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Digitalisation of financial services, access to finance and aggregate economic performance

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ABSTRACT

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The paper presents novel indicators to measure financial sector digitalisation that cover 21 OECD countries over the 1995-2018 period, showing a significant increase in digital penetration though at different speeds and intensities across countries. The indicators are used to study the impact of financial sector digitalisation on economic activity, highlighting significant positive effects on the productivity of downstream industries. A 10% increase in financial sector digitalisation is associated with a 0.1 percentage point increase in productivity growth for the average industry, with a stronger impact in intangible-intensive industries. Digitalisation in finance is also associated with an easing of credit constraints, particularly benefiting intangible-intensive industries and SMEs, via an improvement in credit allocation and market conditions. Results suggest that policy actions aimed at supporting digital infrastructure, promoting competition in communications, fostering finance innovation, and encouraging high-level skill formation (especially in STEM fields) could sustain and enhance productivity growth through financial sector digitalisation.

JEL classification codes: O33; G00; G38.

Keywords: Financial Sector Digitalisation, Productivity, Credit Allocation, Intangibles.

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RÉSUMÉ

Digitalisation des services financiers, accès au financement et performance économique globale

Cet article présente de nouveaux indicateurs pour mesurer la numérisation du secteur financier couvrant 21 pays de l'OCDE sur la période 1995-2018, montrant une augmentation significative de la numérisation du secteur financier avec des intensités différentes selon les pays. Les indicateurs sont utilisés pour étudier l'impact de la numérisation du secteur financier sur l'activité économique, mettant en évidence des effets positifs significatifs sur la productivité des industries en aval. Une augmentation de 10 % de la numérisation du secteur financier est associée à une augmentation de 0,1 point de pourcentage de la croissance de la productivité pour les industries moyennes, avec un impact plus fort dans les industries intensives en actifs immatériels. La numérisation de la finance est également associée à un assouplissement des contraintes de crédit, bénéficiant particulièrement aux industries intensives en actifs immatériels et aux PME, grâce à une amélioration de l'allocation du crédit et des conditions de marché. Les résultats suggèrent que les actions politiques visant à soutenir l'infrastructure numérique, à promouvoir la concurrence dans les communications, à favoriser l'innovation financière et à encourager la formation de compétences de haut niveau (en particulier dans les domaines STEM) pourraient soutenir et améliorer la croissance de la productivité grâce à la numérisation du secteur financier.

Classification JEL: O33; G00; G38.

Mots-clés : Digitalisation du secteur financier, Productivité, Allocation du crédit, Actifs immatériels.

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1. Introduction

The increasing adoption of digital technologies is deeply affecting the global economy changing ways in which institutions, companies and customers interact. Digitalisation is a multifaceted phenomenon that permeates a wide array of domains and sectors, potentially generating disruptive effects especially for doing business (Caputo et al., 2021). The adoption of digital technologies has been particularly disruptive in the financial sector affecting financial market interactions with both businesses and households. Indeed, using digital platforms, mobile applications, cloud computing, big data analytics, Distributed Ledger Technologies (DLTs, such as blockchain), financial institutions can automate processes, streamline operations, and develop innovative financial products and services.[2] Moreover, through advanced data analytics and technology-driven processes, financial institutions can identify creditworthy businesses faster and with greater accuracy. For instance, the use of big data and AI-based models for creditworthiness assessment is particularly impactful when it comes to thin file micro, small, and medium enterprises and other prospective borrowers with potential financial inclusion benefits (OECD, 2021a). To the extent that digitalisation of finance provides easier access to and more efficient use of financial services, it has the potential to address and mitigate the financial constraints experienced by both households and firms with growth potential (ESCAP, 2022). This can foster financial inclusion but also stimulate innovation, and productivity in the economy. [3]

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[2] In latest years, AI-powered technologies can also be an example of how digitalization can improve efficiency of the finance sector. However, the rise of AI technologies occurs only from the second half of years 2010s and it's unlikely captured in our sample of analysis.

[3] Digitalisation in the financial sector also involves potential risks and costs – such as increased cyber security threats, disruption to traditional business models and operational and privacy risks – whose analysis is outside the scope of

However, the empirical evidence on the growth-promoting effects of the digitalisation of the financial sector for the economy and for industries relying on increasingly digital financial services is still scant. This is largely due to the lack of reliable data on both the adoption of digital technologies in finance and the use of digitalised financial services by firms and households -- though measurement has made some recent advances (World Bank, 2021).

This paper provides a contribution in this respect, proposing a new approach to capture the extent of financial sector digitalisation and providing first empirical evidence on the effects of such transformation on economic activity, with a special focus on business sector productivity.[4] The main assumption is that digitalisation of finance streamlines financial transactions and favours a more accurate and comprehensive assessment of creditworthiness by better informed lenders when allocating credit.[5] This reduces costs and enhances access to credit for dynamic businesses. The effects might be particularly beneficial for more financially constrained activities either because of size (e.g., predominance of SMEs) or because of the nature of their production processes (e.g., knowledge-based). To test the robustness of this assumption, the analysis devotes particular attention to intangible-intensive industries often facing unique challenges to accessing traditional financing. Traditional lenders may struggle to accurately assess the value and collateralization of intangible assets (Demmou and Franco, 2021), making it more difficult for businesses in intangible-intensive industries to secure credit. To the extent that digitalisation of finance eases credit constraints in these industries, it has the potential of fostering their productivity growth disproportionately relative to other less intangible-intensive industries.

The analysis is structured in three steps. First, it introduces a novel set of indicators designed to measure the adoption of digital technologies in the financial sector across countries and over time. These indicators are built using the information on intermediate consumption of digital services (from input-output tables) and financial sector investment in ICT (from EUKLEMS & INTANProd data) for a sample of OECD countries over the 1995-2018 period. These indicators map the trajectory of digital transformation in the financial sector across countries, distinguishing its two main subcomponents, intermediate consumption and investment. Second, the study looks at the impact of the growing adoption of digital technology within the financial sector on the aggregate economy. The aim is to evaluate the extent to which financial sector digitalisation promoted productivity growth in other industries facilitating access to finance by growing businesses and improving within-industry credit allocation. To substantiate this working hypothesis, some of the ways in which financial access and allocative efficiency may have been affected by financial sector digitalisation are also investigated. Third, the analysis explores the role that some structural policies can play to facilitate digital financial development and ultimately growth, focusing on those that promote digitalisation at large.

The empirical findings indicate that digitalisation has spread out rapidly in finance over the past three decades, though to very different extent and with diverse patterns across countries. Empirical results show sizeable positive effects of financial sector digitalisation on productivity of downstream industries: a 10% increase in digital adoption translates into a 0.1 percentage point average increase in aggregate

this study. However, by quantifying the benefits, policymakers can better assess the balance between the pros and cons of financial sector digitalisation.

[4] Notice that the analysis does not consider the direct effects of digitalisation via productivity growth in the financial sector itself (as this would require addressing notorious measurement and cross-country comparability issues).

[5] For example, digital technologies can help financial institutions to have data-driven insights for credit assessment and risk management. Algorithms and machine learning models that analyse vast amounts of data, including non-traditional sources, can significantly improve the evaluation of the creditworthiness of businesses. Or, it could allow assessment of previously unscored clients due to lack of credit history or tangible assets.

productivity growth. As conjectured, productivity gains are stronger in intangible-intensive industries[6], where a similar increase in financial digitalisation leads to an increase in productivity growth three times as large as in other industries (0.14 percentage points vs 0.06 percentage points).

Most of these effects appear to be related to improvements in the allocation of credit that enhance the efficiency of resource use, perhaps by reducing financial market frictions. Indeed, exploring the channels, preliminary evidence shows an association between the digital transformation in financial services and both enhanced access to and better allocation of finance. Notably, financial digitalisation is associated with healthier credit markets (in terms of outstanding NPL) and better credit conditions for SMEs (narrower lending spreads vis à vis large firms, less need for collateral and more lending). This provides a tentative explanation for the digital finance/productivity nexus, especially in financially-constrained areas of the economy.

Finally, the analysis suggests that policymakers potentially have four levers to sustain productivity by facilitating financial sector digitalisation: (i) support the development of digital infrastructure, not only in terms of coverage and depth but also guaranteeing safety and resilience to counter emerging risks, (ii) promote competition in the telecommunications sector, (iii) foster finance innovation and (iv) favour high-level skill formation (especially STEM) and the matching of skills to jobs.

While this paper focuses on the impact of digitalisation of the financial sector on productivity growth, it is important to acknowledge that rapid digital penetration can also entail certain risks to financial stability, such as flash crashes, instantaneous runs on deposits, and increased systemic connectivity. These aspects, while outside the scope of the current analysis, are critical considerations. Future research should delve into these financial stability concerns, as they represent significant factors in the broader discussion of digital finance's impact on the economy. In short, while digital finance brings potential gains, these have to balanced out with the risks and costs it may generate (OECD, 2020a; OECD, 2022).

The paper is structured as follows: the next section provides the conceptual framework for our analysis. Section 3 introduces a new indicator of digital adoption in finance and describes the evolution and current trends in the use of digital technologies by the financial sector across countries. Section 4 estimates the ripple effects of digital penetration in financial services on the rest of the economy, focusing on the impact on market sector productivity. Section 5 explores empirically the policy and structural drivers that could foster financial sector digitalisation. Section 6 concludes.

2. Conceptual Framework

Digital adoption has been consistently linked to productivity gains (e.g., Gal et al., 2019). The integration of digital technologies and processes into various aspects of businesses and industries has shown the potential to enhance efficiency and overall performances both in service and manufacturing sectors (Calvino et al., 2018; Bajgar et al., 2019). Yet, despite the rapid diffusion of digital technologies, productivity growth has significantly slowed down over the past three decades (OECD, 2015; Andrews et al., 2016; Sprague, 2021; Lopez-Garcia and Szörfi, 2021).

One potential limit to reaping the productivity benefits of digitalisation is that limited access to finance can hamper the necessary investment for digital adoption and productivity growth (Heil, 2017; Rajan and Zingales, 1998; Duval et al., 2020). Access to finance for productive investment can be hindered by financial transaction costs and financial market frictions. Costs can be monetary (such as commissions, fees or spreads) as well as non-monetary (such as those associated with bargaining, search or opportunity). Financial market frictions are often generated by information asymmetries that may make it

[6] High vs low intangible sectors are identified by examining the ratio between the stock of intangible capital and hours worked in the industry, considering whether it is above or below the median.

difficult for lenders to evaluate the creditworthiness of borrowers. As highlighted by previous research (Demmou and Franco, 2021), these asymmetries are likely to be stronger in intangible-intensive industries where non-physical resources and rights owned (or controlled) by companies -- such as patents, know-how, data, or goodwill -- contribute to a company's competitive advantage or future economic benefits but are difficult to evaluate (especially as collateral) for lenders.

In principle, digital finance could lower financial transaction costs, as the marginal cost of digital services by lenders is likely to be lower than for services offered at the counter and the reduced need for intermediaries is likely to ease the search and bargaining process for borrowers, also alleviating their opportunity costs. Yet, this is not evident from aggregate descriptives. For instance, the cost of financial intermediation was found to be relatively stable until the Great Recession, and then declined only marginally (BIS, 2023; Philippon, 2015). But digital finance could also reduce frictions: by expanding the knowledge base on which lending decisions are made (e.g., due to leveraging on big data or machine learning algorithms), digital finance can better align the information sets of participants in financial transactions, potentially smoothing the lending process and improving the efficiency of credit allocation. In short, by leveraging digitalisation of the financial sector, businesses can benefit from streamlined processes, improved access to capital and enhanced financial intermediation (Philippon, 2016).

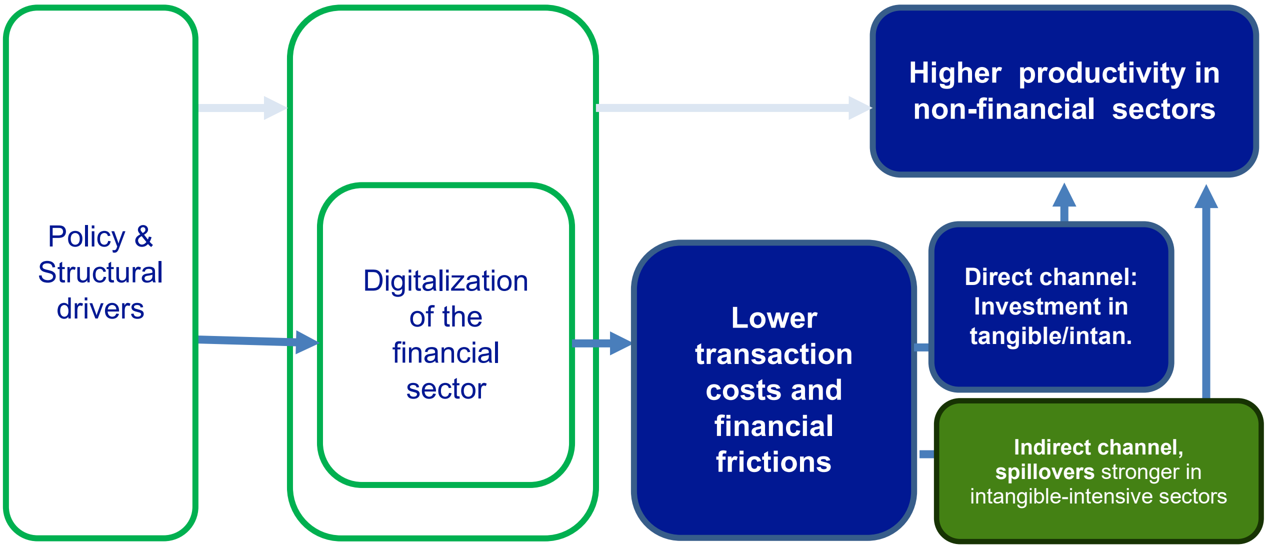
The capacity of digital finance to lower transaction costs and frictions has been documented extensively. Research indicates that automated underwriting processes can result in increased approval rates for borrowers, especially those who are typically underserved (Gates, Perry, and Zorn, 2002). Additionally, advancements in financial technology and machine learning have the potential to lower the cost of credit and enhance financial inclusion (Bazarbash, 2019; Boukherouaa et al., 2021). Other scholars found that technologically-advanced finance providers can use machine learning and big data to create credit scores to process mortgage applications up to 20% faster than others (Fuster et al. 2019).

