solid, further empirical evidence to support ICT as a general purpose technology."*

During the latest phase of ICT inventions and applications, which we dubbed the New Digital Economy (NDE)[3], and which refers to the combination of mobile technology, ubiquitous access to the internet, and the shift toward storage, analysis, and development of new applications in the cloud, the question arises if the NDE is an extension of the previous phase of ICT technology, or whether we are starting a new GPT-phase altogether fueled by artificial intelligence and robotics. The latter issue has been extensively discussed by Agrarwal et al. (2019) who argue that "(H)uman intelligence is a general purpose tool. Artificial intelligence, whether defined as prediction technology, general intelligence, or automation, similarly has potential to apply across a broad range of sectors." (p. 4).

The shift in substitution of digital automation for horse power (such as in CNC machinery), to routine administrative tasks (such as in office software) to substituting for human intelligence (such as with artificial intelligence and robotics) represents the exponential growth in computing power. We therefore will treat the entire ICT era in this paper as one General Purpose Technology. However, the periodisation, especially comparing the pre- and post 2007 period, allows us to tease out some of the productivity effects from the Old Digital Economy, driven by the introduction of the PC and the rise of the internet, vis-à-vis the New Digital Economy.

The time lag factor also plays an important role in the evolutionary school literature on technological change. For example, Perez (2002) distinguished an "installation phase" and a "deployment phase" for any new technological paradigm. During the installation phase, new business spending on machinery, innovation, organizational and management changes exceed the overall output recovery. During this phase, the famous Schumpeter credo of "creative destruction" may put more emphasis on creation than on destruction. Low productivity firms can still survive which has been especially been the case in the past decade's environment of low interest rates, credit growth, and weak wage growth where cheap

[3] van Ark et al. (2016) and van Ark (2016b)

workers could still be relied upon (Andrews et al., 2017). During the deployment phase the fruits of the new technology become more widespread as less productive firms will lose out on the competition and make room for the reallocation of resources to more productive firms and industries.

Beyond the time lag in the diffusion of the technology, there can also be a time lag in the absorption of new technologies. Evidence from recent business studies suggests that the absorption of new digital technologies has been particularly slow in the New Digital Economy. Indeed "digitisation", which is the increase use of digital technology creating new products, new processes, business models and organizational structures, needs to be distinguished from "digital transformation". The latter aims at leveraging digital technologies and the data they produce to connect organizations, people, physical assets and processes, etc. which drives long-term value and productivity (Young, 2016). Digital transformation causes a wide range of complexities raising the cost of transition "that can include an initial duplication of structures and investment, cannibalization of incumbent business, and the diversion of management attention. towards those new technologies." (McKinsey, 2018). More specifically, related to the most recent wave of artificial intelligence, Brynjolfsson et al. (2019) state that:

> *The most impressive capabilities of AI, particularly those based on machine learning, have not yet diffused widely. More importantly, like other general purpose technologies, their full effects won't be realized until waves of complementary innovations are developed and implemented. The adjustment costs, organizational changes, and new skills needed for successful AI can be modeled as a kind of intangible capital.*

It follows that while new digital technologies have rapidly diffused across the economy, the absorption and translation into better business performance has been quite slow and uneven. This is not an unusual phenomenon. For example, Harberger (1998) speaks of two types of growth. One is characterized as "mushroom" growth in which a limited number of sectors, industries or firms experience a much better productivity performance than others. In today's world it means that the exciting prospects of a productivity boost from driverless cars, robotics, and artificial intelligence may be mushroom-like with a limited effect on productivity growth at the macroeconomic level. The second type of growth is what Harberger calls "yeasty" growth once the productivity improvements spread more widely across the economy. Even though we may not yet be fully harvesting the yeast effects of digital transformation, accelerated investment and business spending on ICT assets, cloud and digital services across many industries and rising wage premiums on skilled labour coupled with stronger demand bode well for a broader emergence of automation and digitisation.