This can impact productivity in downstream non-financial industries in two ways (Figure 1). First, digitalisation of financial transactions can help channel more investment (the direct channel). The expansion of credit can occur not only on the extensive margin, allowing more firms to access financing, but also increasing financing for specific firms. For instance, scholars found that digital lenders tend to complement traditional bank lending allowing borrowers to refinance more, rather than targeting new borrowers (Fuster et al., 2019; Tang, 2019). The positive effect of easing financial frictions on the productivity potential of the digital transition can be particularly strong in intangible-intensive industries, which are often key for fostering innovation in a service-led digital economy (Sorbe et al., 2018; OECD, 2020b; OECD, 2021b; Demmou and Franco, 2021). Studies by Corrado et al. (2017, 2021, 2022) have shed light on the importance of financing intangible assets, highlighting the need for innovative funding solutions to support digitalisation efforts.

Second, digitalisation of the financial sector can affect aggregate productivity indirectly. At the firm level, use of digital financial services can help streamline internal processes, free resources and allow reallocation of skilled human capital, generating efficiency gains. A similar phenomenon was observed for digital technologies in general (Mosiashvili and Pareliussen, 2020). At the industry level, productivity can improve due to the reallocation of investment finance to the most productive firms (both incumbents and new entrants), which allows them to expand. In particular, digitally-powered lenders are found to be better at assessing a company's creditworthiness, so that they might be more capable of detecting zombie firms (De Fiore et al., 2023). Through this channel, digital finance can also enhance financial stability, as suggested by some cross-country evidence (Banna and Alam, 2021). In addition, the quality of investment may improve, as it is found that digitally-financed firms make more specialized investment (Feyen et al. 2021). These indirect effects can be particularly strong in intangible-intensive sectors characterized by larger capabilities to adopt new technologies, and that could benefit most from enhanced allocation of productive factors.

Altogether, the combination of easier funding of capital formation, better allocation of capital across industries and firms, and firm-level enhanced use of resources can drive productivity growth in downstream industries that use the digitalised services supplied by the financial industry. By easing the funding of technology adoption and the build-up of the necessary intangible complements, such as organisational capital and skills, adoption of digital technologies in finance can represent an additional channel through which digitalisation boosts aggregate productivity.

Figure 1. Conceptual framework: the relationship between policy, digitalisation of the financial sector and sectoral productivity



Public policies are important for shaping the pace and extent of digitalisation (Pisu et al. 2021), including in the financial sector. In particular, structural policies can boost both the capabilities and the incentives for technology adoption (Nicoletti et al., 2020), for instance by affecting its enabling conditions such as high-quality digital infrastructure (G20, 2016) and skills (Grundke et al., 2018). They can also make digital adoption more productivity-enhancing (Sorbe et al. 2019), for instance by enhancing competitive pressures, including in ICT-intensive industries (e.g., telecommunications) that are key for financial sector digitalisation. Among structural policies, financial sector regulations play a specific role in promoting the digitalisation of financial services, for instance by setting security and privacy standards (including in cross-border transactions) and allowing experimentation of new financial products (e.g., via regulatory sandboxes).

3. Mapping digitalisation trends in the financial sector across countries

Despite the rising importance of digitalisation of financial services, there is a scarcity of reliable indicators to measure the penetration of ICT investment and intermediate consumption of digital services in the financial sector across countries and over time. This section proposes a new set of indicators aimed at measuring the *adoption of digital technologies in the financial sector* that are particularly well-suited for cross-country analysis.[7]

[7] While, as discussed further down, the proposed approach leverages data on intermediate consumption and investment in ICT services and assets, these are not the only sources that are available to measure digitalisation, as detailed in Calvino et al. (2018). Statistical offices have produced surveys specifically geared towards the use of digital technologies, such as the EU ICT use survey by Eurostat, which however does not include the financial sector.

Digitalisation is a multifaceted process that entails a range of activities (Calvino et al., 2018). Among these the adoption of information and communication technologies -- including computers and software -- and their use in production play a central role. ICT often requires large up-front costs from which digital services can be extracted at very low, or even negligeable, marginal cost. Hence, some companies prefer to purchase digital services from service providers, rather than performing the necessary investment themselves. Ultimately, digitalisation occurs via both ICT investment and the purchase of such intermediate digital services (Calvino et al. 2018).[8] Accordingly, the proposed indicator measures the extent of digitalisation considering both **intermediate consumption** of digital services and **investment in ICT assets** at constant prices, per hour worked.

First, an indicator of digitalisation of financial services through **intermediate consumption** of digital services [$DTFS\ Consumption_{ct}$] for country *c* at time *t* is obtained as follows:

$$DTFS\ Consumption_{ct} = \frac{(II_{ct}^{fin,dig}/(PI_{ct}^{dig}))}{H_{ct}^{fin}} \quad (1)$$

where $II_{c}^{fin,dig}$ is intermediate consumption of digital services (J62-J63 in the NACE rev.2 industrial classification) by the financial sector (K64 to K66 in the NACE rev.2 industrial classification) in country *c* which is readily available in the inter-country input-output (ICIO) tables, compiled by the OECD. PI^{dig} is the price index for the value added produced by digital industries, which is retrieved from the EUKLEMS&IntanProd[9] database to obtain our measure in volume terms.[10] It is then possible to scale the volume of intermediate consumption in terms of hours worked in the financial sector, H_{c}^{fin}, in country *c* (Bontadini et al. 2023).

Second, the measure in equation (1) is replicated for **investment** in ICT per hour worked, at constant prices ($DTFS\ Investment_{ct}$), retrieving investment in ICT technologies by the financial sector $IqICT_{c}^{fin}$ from the EUKLEMS&INTANProd database:

$$DTFS\ Investment_{ct} = \frac{IqICT_{ct}^{fin}}{H_{ct}^{fin}} \quad (2)$$

An alternative to investment measures would have been to use stocks of ICT assets. Unlike flow measures such as investment, stocks are the outcome of cumulated investment from previous years and depreciation. However, ICT technologies are characterised by a fast decrease in prices and rapid changes

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Moreover, cross-country comparisons of data from existing country-specific surveys are difficult, hence reducing the size of the sample for analysis. Job postings have also drawn attention as a micro-founded measure. While they are particularly well-suited to study the role of skills in technology adoption they overlook investment in digital assets, such as software and computers.

[8] The role of data as an asset has also drawn increasing attention, but economic research in the data field is still at an embryonic stage, both in terms of the measurement of the asset and its relationship with productivity growth and other intangible assets (Corrado et al. 2023). Therefore, the measure proposed in this paper is limited within current national accounts boundaries.

[9] Data and methodological documentation are available at https://euklems-intanprod-llee.luiss.it/. The EUKLEMS&INTANProd database provides detailed data for 27 EU Member States, the US, Japan and the United Kingdom, across industries over the period 1995-2020.

[10] We deflate intermediate consumption of digital services with the deflator for value added of digital industries, rather than the deflator of intermediate consumption. This is because digital services represent a rather small portion of total intermediate consumption of any given industry and therefore the deflator of value added for digital industries is likely to better capture the price dynamics than the general intermediate consumption deflator.

in quality. When using data on capital as a proxy of technology adoption it is hard to meaningfully compare ICT investment from even five years ago (think of how much computers, softwares or mobile phones have changed in the past few years) with current investment. While part of this is captured by the fast depreciation that is incorporated in the compiling of the EUKLEMS&INTANProd ICT stocks (following the methodology by Colecchia and Schreyer, 2002), using investment rather than stocks allows to focus on the portion of the capital stocks that is the newest and more likely to incorporate the most recent ICT technologies. [11]

The proposed measurement approach therefore accounts for two aspects of digitalisation – intermediate consumption and investment – and considers the indicators in per hour terms.[12] The indicators can be summed and deflated using a composite price index of both components. Therefore, it is possible to estimate the aggregate incidence of Digital Technologies in the Financial Sector ($DTFS_{ct}$) – i.e., the sum of digital investment and intermediate consumption – as a synthesis of two possible channels through which the financial sector can digitalise.

The proposed indicators have two key advantages. First, they cast a “broad net”, capturing the overall digitalisation of the financial sector instead of focusing on a specific set of technologies or business models. Second, the approach provides measures that are comparable across countries and can, in principle, be replicated also to measure digitalisation in other (non-financial) sectors, including the public sector.

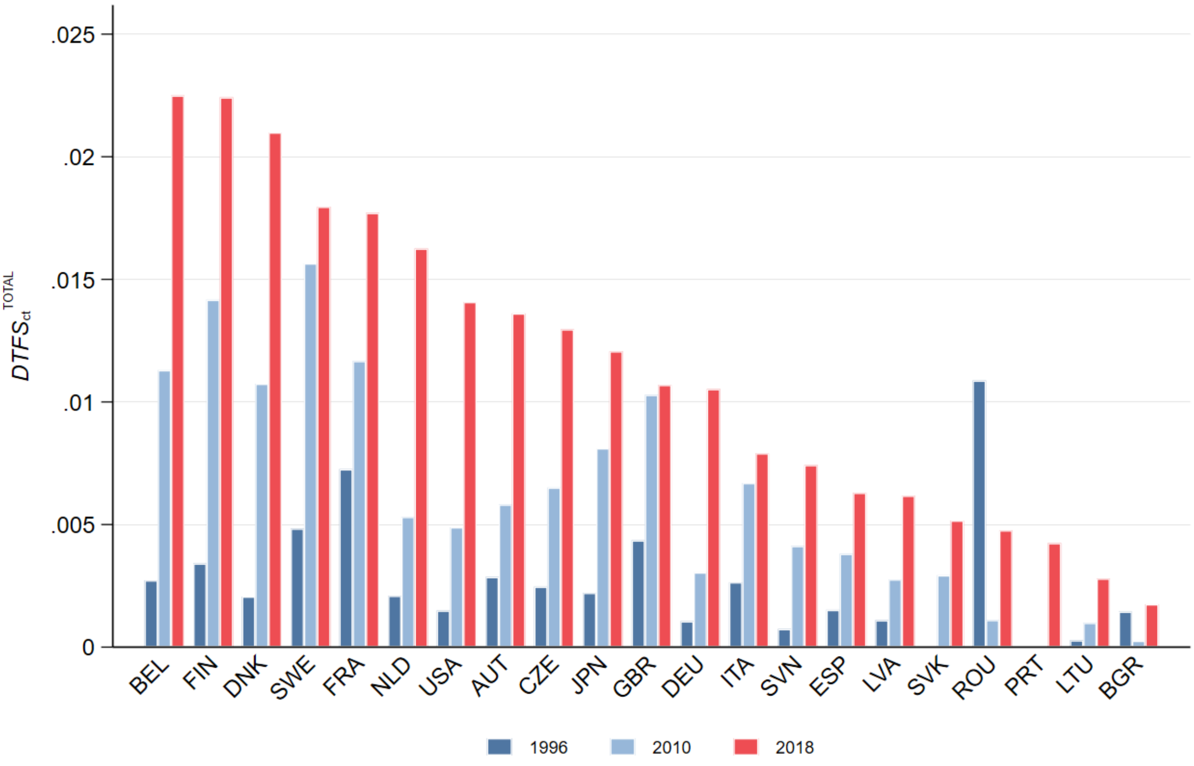
In both these respects, the proposed approach builds on previous work carried out by the OECD (Calvino et al. 2018) but it provides a continuous measure, rather than a taxonomy of sectors according to their digital intensity. It is also worth stressing that the $DTFS_{ct}$ measure looks specifically at digitalisation of production processes, either through intermediate consumption or investment. This is consistent with a conceptual framework linking digitalisation of financial services to productivity.

This sets the proposed measure apart from other contributions looking at users’ adoption of digital technologies, such as the Global Findex database (Demirgüç-Kunt et al. 2022), based on surveys over nationally representative samples. Survey-based data provide a nuanced understanding of consumers’ use of digital technologies but are less informative on *firms’* adoption of digital technologies and how this is related to productivity dynamics across countries’ total economy. In addition, the Global Findex database is available for only a few years (2021,2017,2014 and 2011), while the $DTFS_{ct}$ measure relies on annual national accounts data and the ICIO compiled by the OECD.

[11] Note also that it would be hard to combine intermediate consumption, a flow measure, with ICT capital stocks, that have much larger levels and would likely drive the aggregate DTFS. Using investment allows to combine two flow measures providing a more meaningfully interpretable measure.