Another important explanation for the wide dispersion of the productivity effects of new digital technology arisis from the firm level. Studies at the OECD and MIT have pointed at the rising gap between the top echelon of high-performing firms and the rest (Andrews et al. 2017; Autor et al. 2017). In this study we do not look at this important source of productivity divergence but focus one level higher by looking at performance across industries and its link to the aggregate economy.

3. An Industry Perspective on Productivity Growth in the Digital Economy

To detect structural trends in productivity improvements from a General Purpose Technology perspective, a useful starting point is to apply a taxonomy of digital intensity by industry. For this we follow the taxonomy recently developed by the OECD (Calvino et al., 2018). The study uses multiple dimensions relating to technology, market and human capital-related features:

- Share of ICT tangible and intangible (i.e. software) investment;
- Share of intermediate purchases of ICT goods and services;
- Stock of robots per hundreds of employees;
- Share of ICT specialists in total employment; and
- Share of turnover from online sales.

While the taxonomy is available for two periods (2001-2003 and 2013-2015), we only use it for the 2013-2015 period. Using an overall summary indicator (the "global taxonomy"), we collapse industries at the ISIC Rev. 4 level into two groups: "most digital intensive-using" industries and "least digital intensive-using" ones. Furthermore, we separate out a third group of industries that are defined as producing digital goods and services because of their very different productivity dynamics. Hence our most and least digital-intensive industries are identified as "using" industries compared to producing industries (see Exhibit 1).[4]

Exhibit 1: DIGITAL INDUSTRY TAXONOMY (ISIC rev.4 code/letter in brackets)

Digital Producing Industries: Computer, electronic and optical products (26), Electrical equipment (27), Publishing, audiovisual & broadcasting (58-60), Telecommunications (61) and IT & other information services (62-63)

Least Digital Intensive Using Industries: Agriculture, forestry & fishing (A), Mining & quarrying (B), Food, beverages & tobacco (10-12), Textiles & leather (13-15), Coke & petroleum products (19), Chemicals and chemical products (20), Pharmaceutical products (21), Rubber & plastics; non-metallic mineral (22-23), Basic metals & metal products (24-25), Electricity, gas, steam and air conditioning supply (D), Water supply; sewerage, waste management and remediation activities (E), Construction (F), Transportation & storage (H), Accommodation & food services (I), Real estate activities (L), Education (P), Human health activities (86), Residential care activities and social work activities without accommodation (87-88),

Most Digital Intensive Using Industries: Wood, paper, printing & media (16-18), Machinery & Equipment n.e.c. (28), Transport equipment (29-30), Other manufacturing (31-33), Trade (G), Financial & insurance activities (K), Legal and accounting activities; activities of head offices; management consultancy activities; architectural and engineering activities; technical testing and analysis (69-71), Scientific research and development (72), Advertising and market research; other professional, scientific and technical activities; veterinary activities (74-75), Administrative and support service activities (N), Public administration & defense (O), Arts, entertainment & recreation (R) and Other services (S)

[4] See Van Ark et al. (2019) for more detail on this taxonomy.

Chart 2a compares the contribution of the three groups of industries to labour productivity growth for US, the Euro Area and the United Kingdom for two subperiods: 1996-2006 represents the Old Digital Economy-era and 2007-2018 refers to the New Digital Economy era. Chart 2a shows that the dramatic decline in labour productivity between the pre- and the post 2007-period, which has been described earlier, occurred across all three industry groups. In line with our earlier work (van Ark et al. 2016, van Ark, 2016b) we find that, paradoxically, the largest slowdown occurred in the most digital intensive-using group. We attribute this counterintuitive effect to the time-lag in productivity effects from digital technology due to its general purpose-nature as well as to the delaying effects from the digital transformation process.