[12] Using hours to normalize digital investment and intermediate consumption is in line with standard measures of capital intensity, i.e., unit of capital per hour worked. An alternative normalization would have been to use our two measures at current prices and normalize them by total value added. This approach would have, however, included price dynamics, which for ICT assets and services have been decreasing fast (Colecchia and Schreyer, 2002), possibly leading to a downward bias in our digitalisation measure.

Figure 2. Digital technology in the financial sector (DTFS) over time



Notes: the graph reports the evolution of DTFS, defined as the sum of digital investment and intermediate consumption of digital services, for three sample years and for all countries in our sample.

Figure 2 shows the evolution of financial sector digitalisation as captured by the aggregate $DTFS_{ct}$. While there has been a general rising trend in the usage of digital technologies in the financial sector over time, both levels and patterns differed widely across countries. The different trajectories across countries indicate the differential pace at which digitalisation has been embraced within their respective financial sectors. Certain economies exhibit a pronounced acceleration in digital penetration, indicative of a widespread adoption of ICT and intermediate consumption of related digital financial services. Conversely, there are countries where the progression appears slower, reflecting a more gradual approach to integrating digital technologies.[13]

Additional figures are presented in Annex Figures A1 and A2, highlighting various approaches to the digitalisation of the financial sector. For example, financial digitalisation in the US has expanded steadily and rapidly. It is characterized by investment larger than intermediate consumption. By contrast, in Europe financial sector digitalisation has been pursued to a larger extent via purchases of digital services rather than via investment in ICT. Digitalisation in the UK's financial sector increased rapidly before the financial

[13] The very high values observed for Romania in 1996 are due to significant volatility in the dynamics of prices for value added in the IT and other information services, which we use to deflate our DTS measure. In the data, DTS at current prices increases rapidly between 1995 and 1997, only to then decrease as quickly in until 2002, only regaining its 1997 level by 2010. In parallel, prices have been increasing, especially so in the first years of our time series. This explains the sharp decrease in the observed values at constant prices. For this reason, and due the lack of data on capital stock in EUKLEMS dataset, Romania is excluded from the estimation.

crisis and then stagnated, though at high levels. Conversely, in Germany, the financial sector has experienced a steady digital transformation. In Italy, digitalisation of finance stopped rising after the financial crisis and eventually declined, driven by stagnating investment and shrinking intermediate consumption.

As the indicator measures flows, some cross-country differences might also reflect uneven beginning-of-period ICT capital stocks in the financial sector, such as might be the case for the United Kingdom. Furthermore, larger financial sectors may also have a significant component of the traditional banking sector, which could be less inclined to rapidly embrace digital transformation on a broad scale. This aspect of their structure may help explain why such sectors, including those in the UK and US, tend to have relatively lower $DTFS_{ct}$ indicating a slower pace of adopting digital technologies on a widespread scale.[14] Finally, $DTFS_{ct}$ is a ratio, scaling digitalisation (ICT investment and intermediate consumption of digital services at constant prices) with hours worked in the financial sector. As a result, increases in the index could be due to growing digitalisation or a decrease in the hours worked in the financial sector.[15]

4. Measuring the ripple effects of financial sector digitalisation

What is the impact of increased digital technology use in the financial sector on the productivity of downstream industries? The working hypothesis is that financial sector digitalisation, by enabling cheaper and broader access to credit as well as by enhancing allocative efficiency, has the potential to boost productivity growth at the industry level.

Empirical approach

In order to test this hypothesis, sectoral productivity growth is related to a sector-specific measure of the $DTFS_{ct}$ indicator (see below). Labour productivity growth is gathered from the EUKLEMS&INTANProd database, providing data for productivity analysis at the sectoral level and covering the EU countries plus UK, US and Japan. Labour productivity is computed as value added over hours worked, where value added is measured consistently with the inclusion of intangibles among capital assets. The sector-specific indicator is obtained by weighting the country-level $DTFS_{ct}$ indicator by the sector-specific intermediate consumption of financial services[16]. The final estimation sample includes 19 countries and 36 sectors over the years 1996-2018.[17]

As the econometric estimates might be affected by endogeneity, the analysis uses the average country-specific values across sectors and years of intermediate consumption of financial services (denoted

[14] In Figure A.6 this point is illustrated by plotting the growth rate in $DTFS_{ct}$ between 2005 and 2018 and the share of the total economy's output that the financial industry accounts for, finding as expected a negative relationship.

[15] Figure A.5 shows that both of these are occurring in Belgium and the Netherlands for example, which explains the marked increase in DTFS in 2018 with respect to 2010.

[16] More precisely, the sector-specific indicator is obtained by interacting in each country digitalisation of the financial sector with the share of intermediate consumption of financial services in total output of each non-financial sector.

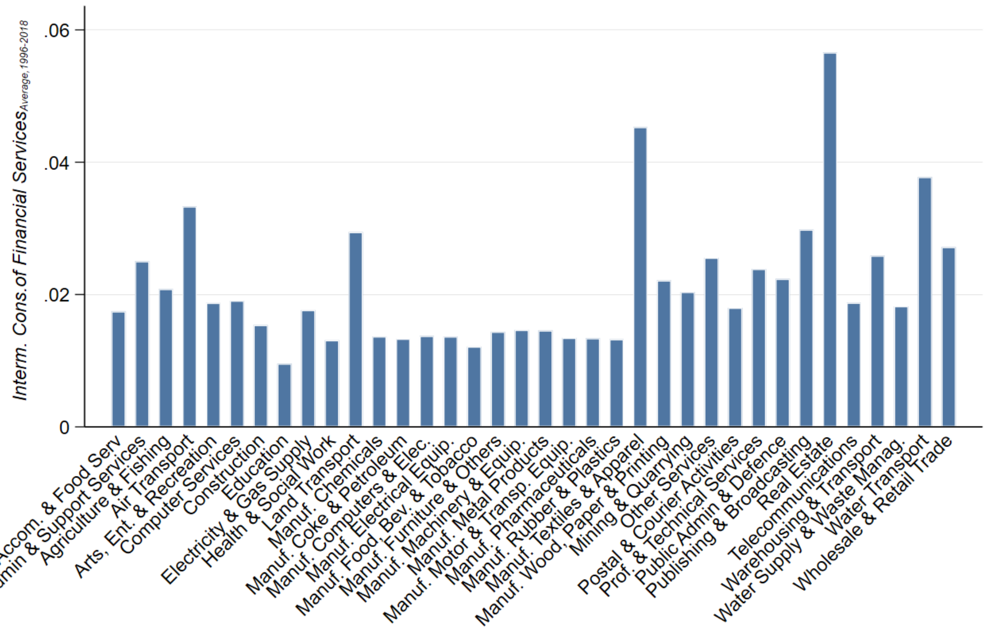
[17] The final estimation sample includes all country-sector-year observations derived from the two primary datasets used to construct the relevant variables. Due to mismatch between them, country-sector-year coverage might differ. For instance, our analysis is limited to data up to 2018. This limitation arises because, while the EUKLEMS & IntanProd dataset covers years up to 2020, the ICIO dataset is only available up to 2018.

$IntConsFin_{cts}$) computed excluding the data for the specific country-sector-year in question, rather than the country-specific current intermediate consumption of financial services:[18]

$$Interm.Cons.of\ Financial\ Services_{cts} = \frac{\sum_{i=1\ \forall\ i \neq c}^{C} \frac{II_{its}}{X_{its}}}{C-1} \tag{3}$$

where II_{its} is the intermediate consumption of financial services and X_{its} is the value of total output in country *i* and sector *s.* In order to interpret this sector-specific indicator it is important to keep in mind that such intermediate consumption covers a wide array of financial products, which include for instance online banking services, portfolio management, handling of commercial credits and financial consultancy services.

Figure 3. Finance as intermediate input across sectors.



Notes: The graph reports the average consumption of financial services, calculated as the average over countries of the ratio between consumption of intermediate financial services to total output of the sector, in the period 1996-2018 (i.e., the period of our analysis), for all sectors in our sample.

Figure 3 plots $Interm.Cons.of\ Financial\ Services_s$ over the 1996-2018 period (Annex Figure A3 plots the dispersion of this indicator across countries in different sectors). Sectors with the largest exposure to financial services include the manufacturing of textile and leather products (C13-C15) and service industries, notably transport (H49, H50, and H51 are land, water, and air transportation services, respectively) real estate (industry L) and digital services (J58-J60). Aside from different exposure to a wide array of financial services, these results also reflect differences in the structure of the production processes. For instance, high-tech manufacturing industries purchase a wide array of complex and processed

[18] Arguably, taking the sample average across countries is better than relying on a representative country, which would completely disregard differences in the economic and institutional development of countries in the sample.

intermediate products from many sectors, other than the financial industry. By contrast, in low-tech industries that purchase relatively unrefined intermediates (such as textile) or in services that typically have a lower overall content of intermediates, intermediate consumption of financial services represents a larger share of the industry's output.

The estimates are based on a productivity growth equation augmented with the measure of sector-specific adoption of digital finance:

$$Labor\ Productivity\ Growth_{cts} = \beta_0 + \beta_1 (\log)DTFS_{cts} + X_{cts} + FE_{ct} + FE_s + \epsilon_{sct} \quad (4)$$

where (log) $DTFS_{cts} = \log(DTFS_{ct}) * \log(IntConsFin_{cts})$ is a shorthand for the sector-specific indicator of DTFS. The measure of productivity growth is the change in the logarithm of real value added (VA) – adjusted to account for non-national account intangible assets as in Corrado et al (2017) – divided by hours worked (H). X_{cst} represents a set of control variables. FE_{ct} and FE_{s} are country-year and sector fixed effects to control for sector-specific omitted factors and for unobserved economy-wide shocks within a given country-year.[19]

Equation (4) is a reduced-form relationship between the proxy for country-time-sector exposure to digitalisation of the financial sector ($DTFS_{cts}$) and sectoral productivity growth. In line with standard productivity analysis, in the baseline model specification the control set X_{cst} includes the (logarithmic) change in the total capital stock – or, alternatively, of its tangible and intangible components separately -- at constant prices and per hour worked observed in the corresponding country-sector. However, as controlling for the change in the capital stock absorbs any direct effect of $DTFS_{cts}$ via (measured) capital deepening, an alternative model specification excluding the change in capital stock is also estimated. Comparison between the coefficients of $DTFS_{cts}$ in these two alternative specifications allows in principle to gauge the relative importance of the direct and indirect channels through which $DTFS_{cts}$ can affect sectoral productivity growth. Additionally, omitting only one of the two capital components (tangible or intangible) allows in principle to gauge to what extent the direct effects are driven by one or the other type of capital accumulation.

The contribution of financial sector digitalisation to productivity growth of downstream industries

The estimates of the baseline model show a positive and statistically significant effect of the digitalisation of financial sector on labour productivity growth (Table 1, Column 1).[20] The results are robust to lagging capital growth to account for potential endogeneity concerns (Column 2) as well as to distinguishing between intangible and tangible assets (Columns 3 and 4). The magnitude of the coefficients implies, for example in column 1, that a 10% increase in the digitalisation of the financial sector leads to an increase of 0.1 percentage point in labour productivity growth in the average industry.[21]

[19] The main text uses the baseline specification that achieves the best balance between precision, general validity of the estimates and identification. A more demanding structure of fixed effects (e.g., country-sector and/or sector-time FEs) that relies more on within variation would i) increase measurement error issues and ii) reduce meaningful variation (since our variable of interest exploits country-time and sector variation). However, the results are broadly unchanged when conducting a wide range of robustness exercises using different structures of fixed-effects (See Annex C).

[20] For the sake of clarity, the main text presents only estimates for the main variable of interest. A table with all estimated coefficients (all of which have the expected signs) is reported in Annex B. The discrepancy in observation counts across the various columns of Table 1 are due to different coverage of the capital growth variables.

[21] Even if the estimate should not be considered as causal but only as suggestive correlation, one can use the obtained estimate and compare it with the total change reported in Appendix Figure A1. Doing so, one obtains that he

Exploring the relative importance of the direct and indirect channels (Annex Table B2) suggests that most of the estimated effects of $DTFS_{cts}$ on productivity originate from indirect sources, such as better allocation of financial funds across firms within industries – for example by avoiding zombie firms (De Fiore et al., 2023) -- or easier entry and exit, rather than from stronger capital deepening at industry level. Indeed, omitting the change in capital stock from the equation increases only slightly the estimated impact of $DTFS_{cts}$ on productivity (Annex Table B2, Column 1).[22]

Table 1. Digitalisation of the financial sector is associated with higher productivity in downstream industries

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.010***	0.012***	0.010***	0.014***
	(0.003)	(0.004)	(0.003)	(0.004)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,425	10,905	9,194	8,775

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. A table with all estimated coefficients is reported in Annex B. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm.Cons.of\ Financial\ Services_{cts}$). Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

A more robust way to highlight the apparent predominance of the indirect channel is by decomposing the estimated contribution of $DTFS_{cts}$ to productivity growth into its contribution to each of the determinants of productivity growth identified via a growth accounting decomposition (Figure 4 and Annex Table B3). Such method starts from recognizing that labour productivity growth can be decomposed into the contributions from capital per hour worked, the labour composition effect and multifactor productivity growth.[23] Then, it is possible to regress each of the three components separately on the level of digital finance as in equation

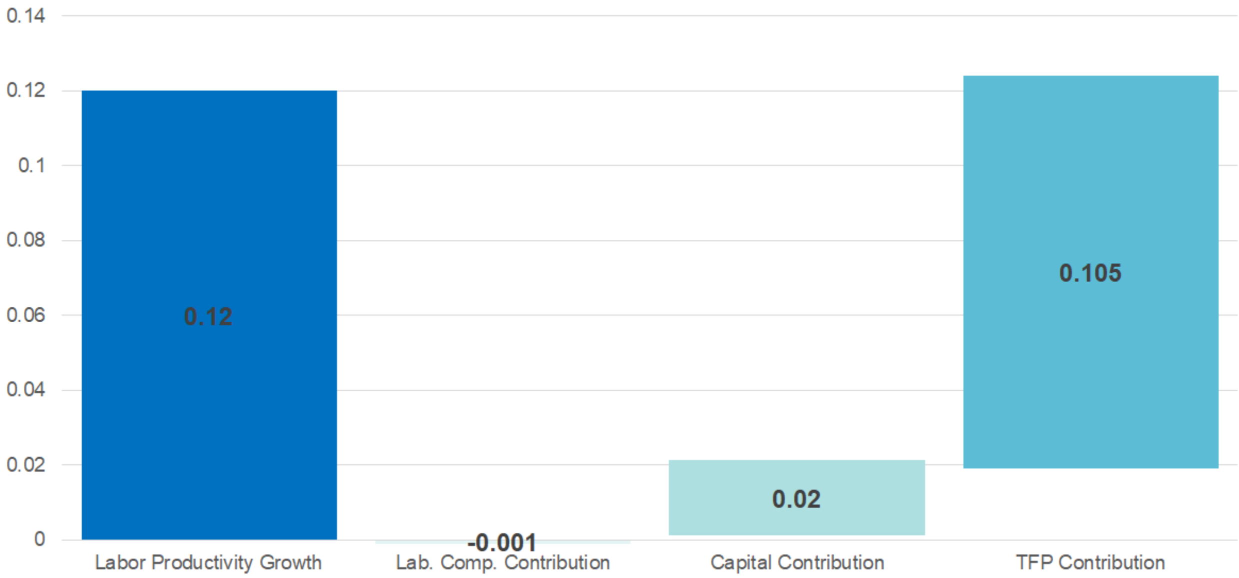
contribution of digital finance to total productivity growth over 2005-2018 is generally in the order of 1-2 percentage points over the 14 years considered. For comparison, recent automation technologies are expected to have effects in the order of 10-20 percentage points increase on productivity over the same horizon (McKinsey Globa Institute, 2017), and other studies find that a substantial part of these gains is due to spillovers similar to the ones we observe for digital finance (Oxford Economics, 2017; Wei et al, 2024)

[22] Moreover, most of the direct effects seem to be channelled by tangible assets accumulation (Annex Table B1, Columns 4 and 5).

[23] This derives from the accounting decomposition of real GDP growth into labor, capital and TFP growth at previous-year factor shares, subtracting the growth rate of hours worked from both sides of the equation.

(4). The estimated coefficients will estimate the relationship between digital finance and growth of capital per hour worked, labour costs per hour (a measure of the contribution of labour composition to total labour productivity growth), and multifactor productivity growth. The results suggest that most of the influence of $DTFS_{cts}$ operates via multifactor productivity, which at industry level summarizes mainly productivity gains obtained via an enhanced allocation of labour and capital within and across firms as well as productivity-enhancing firm industry firm demographics.

Figure 4. Contribution of digital finance adoption to productivity growth, growth accounting determinants



Notes: The graph displays the estimated impact of a 10% increase in DTFS to productivity growth into its contribution to each of the determinants of productivity growth identified via a growth accounting decomposition. The first bar displays results obtained using as dependent variable the labour productivity growth (corresponding to estimates in Column 2, Table 1). The other bars display results obtained using as dependent variables the contributions to labour productivity growth of labour composition, capital and TFP, respectively. Corresponding estimates are presented in the Annex Table B3.

Annex C provides a battery of other robustness checks, such as using alternative definitions of the usage of financial intermediate inputs (e.g., utilizing total intermediate consumption instead of total output in the denominator of Equation 3, using the median rather than the average value of pre-sample total intermediate consumption, using current intermediate consumption of financial services observed in sector-country 'sc', or the average intermediate consumption of financial services observed in sector-country 'sc' up to year 't-1'). The analysis also explores alternative industry coverage (e.g., replicating the analysis by systematically removing one sector at a time from the estimation sample). Additionally, the robustness checks investigate sensibility to alternative country coverage (e.g., sequentially excluding one country at a time from the estimation sample), different fixed-effect structures (e.g., conducting two additional robustness exercises by replicating the analysis, incorporating sector-year fixed effects and sector-country fixed effects), and different clustering levels (e.g., clustering standard errors at the sector level). The results of the baseline model remain broadly unchanged. Furthermore, an additional robustness check controls for possible confounding factors related to financial market conditions by interacting the long-run interest rate with the industry-level measure of the intermediate consumption of financial services. The results, detailed in Table C.10, reveal that the inclusion of this additional interaction has minimal impact on the estimated effects of $DTFS_{cts}$. Finally, one might be worried that the results partially capture the effect of rising digitalisation in downstream industries rather than the effect of digitalisation of the financial sector on downstream industries' productivity. To check the robustness of the results to this threat, Table C. 11 in the appendix replicates the baseline regressions including controls for digital intensity of the downstream industries.[24] Reassuringly, the results remain significant and of magnitudes that are very close to the baseline specification.

Disentangling Digital Consumption and Investment in Finance

Using the two subcomponents of the $DTFS_{ct}$ indicator also allows exploring whether productivity is differently affected by the consumption of intermediate digital services or digital investments made by the financial sector. There is significant variability across countries in the levels and time patterns of these two kinds of expenditures leading to financial sector digitalisation, which could have distinct effects on the productivity performance of downstream sectors that rely on financial services.

Table 2. Separating the contribution of the consumption and investment components of digitalisation of the financial sector

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) $DTFS^{\text{Consumption}}{}_{cts}$	0.006	0.006	0.006	0.007*
	(0.004)	(0.004)	(0.004)	(0.004)
(log) $DTFS^{\text{Investment}}{}_{cts}$	0.003	0.004	0.002	0.006
	(0.004)	(0.005)	(0.004)	(0.005)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,407	10,887	9,182	8,763

Notes: The table reports OLS estimates. The unit of observation is the sector *s* in country *c* in year *t*. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS^{Consumption}_{cts}$ ($DTFS^{Consumption}_{cts}$) is consumption of digital technology (investment in digital technology) in the financial sector observed in the corresponding sector-country-year. Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

To address this question, Table 2 replicates the baseline regression replacing the indicator of digitalisation of the financial sector $DTFS_{ct}$ first with $DTFS\ Consumption_{ct}$ and then with $DTFS\ Investment_{ct}$. All point estimates presented in Table 2 are positive; however, they lack statistical precision. These findings suggest that to identify a significant effect of financial sector digitalisation on productivity, it is necessary to consider both channels of digital penetration: through intermediate consumption and through investment. This suggests some kind of substitutability between these two types of expenditures. Moreover, the estimated

[24] Digital intensity of downstream industries is defined in an analogous way as for the Finance industry, i.e., as the sum of intermediate consumption from digital sectors and investment in ICT per hour worked. The measure is lagged one period to avoid endogeneity and "bad controls" issues.

coefficients are similar for both sub indicators suggesting that there is no privileged path to financial sector digitalisation (investment or consumption) in terms of effectiveness for promoting productivity growth.[25]

The mediating role of intangible-intensive industries

Lastly, the analysis focuses on whether the impact of financial sector digitalisation on the productivity growth of downstream industries depends on the extent of intangible-intensity of their capital assets. Industries relying heavily on intangible assets are likely to be more financially constrained than other industries due to the inherent difficulties in collateralizing intangible assets for securing loans or accessing traditional forms of financing. Unlike physical assets, which can serve as tangible collateral, intangible assets - intellectual property, brand value, and innovative capabilities - are not easily quantifiable or transferable. To the extent that digitalisation of finance eases these constraints (e.g., by facilitating the evaluation of creditworthiness by financial institutions), intangible-intensive industries may benefit from it more than other industries.

To verify this conjecture, equation (4) is tested separately for industries characterized by high and low intangible intensity, discriminated based on being above or below the median stock of intangibles per worker. To reduce endogeneity concerns, intangible intensity is computed using the time-window 1995-2000.[26]

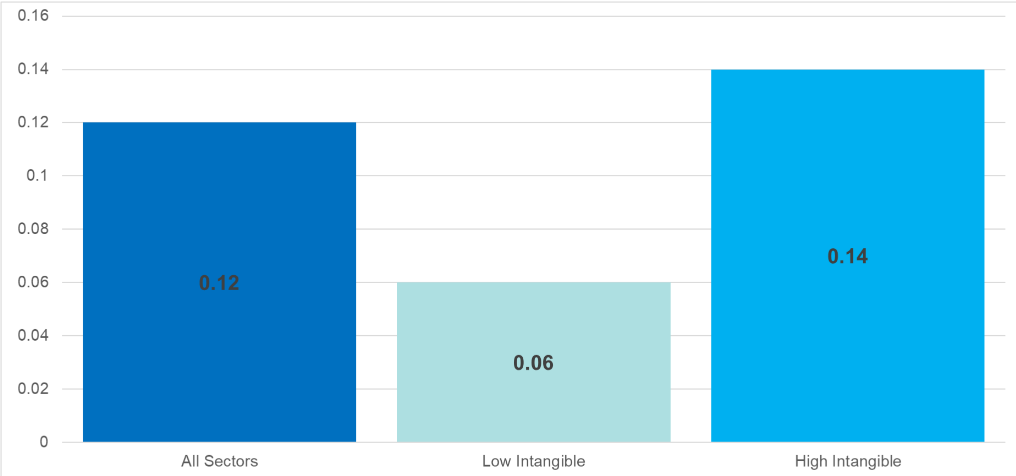
Estimation results are depicted in Figure 5 (the corresponding table is in Appendix D). The first bar replicates the full sample results of Table 1 (Column 2). The next two bars display the estimates obtained by breaking down sectors with low and high intensity of intangible capital, respectively. The estimates suggest that acquiring financial services from a highly-digitalised financial sector has a stronger effect on productivity growth in sectors where organizational capital, data, intellectual property and research and development are relatively more relevant.[27]

[25] Annex Table B4 also investigates whether a complementary relationship exists between the two approaches towards digitalising the financial sector, with no conclusive result.

[26] Figure A4 in Annex A reports different sectors according to their intangible intensity. Examples of high-intangible sectors are Manufacture of electrical equipment and Manufacture of computers and electronics, while examples of low-intangible sectors are Construction and Accommodation and food service activities.

[27] Annex Table D2 shows that this differential effect vanishes if the same experiment is performed when distinguishing between industries that have high or low tangible capital intensity, confirming the special role played by financial sector digitalisation vis à vis intangible-intensive industries. Given the nature of the indicator of digital finance, which relates to the whole finance sector, this result could also capture the rising role of non-banks entities, such as venture capital funds. These operators are in fact generally more digitalised than traditional banks (BIS, 2024).

Figure 5. The contribution of financial sector digitalisation to productivity in high and low intangible intensity industries



Notes: The graph displays the effect of a 10% increase in $DTFS_{cts}$ on productivity growth. The first column displays results obtained with the full sample. The second (third) column displays results obtained using low (high) intangible sectors only. Corresponding estimates are presented in Annex Table D1.

These results are consistent with the idea that digital finance has the potential to reduce financial market frictions, facilitating the growth of industries whose capital base is more difficult to evaluate for lenders. This is especially relevant for sectors with high levels of intangibles, where traditional methods of assessing creditworthiness may not fully capture the value of a company's assets. Through more precise collateral estimation and identification of high-growth firms, digital finance can help to boost and revive overall productivity growth.

Mechanisms at work

A working hypothesis so far has been that digitalisation of the financial sector facilitates access to credit and improves the efficiency of credit allocation, benefiting especially creditworthy firms that have difficulties in financing their activities (such as intangible-intensive companies). To provide some evidence of the relationship between digital finance and credit markets, this section investigates how digitalisation of the financial sector affects specific credit-related outcomes. The focus is set on non-performing loans and access to credit by SMEs for which cross-country historical data has recently been made available by the World Bank and the OECD (OECD, 2020c). The following empirical model is estimated:[28]

$$CE_{ct}^{v} = \beta_0 + \beta_1 \log(DTFS_{ct}) + FE_c + FE_t + \epsilon_{sct} \; ; \qquad (5)$$

where CE_{ct}^{v} are credit environment outcomes, $DTFS_{ct}$ is the indicator of digitalisation of financial services in country *c* at time *t*, and FE_c and FE_t are country and year fixed effects to control for country-specific omitted factors and for unobserved common shocks within a given year across observations.

The different outcome variables (CE_{ct}), indexed by v, capture several features of the credit environment in a given country and year. Firstly, the analysis looks at the percentage of non-performing loans, providing insights into the ability of a digitalised financial system to better allocate funds to healthy firms. Secondly, the interest rate spread between small and medium-sized enterprises (SMEs) and large firms is considered

[28] For further information regarding sources, variable definitions, country and time coverage, please refer to Annex G.

to test whether digitalisation of finance has eased access to credit by narrowing the interest rate differential, possibly due to better screening of borrowers. Thirdly, the share of SMEs that require collateral for accessing loans is also used to proxy for the ability of digital finance to reduce information asymmetries between lenders and borrowers. Finally, the link between financial sector digitalisation and the percentage of long-term lending provided to SMEs as a proportion of total lending is examined, given that long-term lending is crucial for businesses to undertake strategic investments, expand operations, and foster sustainable growth.