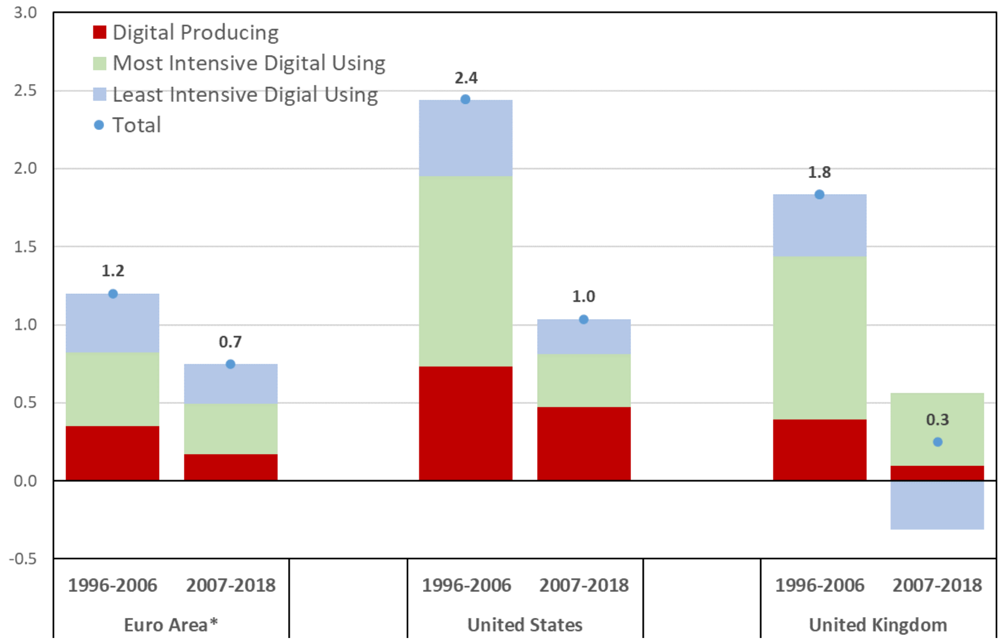
Chart 2b shows the same picture, but by removing the 2008-09 recession and its immediate aftermath (2010-2012), provides a cleaner comparison between the heydays of the Old Digital Economy and the New Digital Economy. In particular the productivity advantage which the UK and the US enjoyed over the Euro Area before 2007 has largely eroded since then because of a slowdown in productivity from intensive digital-using industries. Since 2013, when looking at the digital-producing and intensive digital-using industries combined, the contributions from the two industry groups to productivity growth are about the same in the Euro Area, the UK and the US. The main differences are the larger contribution from digital-producing industries in the US, and the negative contributions from the less digital-intensive industries in the UK, whereas the Euro Area shows the most balanced path.

The divergence in productivity contributions from digital-producing industries feeds directly into current debates about the predominance of digital production in the United States. The large volume of demand for US-based digital products and services may be one reason for its continued strength. It punches well above its weight by contributing for more than half of productivity growth since 2013 while accounting for just over 8 percent of value added.

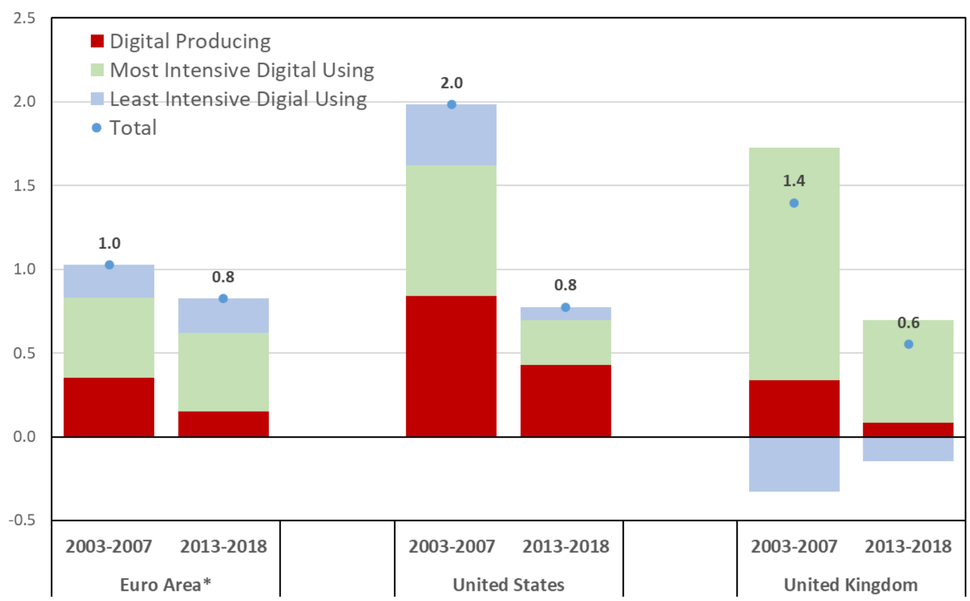
Table 2 compares the productivity contributions from digital producing and most and least intensive-using groups six Euro Area economies, the United Kingdom and the United States. The country estimates suggest the productivity contribution from the digital producing sector dropped significantly in all European countries, and especially in the UK and the Netherlands. In contrast, digital-using industries in Germany, France and the United Kingdom have performed relatively well despite not having a large digital-producing sector.