Estimates in Table 3 show a statistically significant association between digital technology in the financial sector (DTFS) and the key credit environment variables. Financial sector digitalisation is associated with better credit allocation (Column 1), lower credit penalty for SMEs vs large firms (Column 2), easier credit conditions via collateral requirements (Column 3) and more long-term lending for SMEs (Column 4).[29] Interpreting results causally, the magnitude of the coefficients implies, for example (Column 2), that increasing the digitalisation of the financial sector from the median level to the top 75th percentile value in our sample (an increase of around 42%) could lead to a decrease in the interest rate spread between large and small firms of 0.34 percentage points. This effect is sizeable, especially when considering that the average spread in our sample stands at 1.07 percentage points.

While further analysis needs to be done with more refined datasets (especially at the firm level) to test the robustness of these results and their causal interpretation, they provide preliminary evidence on some of the channels that may link digitalisation of the financial sector to improved aggregate productivity performance. These include, as hypothesized in previous sections, both a reduction of financial transaction costs on the credit market and an easier screening of borrowers that leads to a better allocation of credit.

Table 3. Digitalisation of financial sectors is associated with a better credit environment

Dependent Variables:	(1) Non-performing loans (%)	(2) Δ Interest rate SMEs vs Large	(3) Collateral SMEs	(4) Long-term lending SMEs (% total)
(log) $DTFS_{ct}$	-0.711* (0.373)	-0.816*** (0.311)	-7.757** (3.828)	4.373* (2.359)
Observations	436	187	87	108

Notes: The table reports OLS estimates. The unit of observation is country c in year t. The dependent variable is displayed at the top of each column. $(log)DTFS_{ct} = \log(DTFS_{ct})$ where $DTFS_{ct}$ is digital technology in the financial sector observed in the corresponding country-year. Data on non-performing loans are sourced from World Bank Indicators, while variables related to access to credit by SMEs are obtained from the OECD SME Scoreboard. Robust standard errors are presented in parentheses. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

To mitigate potential omitted variable bias, controls for business cycle effects, the share of SMEs in the economy, corporate indebtedness and financial development indicators were added as additional explanatory variables. The results of Table 3 (shown in Annex Table E1) remain robust to such controls.[30]

29 The discrepency in observation counts across the various columns of Table 3 are due to different coverage of the credit variables in the OECD dataset.

30 We further conduct robustness checks by excluding years associated with significant periods of turmoil in European economies. The results from these additional exercises are presented in Tables E2-E5.

5. Policy and structural drivers of digitalisation of the financial sector

As illustrated in the previous sections, digitalisation of the financial sector potentially generates relevant benefits in terms of better access to credit and higher productivity growth, making the evaluation of the structural and policy drivers for promoting the digitalisation of financial services an important issue for economic growth. Thus, in this section, the measure of digitalisation of the financial sector is associated with a range of policy and structural indicators collected from different sources and this correlation is tested in the following simple model across countries and over time:

$$\log(DTFS_{ct}) = \beta_0 + \beta_1 PV_{ct}^{v} + FE_c + FE_t + \epsilon_{ct} \;; \qquad v \in Policy\ variables \tag{6}$$

where PV_{ct}^{v}, is the main variable of interest and v spans the following policy and structural indicators:

- The first, *PMR Communications* (drawn from the OECD PMR Database) measures the extent to which regulation curbs competition and dynamism in communications, a sector that is key for digitalisation.
- The second, *Gross domestic spending in R&D* (drawn from the OECD Main Science and Technology database) is a proxy for a country's innovation effort, which includes innovation in the digital field and contributes to the ability of a country to absorb new technologies. Notice that this indicator covers both public investment and private spending on R&D, which – as previous research has shown (Westmore, 2014) – is heavily influenced by a range of public policies (such as tax incentives and subsidies).
- The third set focuses instead on the characteristics of the workforce and includes the tertiary education enrolment rate, tertiary education enrolment in STEM subjects, the proportion of workers who are well matched[31] and the relative size of the youth population (all these indicators are taken from the OECD World Indicators of Skills for Employment). The assumption is that a younger, high skilled and well-matched workforce is more likely to support the digitalisation of the financial sector (both directly via the ability to supply digitalised services and indirectly via demand for such services). Clearly, both skills and job matching are affected by public policies in education, training and labour markets.
- Finally, the infrastructure dimension is measured by the number of secure internet servers every million people and of fixed broadband subscriptions per hundred inhabitants (sourced from World Bank Development Indicators). A broadly diffused and secure digital infrastructure is crucial for supporting the adoption and diffusion of digitalised financial services. As illustrated by a number of policy reports (e.g., OECD, 2019), public policies have an important bearing on the development of high-quality digital infrastructure.

Table 4 below reports the results of the analysis, with Columns (1)-(4) including the four sets of policy and structural drivers one at the time. Anticompetitive product market regulation in communications is negatively related to the level of digitalisation in finance, signalling that lack of competition and dynamism in communications might discourage innovation and digital adoption in the financial sector. Gross domestic spending on R&D is instead positively related to digitalisation of the financial sector, suggesting that promoting investment in R&D enhances the absorptive capacity of new digital technologies in finance. Turning to the labour market dimension, both the tertiary education enrolment rate, the tertiary education enrolment in STEM subjects, and the proportion of workers who are well matched are positively and significantly related to digitalisation of the financial sector, while the share of youth seems not to be a

[31] The proportion of workers who are well matched is defined as the proportion of workers whose educational attainment is equal to the one normally required by their job.

significant driver. This is consistent with the idea that a highly skilled workforce is key for the adoption of digitalisation in financial services, providing additional reasons for focusing government policies on improving skills and removing labour market frictions. Finally, the number of secure internet servers and of fixed broadband access per capita are also positively and significantly related to digitalisation of the financial sector, pointing to the need to support such digitalisation with adequate infrastructure investments, which can be encouraged by public policies (e.g., via competitive contracting out, place-based policies or public-private partnerships).

The correlation of financial sector digitalisation with regulation, R&D, skills and infrastructure remains broadly significant when all these dimensions of policies and structural drivers are pooled in the same regressions (columns 5 and 6). As the PMR Communications has a lower sample coverage the number of usable observations (column 5) is reduced causing R&D to lose significance. Hence, the regression in column (6) replicates this exercise excluding the PMR and, while R&D recovers its significance, the other results do not change.

To ensure that the policy and structural drivers have a direct impact on the digitalisation of the financial sector, rather than just promoting digitalisation in general, the analysis in Table 4 was replicated by including an additional control variable that combines the intermediate consumption of digital services and investment in ICT assets for the entire economy, excluding financial services. The results (see Annex F) are robust to this change in specification, suggesting that the identified set of policy and structural drivers directly impact the digitalisation of the financial sector (in addition to any potential overarching effects on digitalisation in the rest of the economy).

Table 4. Policy and structural drivers of digitalisation of the financial sector

	Policy drivers		*Structural drivers*		*Combined*	
Dep. variable: (log) $DTFS_{ct}$	(1) PMR	(2) Research	(3) Workforce	(4) Infrastructure	(5)	(6)
PMR Communications (log)	-0.0797***				-0.0535**	
	(0.0264)				(0.0225)	
Gross domestic spending on R&D (as % GDP) [GERD]		0.417***			0.0638	0.302**
		(0.123)			(0.0610)	(0.123)
Tertiary level enrolment rate			0.0124***		0.0138***	0.0110***
			(0.00240)		(0.00207)	(0.00259)
Share of tertiary enrolments in STEM subjects			0.0349***		0.00509	0.0173**
			(0.00876)		(0.00694)	(0.00743)
Proportion of workers who are well matched			0.0422***		0.0146***	0.0427***
			(0.00716)		(0.00524)	(0.00732)
Relative size of youth population			0.0147		0.0105	-0.00341
			(0.0144)		(0.00841)	(0.0120)
Secure Internet servers (per 1 million people)				4.16e-06***	3.13e-06***	9.36e-07
				(1.52e-06)	(1.08e-06)	(1.44e-06)
Fixed broadband subscriptions (per 100 people)				0.0157*	0.00501	0.0161**
				(0.00890)	(0.00331)	(0.00666)
Observations	359	460	412	460	335	412

Notes: The table reports OLS estimates. Country and year FEs are include in all columns. The dependent is (log) $DTFS_{ct}$ and corresponds to the digital technology in the financial sector observed in the corresponding country-year. Columns 1 and 5 include the variable ComFin that corresponds to the ratio between the intermediate consumption of telco services in the financial sector and the total value added of the financial sector. Robust standard errors are reported in parenthesis. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

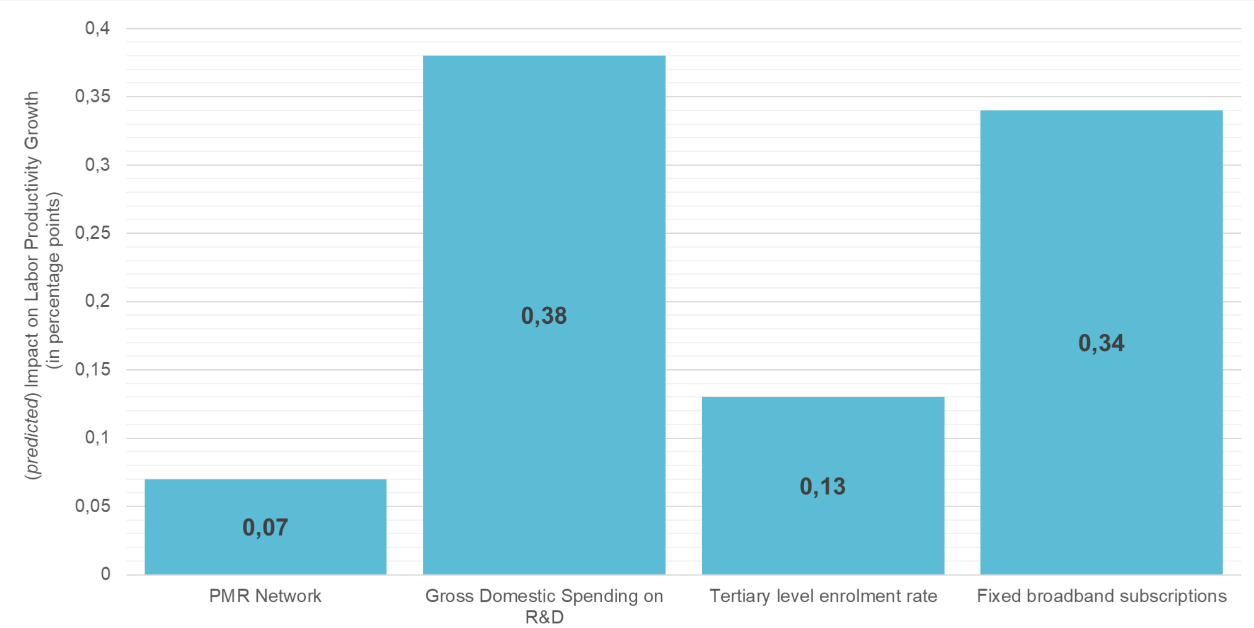
While it is important to acknowledge certain caveats regarding the limitations of drawing causal inferences solely from cross-country regressions, estimates presented in Table 4 offer valuable insights into the possible structural and policy drivers of digitalisation in the financial sector, with four key policy levers emerging:

- First, setting product market regulation right, particularly in the communication sector, can have a significant impact on the digitalisation of the financial sector. Implementing policies aimed at simplifying and easing regulatory constraints while promoting a competitive and dynamic market environment that levels the playing field and facilitates entry by innovative players could encourage higher levels of digitalisation in finance, thereby boosting its transformative potential.
- Second, by enhancing workforce skills, via appropriate education and training policies, and reforming labour markets to facilitate the matching of skills to jobs, policies can also influence digital adoption in the financial sector. This is consistent with previous research (Corrado et al., 2022; Nicoletti et al., 2020), highlighting the critical role of skilled human capital in driving the digital transformation.
- Third, promoting investment in R&D, via both direct funding and fiscal incentives, can create an environment conducive to digital adoption in finance by both increasing innovative activity and facilitating the use of innovative tools. R&D subsidies should be considered with caution as they risk crowding-out private investment and face backlash from general public.
- Finally, encouraging investment in modern and secure digital infrastructure, via adequate regulation and incentives, is also key to shaping the digital landscape of the financial sector. Robust and reliable infrastructure, including digital connectivity and access to cutting-edge technologies, provides a solid foundation for the integration of digital solutions within financial services.

To illustrate the economic significance of these findings, Figure 6 illustrates the estimated impact on productivity growth of changes in policies that would result in a significant (but reasonable) increase of financial sector digitalisation. The impact is computed by combining the estimates of Table 1 (showing the effects of changes in financial digitalisation on productivity growth) and Table 4 (showing the association between changes in policies and the extent of financial sector digitalisation).[32] The policy experiment consists in moving each structural factor that is affected by policy levers from the lower 25th percentile value in the cross-country sample to the median level. For instance, let's consider the scenario of increasing gross domestic spending on R&D (as % of GDP) from the lower 25th percentile value in our sample (approximately 1%) to the median level (approximately 1.84%). Under this assumption, the estimated annual gain in labour productivity growth would be approximately 0.38 percentage points (pp), resulting from a 32% increase in financial sector digitalisation. This potential productivity effect is sizeable, considering that the average annual labour productivity growth observed in the cross-country sample is around 0.5%.

[32] The implicit assumption is that the policy experiment has no direct effect on labour productivity growth, and any effects are channelled solely through enhancements in the digitalisation of the financial sector. The implication is that estimated gains in productivity growth represent a conservative estimate of the effects of policy-induced changes in structural policy conditions.

Figure 6. Policies to enhance financial sector digitalisation: the impact on productivity



Note: The graph displays the potential impact of policy changes on productivity via changes in financial sector digitalisation. The policy change consists in moving each policy and structural factor from the lower 25th percentile value in the cross-country sample to the median level (or from the median to the lower 25th percentile value in the case of PMR). Using the coefficients in Table 4, the impact of the implied policy experiment on the digitalisation of the financial sector is gauged. Subsequently, the estimated change in digitalisation is used to estimate the effect on productivity growth using the coefficient estimates in Table 2 (Column 2).

Overall, the findings suggest that a combination of workforce skills, favourable product market regulation, adequate infrastructure, and dedicated research efforts can act as key drivers in advancing the digitalisation of the financial sector and sustain productivity growth. By understanding and leveraging these drivers, policymakers can design effective strategies and interventions to accelerate digital transformation, unlocking its potential to enhance financial services, close performance gaps among firms and foster inclusive economic growth.

The structural policy variables considered in this empirical analysis are by no means exhaustive of the policy levers that can be activated to influence the digitalisation of the financial sector.[33] Regulations in both digital and financial markets also play a pivotal role in driving the digital transformation (Box 5.1). For instance, the regulation of access to data and platform activity is crucial for establishing a secure and competitive digital financial environment. New regulatory approaches, such as sandboxes, have the potential to encourage experimentation that can stimulate the provision of innovative digital financial services. Additionally, competition within the banking industry can serve as a driver of technological innovation. A more competitive environment may further incentivize financial institutions to adopt innovative technologies and develop new financial products and services tailored to meet the diverse needs of consumers. Cross-country empirical analysis in this area is thwarted by the dearth of comparable data on regulations and policies that are specific to financial markets. But, data permitting, future research could delve into the intricate interplay between digitalisation, regulations, and competition, providing comprehensive insights into the forces shaping the transformation of the financial industry.

[33] In addition, the COVID19 pandemic was a very strong conjunctural driver of digitalisation of finance. The pandemic is outside the scope of our analysis due to data limitations, but future research should shed light on this.

Box 1. Policies for Promoting Digitalisation of the Financial Sector

Key dimensions: regulation, infrastructures and skills

Key barriers to demand for digital services in finance have long been identified as 1) lack of trust, complexity, absence of legislation ensuring fair market competition; 2) inadequate infrastructure, high costs, low operability; and 3) low awareness, low literacy, digital skills gap (OECD, 2017). Policies to tackle these barriers and foster demand for digital services include regulatory interventions, infrastructure investment, and investment in financial skills and literacy.

Regulation

Finance is a heavily regulated industry, with entry/exit flows governed by specific rules (BIS, 2024). Hence, regulatory policies are key but could face trade-offs between different policy objectives. First, policy experience highlighted that digital technologies can democratise access to finance but also exacerbate concentration of market power, discrimination, and segmentation (BIS, 2023). Traditional banking sectors are often heavily regulated, and specialized entrants offering digital financial services can represent a positive boost to competition. Yet, digital financial providers often have characteristics that require different regulation (e.g., virtual interaction, potential network effects, diversified activities in non-banking sectors), and authorities must consider long-term risks of monopolization and increased financial instability (Ehrentraud et al. 2020). To strike a good balance, financial regulation in advanced economies tends to adopt a technology-neutral stance, meaning that digitalising financial markets may not always require specific regulations.

A second policy trade-off arises on the consumer side. Authorities need to foster innovations and at the same time safeguard consumers. Risks associated with technology-driven financial innovations include data misuse, inadequate disclosure, lack of security and uninformed consumer misuse. A third tension is in the choice between activity-based and entity-based rules, where the need for common standards to avoid regulatory arbitrage and favour transparency can conflict with the need to enhance efficiency and assess specific needs of digital finance providers (Borio et al., 2022).

Finally, a significant challenge arises with the pacing problem, wherein regulatory frameworks find it challenging to match the swift developments in Fintech (Marchant, 2011). This issue consists in the difficulty of keeping regulation up-to-date despite the exceptionally rapid growth of digitalisation of finance. To get an idea, in 2021 76% of adults had access to a digital transaction account, a figure that was only 51% a decade earlier (Demirgüç-Kunt et al. 2022).

Infrastructure

Ensuring appropriate physical and technological infrastructure is also critical to fostering digital finance growth. Government entities are implementing public policies and initiatives to establish the necessary foundations for a digital infrastructure supporting these services (OECD, 2017). This may involve initiatives such as building a national broadband network, developing digital identities and authentication systems, encouraging interoperability among essential networks and platforms (e.g., telecoms, banking systems), and creating overarching frameworks or strategies for data protection and cybersecurity, either at the national level or specifically tailored for the financial industry, among other measures.

Skills

A final critical policy area is skill development. Together with other intangible assets, skills were shown to be a crucial complementary investment for digital adoption (Corrado et al., 2022; Nicoletti et al., 2020). It is therefore important to take stock of evidence on the state of financial literacy and review financial literacy strategies and programs as done in the OECD/INFE surveys (OECD/INFE, 2017, 2023).

Relevant country experiences

Sweden

Among developed countries, Sweden is one of the most advanced in digital finance, in particular in terms of the investment component in Figure 2. In terms of regulation, not only Sweden benefited from EU-level harmonized rules but also guaranteed to The Swedish Financial Supervision Authority (FI) a particularly wide legal mandate. Among other initiatives, FI established an Innovation Hub, a central contact point to streamline queries and provide support, advice, guidance to either regulated or unregulated firms to help them navigate the regulatory, supervisory, policy or legal environment (IMF, 2023; World Bank, 2020a,b). Also, in terms of infrastructures and skills, Sweden stands at the forefront in the adoption and utilization of digital technologies. Both individuals and businesses extensively engage with the internet, and the digital gaps based on age, education, income, and company size are narrower compared to most OECD countries. Sweden also excels in broadband availability, quality, and affordability, ranking among the top performers in the OECD (OECD, 2018).

South Korea

The case of South Korea exemplifies the challenges and different risks that policy can face in regulating digital financial services (Beck et al., 2021). South Korea's banking sector initially operated within an oligopolistic structure with limited adoption of digital technologies, despite being a highly digitalised country with advanced infrastructure and literacy. Accompanied by a policy of laissez-faire, competition improved as new digital financial services emerged, both from new start-ups and established BigTech companies. However, over a decade, some inefficiencies emerged: P2P lending platforms lost credibility due to widespread fraud, and while start-ups multiplied, many struggled with efficiency. Eventually, the industry turned back into an oligopoly, primarily dominated by financial subsidiaries of BigTechs. Recognizing the need for change, the government implemented measures aiming at reinvigorating entry in the financial market, alongside a more proactive regulatory stance, including the introduction of a "Regulatory Sandbox" in 2019. A regulatory sandbox (Bromberg et al., 2017; World Bank, 2020a,b) is an established framework by a financial sector regulator, facilitating the controlled, small-scale testing of innovations by private firms under the regulator's supervision. These virtual environments facilitate live testing of new products or services in a controlled and time-bound manner. It is still early to assess the success of the Korean experience, but besides efficiency considerations analysts start pointing at significant concerns in terms of inclusion related to digitalisation of the financial sector (Nam and Lee, 2023).

Czech Republic

The Czech Republic scores in the average in terms of the digital finance indicator of Figure 2. Interestingly, the establishment of a regulatory sandbox by Czech Authorities was discussed recently to foster innovation in the financial sector while managing emerging risks associated with new technologies, benefiting all stakeholders involved (OECD, 2023). The sandbox's design emphasizes facilitating innovation, promoting competition and inclusion, and attracting digitalised financial enterprises, with participation criteria ensuring adherence to regulatory standards. An Advisory Board assists in preselecting participants, with final decisions made by the Authorities, facilitating a supportive environment for testing new financial products and services. The sandbox aims to maintain legal certainty by applying existing rules, aiding supervisors in monitoring FinTech activities and ensuring compliance with evolving regulations. Expectedly, digitalised financial enterprises stand to gain from enhanced communication, tailored guidance, and clarity on licensing, enabling informed decision-making and compliance with regulations. In addition, authorities can better understand and respond to the changing risk landscape, signaling openness to safe financial innovation and boosting investor confidence.

Emerging economies

A number of emerging economies also offer examples of alternative policy approaches. China is known for having adopted initially a "wait and see" approach, allowing new business models like mobile payments to develop with minimal regulation, leading to the rapid growth of platforms such as AliPay and WeChat Pay. Over time, the country implemented a "test-and-learn" approach, making progressive and small regulatory adjustments, launching inclusive finance products, and at the same time establishing comprehensive Fintech regulations. This allowed policy makers to progressively improve the stability of the financial system, even if its complexity was high at that point, so that some observers argue that regulation arrived too late (Chorzempa and Veron, 2023).

India adopted a proactive approach from the early phase of Fintech development. Not only the government focused building the necessary infrastructure, but also directly supported a large number of ventures (e.g., FINO). In addition, to increase trust in digital finance, the Central Bank introduced consumer protection measures (e.g., an ombudsman scheme for digital transactions) and enhanced customer protection (e.g., limiting liability on unauthorized transactions). This resulted in benchmark grassroot projects like “India Stack”, the largest AI global repository, that functioned as a base for a number of start-ups that counter-balanced BigTech services.

Finally, Latin America and the Caribbean have made strides in digital financial technologies, presenting both hope and scepticism. For example, positive impacts of digital finance including on downstream firms’ productivity were observed in Peru (Cusato Novelli et al. 2023)

6. Conclusion

The rising role of digital technology in the financial sector goes beyond its immediate impact on financial services. By lowering financial transaction costs, fostering inclusive access to financing and lessening financial market frictions, financial sector digitalisation can unleash the potential for innovative firms to flourish, creating a virtuous cycle that not only bolsters individual businesses but also serves as a catalyst for boosting aggregate productivity.

This paper provides three main contributions in this respect. First, it introduces a novel indicator to measure the spread of digital technologies in the financial sector, that allows both researchers and policymakers to track its progress over time. Second, it offers a fresh exploration of the impact of digitalisation of financial services on the economy, and particularly on its role in enhancing business sector productivity growth. There are two main channels potentially at work here: first, financial sector digitalisation by easing access to finance can directly support capital accumulation, thereby increasing the productivity contribution of capital deepening; second, a wider adoption of digital financial services favours reallocation of investment finance to more efficient firms and industries, thereby fostering aggregate productivity growth. The special role played by digital finance in intangible-intensive industries was highlighted in this context. Finally, the paper develops supporting evidence to inform policymakers about some of the levers that can be activated to encourage financial sector digitalisation via better regulation, better skills, better infrastructure and more innovation.

Future research can follow different directions to deepen the understanding of the multifaceted effects of digital adoption in finance and uncover opportunities to further harness its potential for growth, innovation, and inclusive development. First, delving deeper into how digital finance can support firms’ innovation patterns and business dynamics would provide valuable insights. Exploring the mechanisms through which digital finance influences firms’ innovation strategies, including the adoption of emerging technologies, could uncover new avenues for policy interventions that boost productivity and competitiveness. Understanding the impact of digital transformation on different types of firms, such as start-ups versus established companies with the possible utilization of firm-level data, would help tailor policies and support mechanisms accordingly.

Second, examining the mechanisms behind the link between digital technology in the financial sector and investment, possibly distinguishing between tangible and intangible assets, could further clarify the channels through which financial sector digitalisation affects productivity. In this context, a specific focus might also be set on investment in green technology. Understanding how digitalisation of finance can drive sustainable investments and support the transition to a greener economy would be important for the growth agenda of policymakers. Another potential channel that could be explored is the distinction between the role of traditional banking and non-bank entities.

Third, investigating the household side of digital finance to explore the potential double dividend of digital technology in the financial sector, in terms of both boosting productivity and improving inclusiveness and fairness in the economy, might be of interest to policymakers. Understanding whether and how digital financial services can enhance access to financial resources for underserved populations and promote financial inclusion is an important step towards achieving a more equitable society. Additionally, exploring the impact of digital finance on households' financial behaviour, such as savings and investment patterns, could provide information on the broader macroeconomic implications of digitalisation in the financial sector.

Finally, the policy levers considered in this paper can be enriched and extended by looking at the ways in which regulations and policies that are specific to financial and digital markets can influence the digitalisation patterns of the financial sector. This may require the collection of comparable cross-country data and the construction of indicators that are specific to financial market regulations. These sector-specific policies could also have a bearing on the channels through which financial sector digitalisation affects aggregate economic performance.

In this connection, future research should also acknowledge that the digitalisation of the financial sector brings forth not only potential gains but also potential risks and costs, including heightened cybersecurity threats, disruption to traditional business models, possible build-up of market power and operational and privacy risks. An in-depth empirical analysis of these risks is beyond the scope of this paper, but they deserve to be considered in any policy discussion balancing out the costs and benefits of promoting digital finance.