Charts 2a and 2b: Growth of output per hour and contributions from digital-producing and most and least intensive-using sectors, in %

a) 1996-2006 and 2007-2018



b) 2003-2007 and 2013-2018



Notes: For taxonomy used see exhibit 1; for the aggregation method see van Ark et al, (2019); Euro Area aggregate is based on data for 12 countries (Austria, Belgium, Germany, Greece, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal). Data for national accounts-based employment and value added data was not available for 2018 for Spain, Germany, Greece, Portugal, and are therefore based on short-term employment and production statistics, and anchored to higher level industry data from the national accounts to ensure consistency.
Sources: Conference Board calculations using data from Eurostat; BEA; BLS; ONS.

Table 2: Growth of GDP per hour worked and contributions from digital-producing and most and least intensive-using sectors, in %

		Total	Digital Producing	Most Intensive Digital Using	Least Intensive Digital Using			Total	Digital Producing	Most Intensive Digital Using	Least Intensive Digital Using
United States	1996-2006	2.44	0.73	1.22	0.49	France	1996-2006	1.70	0.38	0.63	0.69
United States	2007-2018	1.04	0.47	0.34	0.22	France	2007-2018	0.69	0.15	0.30	0.23
United States	2003-2007	1.98	0.84	0.78	0.36	France	2003-2007	0.95	0.36	0.40	0.18
United States	2013-2018	0.77	0.43	0.27	0.08	France	2013-2018	1.09	0.15	0.45	0.49
Euro Area*	1996-2006	1.20	0.35	0.47	0.38	Italy	1996-2006	0.37	0.22	0.18	-0.03
Euro Area*	2007-2018	0.75	0.17	0.32	0.26	Italy	2007-2018	0.23	0.07	0.26	-0.10
Euro Area*	2003-2007	1.02	0.35	0.48	0.20	Italy	2003-2007	0.03	0.17	0.25	-0.39
Euro Area*	2013-2018	0.82	0.15	0.47	0.21	Italy	2013-2018	0.44	0.04	0.38	0.02
United Kingdom	1996-2006	1.84	0.40	1.04	0.40	Spain	1996-2006	-0.35	0.12	0.35	-0.82
United Kingdom	2007-2018	0.25	0.10	0.47	-0.31	Spain	2007-2018	1.10	0.10	0.39	0.61
United Kingdom	2003-2007	1.40	0.34	1.39	-0.33	Spain	2003-2007	0.29	0.21	0.63	-0.55
United Kingdom	2013-2018	0.55	0.08	0.62	-0.15	Spain	2013-2018	0.43	0.16	0.45	-0.19
Germany	1996-2006	1.45	0.42	0.36	0.66	Netherlands	1996-2006	1.96	0.40	1.08	0.48
Germany	2007-2018	0.98	0.26	0.35	0.37	Netherlands	2007-2018	0.86	0.12	0.46	0.27
Germany	2003-2007	1.43	0.43	0.40	0.59	Netherlands	2003-2007	2.03	0.45	0.85	0.74
Germany	2013-2018	0.96	0.14	0.54	0.27	Netherlands	2013-2018	0.91	0.14	0.47	0.31

Notes: See Charts 2a and 2b.