Results in this paper should help policymakers make more informed decisions by offering a first empirical evaluation of the benefits generated by financial sector digitalisation. By conducting a comprehensive assessment of the potential returns, this paper allows to better evaluate the trade-off between the advantages and disadvantages that arise from embracing digitalisation in the financial industry.

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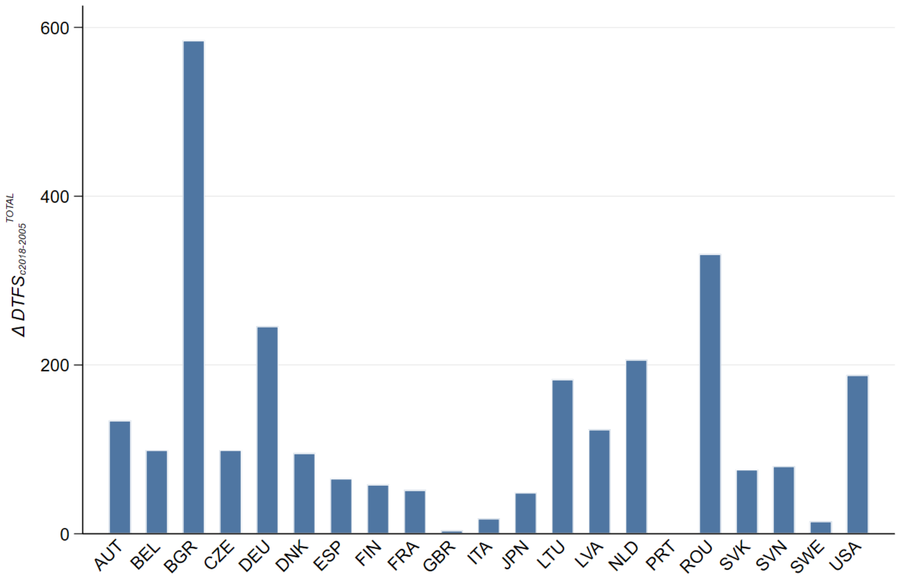
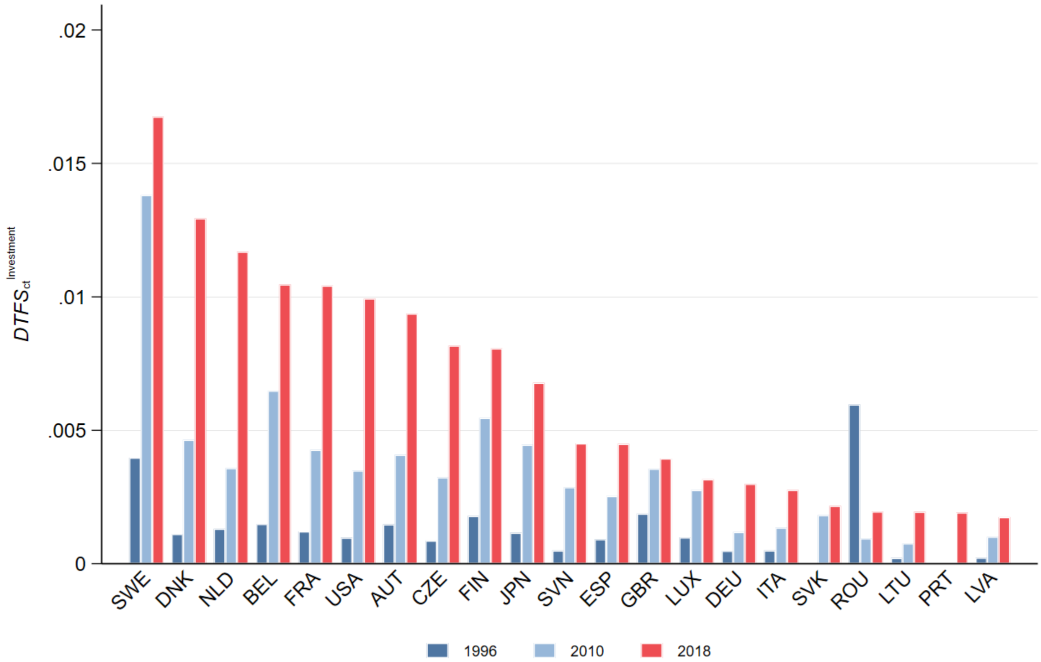
Annex A. Additional Figures

Figure A.1. Percentage points change in digital technology in the financial sector (DTFS) between 2005 and 2018



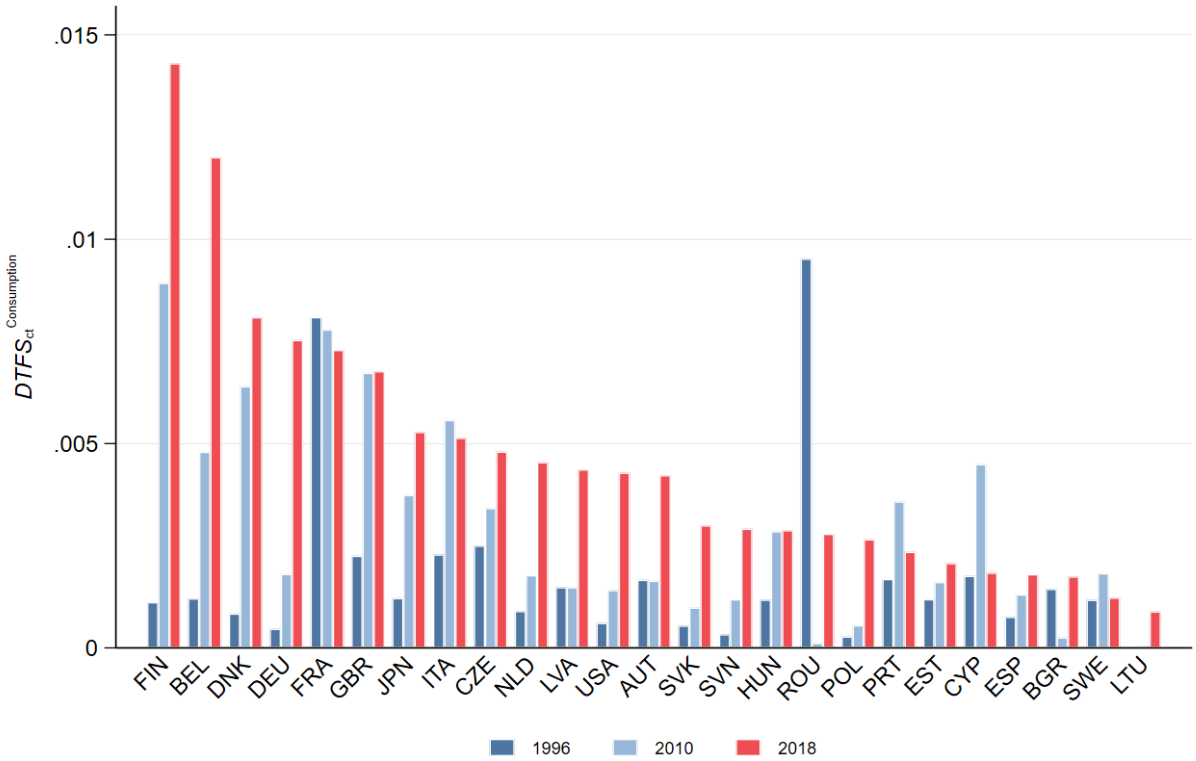
Notes: the graph reports the evolution of DTFS between 2005 and 2018, where DTFS is our indicator for digitalisation of the financial sector, and it's defined as the sum of digital investment and intermediate consumption of digital services, for all countries in our sample.

Figure A.2. Trends in financial sector digitalisation – Investment



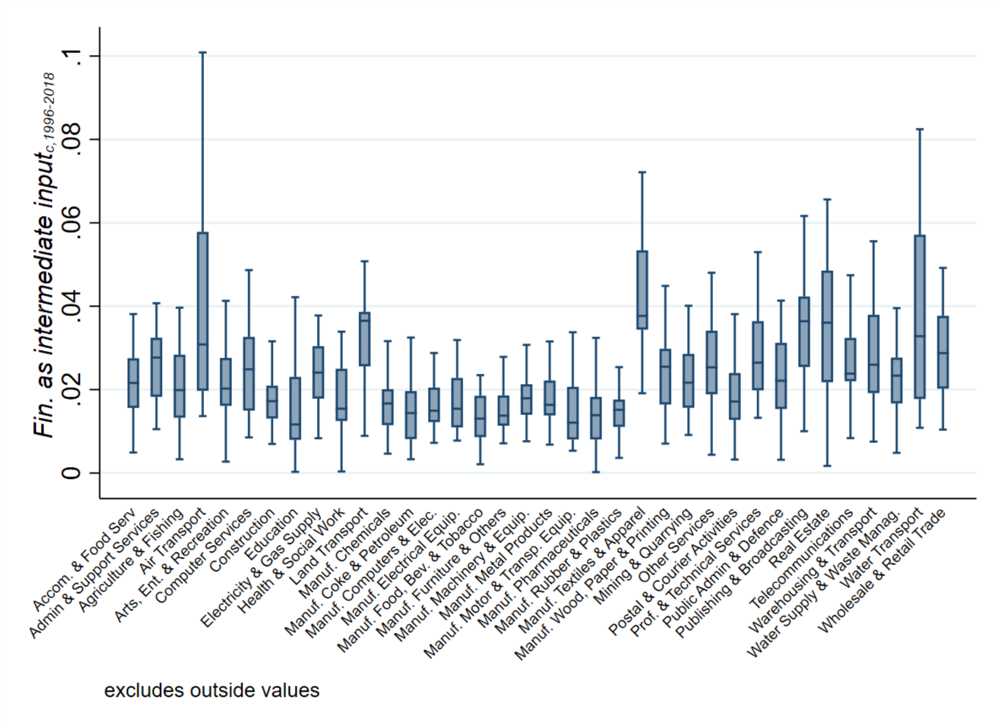
Notes: The graph reports the evolution of *Investment per hour worked* (DTFS Investment, i.e., the constant prices investment in ICT technologies by the financial sector per hour worked).

Figure A.3. Trends in financial sector digitalisation – Consumption



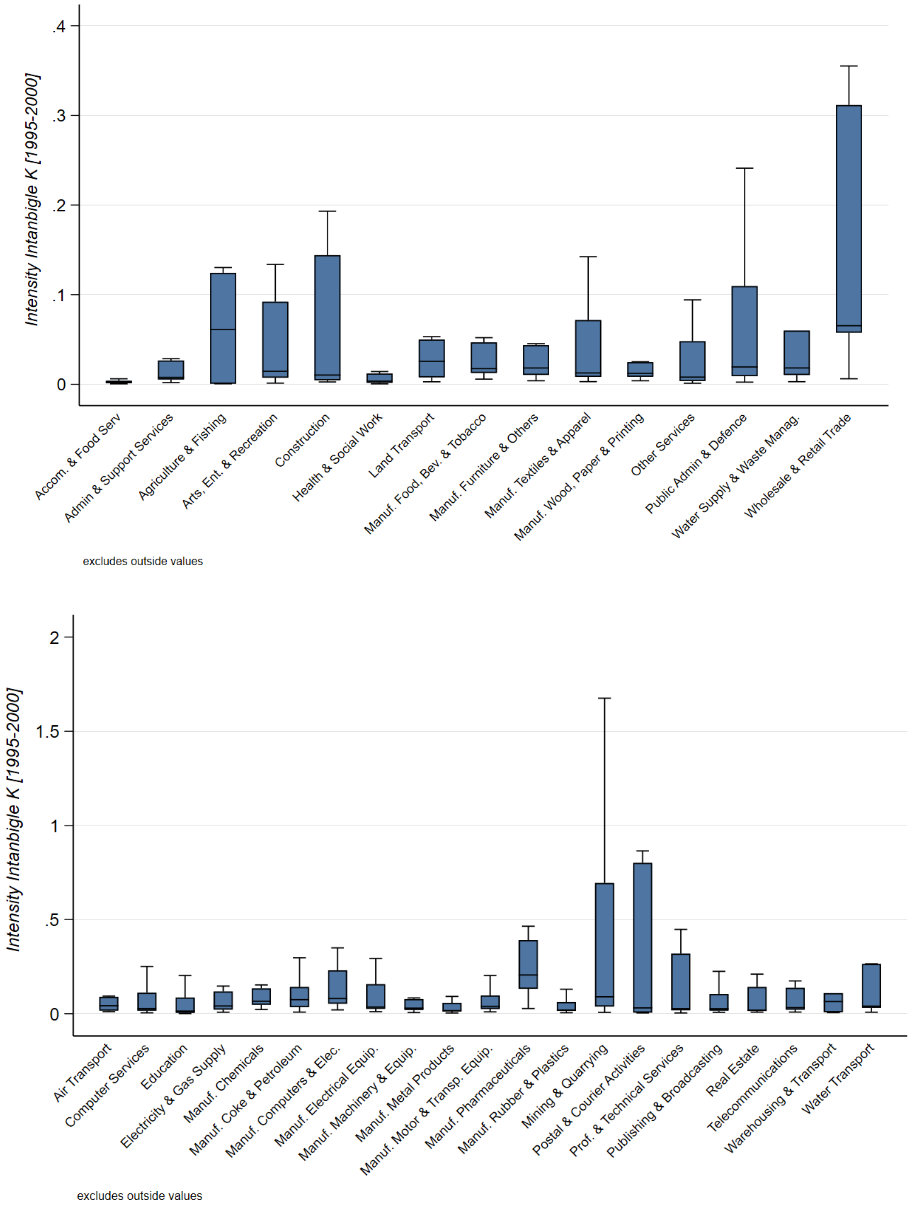
Notes: The graph reports the evolution of *Consumption per hour worked* (DTFS Consumption, i.e., the price-adjusted intermediate consumption of digital services in the finance sector per hour worked).