Sources: Conference Board calculations using data from Eurostat; BEA; BLS; ONS

Van Ark et al. (2019) exploit the full richness of the labour productivity data by industry to analyse how concentrated or widespread productivity growth is. They plot the cumulative contribution of individual industries to aggregate productivity growth against the cumulative share of these industries in aggregate value added (Harberger, 1998; Timmer et al., 2010). It shows that, while all three regional entities saw a slowdown in labour productivity, the share of value added representing industries that contributed positively to labour productivity in the US dropped from 76 percent (2003-2007) to 59 percent (2013-2018). In the UK the corresponding share dropped from 66 percent to 47 percent. In contrast, industries representing 82 percent of value added in the Euro Area generated positive productivity growth rates from 2013-2018, up from 57 percent from 2003-2007.

In sum, our analysis of the industry data suggests that while macro productivity growth has weakened over the past 15 years, the US has performed relatively well in digital-producing industries and the Euro Area, and especially the United Kingdom, have been relatively strong performers in digital-using industries. The UK also had a fairly large number of less intensive digital-using industries which showed productivity declines. The analysis confirms that specialization patterns maybe conducive to additional productivity gains of the three regional entities.

4. Innovation Competencies and Productivity

As digital transformation is beginning to show bigger productivity effects, its disruptive impact on labour markets is also being felt more broadly. It has become an important concern from the perspective of job creation, the share of labour income in total GDP and its distribution. The productivity effects that come with digitisation may, on balance, have limited net job creation so far (Autor and Salomons, 2018). While it is unavoidable that digitisation destroys jobs in old industries, it should also create new jobs in industries that can grow faster by using the new technology.

An important precondition for that is the formation of appropriate skills for the New Digital Economy. The transition of skills therefore needs to be accompanied with new competencies which enable workers to apply digital technologies in producing new products and services that fulfill the needs of consumers. This helps to create a virtuous cycle in which new jobs and raise living standards through higher wages and greater utility from the consumption of those products and services.

In this section our focus is on how innovation competencies of the workforce align to the needs of the digital transformation process. Using the same OECD taxonomy as in our analysis above, Grundke et al. (2018) show that:

> *"… digital intensive industries especially reward workers having relatively higher levels of self-organisation and advanced numeracy skills. Moreover, for workers in digital intensive industries, bundles of skills are particularly important: workers endowed with a high level of numeracy skills receive an additional wage premium, if they also show high levels of self-organisation or managing and communication skills."*

To measure the extent to which competencies relate to industry productivity growth, we apply a novel approach developed by The Conference Board to assess the innovation potential of occupations. Hao et al. (2018) assign an innovation potential score to each occupation on the basis of 65 innovation-related job characteristics which are obtained from more than variables on job characteristics for more than 700 occupations from the O*NET database, the primary US source of information on occupations (US Bureau of Labor Statistics). The authors then applied factor analysis to ultimately group those characteristics in twelve competencies:

1. STEM
2. Adaptability/Flexibility
3. Autonomy
4. Empowerment
5. Decision Making
6. Cooperative teams and group interaction
7. Creativity
8. Mistake handling
9. Learning culture
10. Conflict handling
11. Enterprising
12. Deal with external customers

One of the insights from quantifying competencies is that the innovation potential of occupations (IPO) seemss more widely dispersed than is mostly assumed. For example, while a sales manager may not at face value be assumed to contribute much to the innovative potential of an organization, this occupation does get a relatively high IPO score –higher than for example a physicist. This is related to the sales manager's crucial role in representing the customer's voice in both the beginning and the end of an innovation cycle.

Using tabulations of occupations by industry for individual countries, we have constructed weighted IPO averages by industry by country (van Ark et al., 2019). We generally find that services industries such as advertising and market research, legal, accounting and management consulting as well as research and development have a relatively high innovation potential. In contrast, at the lower end of the list are agricultural industries, as well as goods producing industries such as clothing, food and drinks and basic metals manufacturing.

Exhibit 2 shows a comparison of UK industries which showed either an increase or a decline in the IPO score between 2007 and 2017 relative to whether labour productivity growth was positive or negative over the same period. In each quadrant we also report the GDP share of the five most important industries in terms of their value added share. The exhibit shows that most industries employed workers with increased innovative potential scores as the top two quadrants account for as much as 85% of all GDP in the UK in 2017. A larger share of those industries (48% of GDP) also showed positive productivity growth, dominated by industries such as construction, health care, retail trade, public administration and finance, while 37% of GDP was in industries with increasing IPO scores but falling productivity, including large sectors such as real estate and education. Only 15% of 2017 GDP in the UK is located in industries with falling IPO scores between 2007-2017, even though about 11 percent of those industries still exhibited positive productivity growth, including large sectors such as wholesale trade and trade in vehicles where other factors than innovation skills of the workforce were driving productivity.

Exhibit 2 – Change in IPO score and labor productivity growth from 2007-2017, top 5 industries by value added share (% of GDP share in 2017, in brackets)

	Negative productivity growth (LP)	Positive productivity growth (LP)
Positive IPO change (IPO)	**TOTAL:** GDP share: 38% Industry weighted change in IPO score: 7.2% Industry weighted LP growth: -0.9% Five most important industries: 1. Real estate activities (L) (13.6%) 2. Education (P) (5.7%) 3. Hotels and restaurants (I) (3.0%) 4. Telecommunications (J61) (1.8%) 5. Land transport (H49) (1.7%)	**TOTAL:** GDP share: 47% Industry weighted change in IPO score: 4.8% Industry weighted LP growth: 1.1% Five most important industries 1. Construction (F, 6.1%) 2. Human health activities (Q86, 5.4%) 3. Retail trade (G47, 5.0%) 4. Public administration (O, 4.7%) 5. Finance (K64, 4.3%)
Negative IPO change (IPO)	**TOTAL:** GDP share: 4% Industry weighted change in IPO score: -1.8% Industry weighted LP growth: -1.4% Five most important industries: 1. Residential care and social work (Q87-88) (1.9%) 2. Warehousing (H52) (1.1%) 3. Farming (A01, 0.6%) 4. Water supply (E36, 0.3%) 5. Basic metals manufacturing (C24, 0.2%)	**TOTAL:** GDP share: 11% Industry weighted change in IPO score: -2.2% Industry weighted LP growth: 1.8% Five most important industries 1. Wholesale trade (G46, 3.6%) 2. Wholesale and retail trade vehicles (G45, 1.8%) 3. Insurance (K65, 1.6%) 4. Architects and engineering (M71, 1.5%) 5. Recording activities (J59_J60, 1.0%)

Notes: For the underlying methodology used see van Ark et al. (2019); Data is available at on the level of 63 individual industries, based on the ISIC rev.4 classification.
Source: The Conference Board Innovation Potential of Occupations Dashboard, Hao et al. (2018); Office for National Statistics.

The analysis shows that clearly the relationship between IPO scores and productivity growth is not perfect. More research is needed on how innovation competencies and productivity influence on each other and which other factors might be at play. However, it is encouraging to see that almost half of GDP in the UK are in industries where workers have improved innovation competencies and show positive productivity growth.

5. How to not miss the productivity recovery again

As the global economy has entered a massive recession in 2020, triggered by the COVID-19 pandemic, productivity has strongly contracted in a short period of time. During the first quarter of 2020, GDP per worker in the Euro Area dropped at 3.4 percent and in the UK at 2.8 percent compared with the previous quarter. These numbers dramatically worsened during the second quarter when the pandemic hit at its hardest, and GDP per worker further deteriorated to -9.5 in the Euro Area and -19.9 percent in the UK (Eurostat). Many advanced economies have put in place job retention schemes and short-time working arrangements to limit job losses, in the hope of preventing a rapid loss in incomes and to facilitate a return to work once the economy opens up again. The reduction in hours worked will therefore be much larger than the loss of jobs, so that estimates of output per hour are likely to show more moderate declines than output per worker. For example, in the United Kingdom, GDP per hour dropped at 1.3 percent in the first quarter and only slightly at 2.5 percent more in the second quarter (ONS).

The most notable exception to the decline of productivity during the pandemic is the United States, which showed an increase in output per hour at 2.8 percent during the second quarter compared to the first as hours declined at about 12 percent vis-à-vis output which dropped at 9.1 percent (BEA and BLS).[5] The lack of short-time working schemes in the US combined with the high incidence of marginal jobs in the services sector, which were especially hard hit during the COVID-19 crisis, are among the reasons for this more limited drop.[6]

Coming out of the crisis, one may expect to see output recover faster than working hours causing a procyclical recovery of productivity. First, the recession will have caused some companies to go bankrupt, which often are the least productive ones. Second, incumbent companies tend to be cautious in rehiring until the recovery has taken hold and will consider the need to restructure in the light of changes in in the structure of demand. For example, in the post-COVID 19 world changed consumer behaviour may accelerate the delivery of goods and services to online or change the nature of demand for business or leisure travel. Recent research for the United States shows that more than one third of US jobs may not be recovered in the medium-term (Barrero et al. 2020). It also remains to be seen how large permanent job losses resulting from the crisis will be for other countries once their employment protection programs wind down.

How can another phase of sluggish productivity growth, as it occurred over the past 15 years, be avoided? The key to a successful medium-term recovery is to turn the post-recession procyclical productivity rebound into a new era of sustained productivity growth. Those effects in part arise from a "cleansing effect" as the failing firms are often the less productive ones, new and more productive firms enter and incumbent companies absorb the resources (labour and capital) that have been freed up during the recession to drive technological change and innovation (Foster at al. 2016). However, such reallocation of resources requires a competitive business environment with low entry barriers that allows "zombie firms" and other types of low productive companies to leave the market and new firms to start up. Some of the latest research shows that the business environment in the US hasn't been very conducive to dynamic market competition in recent years, while European markets are in fact more competitive (Philippon, 2019).

[5] The US estimates from the Bureau of Labor Statistics reported here have been non-annualised for sake of comparison. Beyond the specifics of the current crisis, the atypical cyclical behaviour of productivity in the US has been documented by Fernald and Wang (2016).

[6] In fact BLS estimates for productivity in the manufacturing productivity show a substantial decline for the US as well.

Our research suggests that, once the recovery gets underway, digital transformation may have sufficiently matured to provide the key to a sustained recovery in productivity. Digital transformation goes beyond the invention of new digital technologies and needs to lead to diffusion and adoption across the economy. Firms must also create the capacity to absorb and apply technology by way of a skilled workforce, investments in organizational capabilities such as agility and resiliency, and a strong innovation culture. New innovations (including those from digital technology or biosciences, as well as innovative solutions for services) may be developed by individual firms in their drive toward revenue and profits. These activities will benefit entire industries or sectors when adopted more broadly creating spillover effects in the form of total factor productivity growth.

The accelerated shift toward remote working, as a result of COVID-19, accentuates the importance of digital transformation as a driver of the productivity recovery. Pre-COVID research has shown that employees who work from home can be highly productive, provided the working conditions at home are right (Bloom et al. 2013). However, this productivity gain is not a given. For example, management research shows a weakening of innovation in remote work settings, especially in hybrid settings with some employees working in the office and others working at home. There seems to be a clear advantage to firms that had previously adopted digital technologies to be better at adopting new technologies, and create new products (Riom and Valero, 2020). The potential productivity benefit from virtual work should be an integrated part of a firm's innovation and business strategy (Gratton, 2020).

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