Figure A.4. Finance as intermediate input across sectors – Distribution across countries



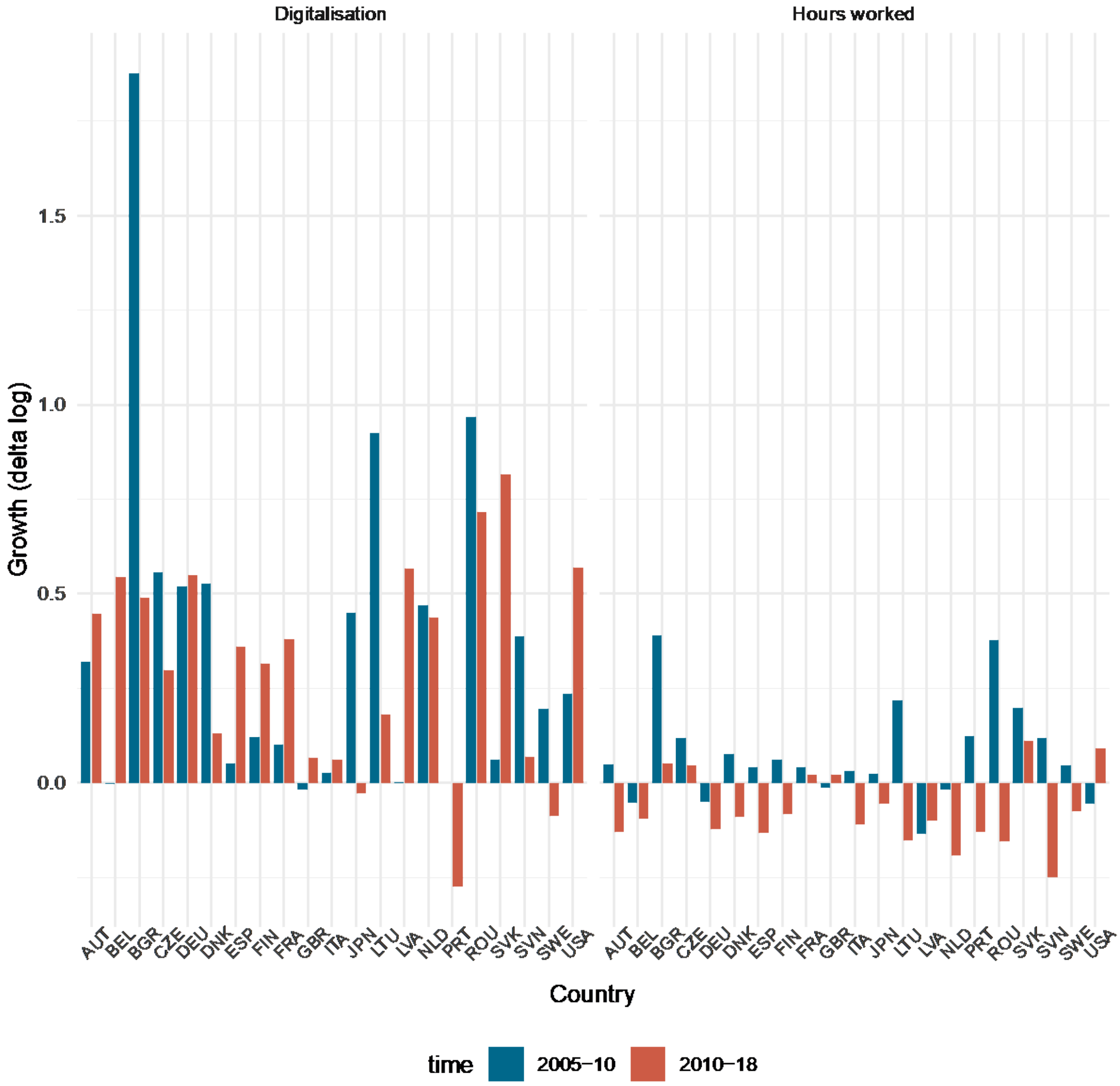
Notes: The graph reports the distribution across countries in the sample of intermediate consumption of financial services, calculated as the average over countries of the ratio between consumption of intermediate financial services to total output of the sector, in the period 1996-2018 (i.e., the period of our analysis), for all sectors in our sample.

Figure A.5. Intensity of Intangible Capital



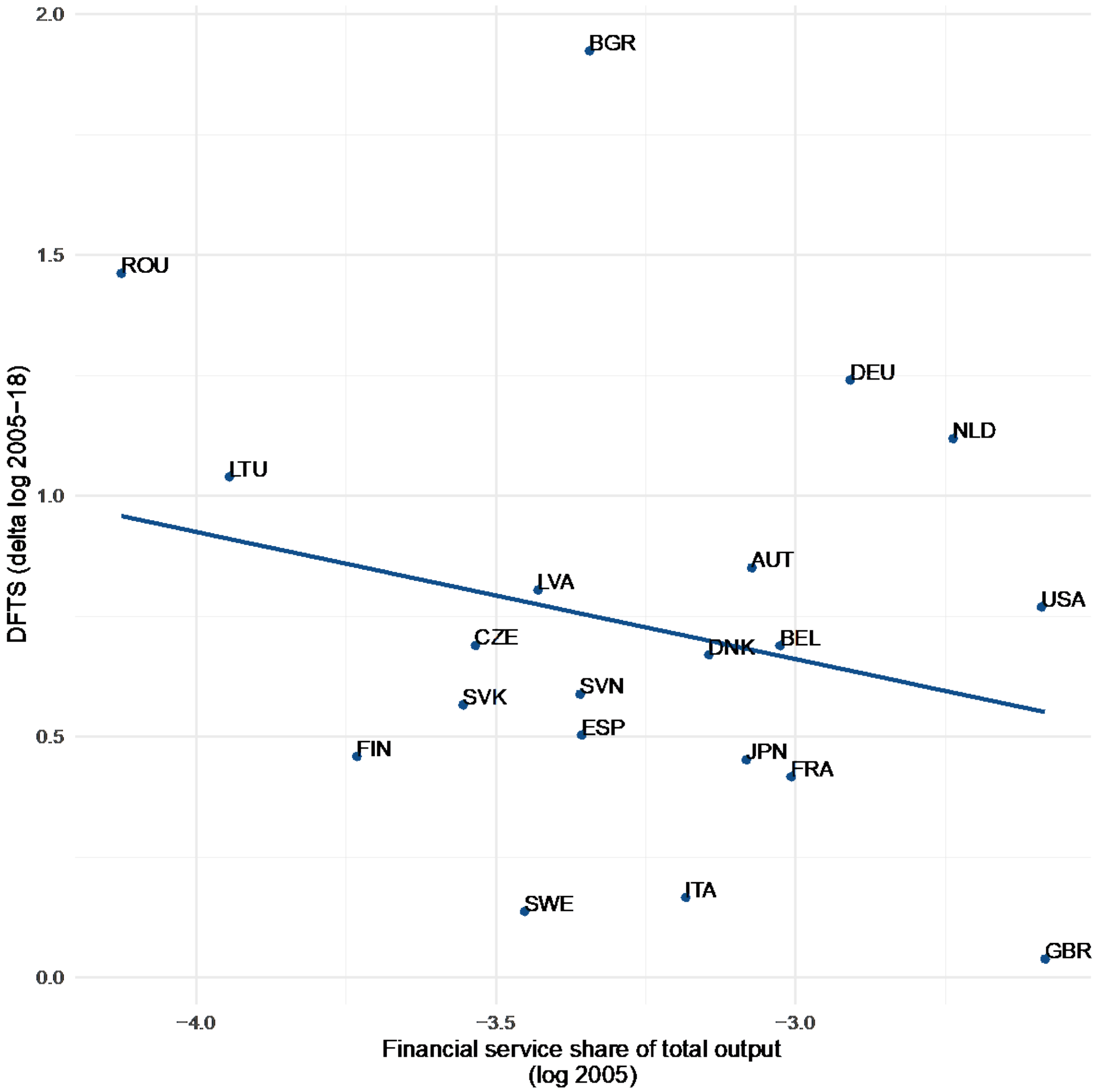
Note: The figure displays intensity of intangible capital across countries, defined as the ratio between the stock of intangible capital and employment, using as reference period the years 1995-2000. The first (second) panel displays sectors with low (high) intensity.employment, using as reference period the years 1995-2000. The first (second) panel displays sectors with low (high) intensity.

Figure A.6. Growth rates in digitalisation and hours worked across countries.



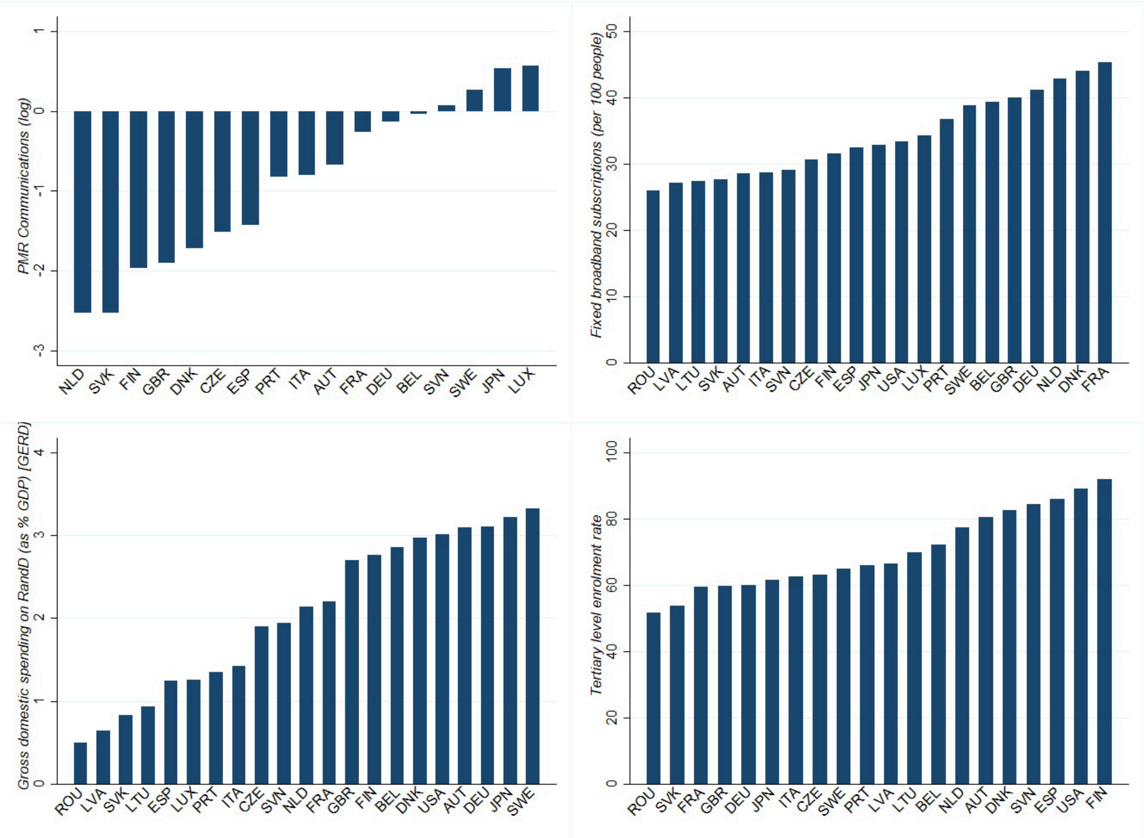
Notes: The graph reports growth rates for the 2005-10 and 2010-18 periods of the two components of DTFS measures. Digitalisation here is the aggregation of intermediate consumption of digital services and investment in ICT assets both at constant prices as described in the main text.

Figure A.7. Growth rate in DTFS and financial industry's size in the economy.



Notes: The graph plots the share in total output of the financial service industry in 2005 against the growth rate of DTFS over the 2005-18 period.

Figure A.8. Initial levels of key policy drivers of digital finance.



Notes: The graph reports the first available estimate of key policy drivers of Table 4. Such estimate refers to 1995 in all cases except for LUX (2015), PRT (2010), and SVK (2000). PMR Communications is fully missing for LTU, LVA, ROU, and USA.

Annex B. Additional Results

Table B.1. The impact of digitalisation of the financial sector on productivity – All coefficients

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.010***	0.012***	0.010***	0.014***
	(0.003)	(0.004)	(0.003)	(0.004)
Interm. Cons. of Financial Services$_{cts}$	0.059***	0.073***	0.056***	0.082***
	(0.018)	(0.022)	(0.021)	(0.026)
Capital Growth$_{cts}$	0.375***			
	(0.043)			
Capital Growth (Lagged)$_{ct-1s}$		-0.042		
		(0.038)		
Tangible Capital Growth$_{cts}$			0.231***	
			(0.050)	
Intangible Capital Growth$_{cts}$			0.227***	
			(0.039)	
Tangible Capital Growth (Lagged)$_{ct-1s}$				-0.049
				(0.042)
Intangible Capital Growth (Lagged)$_{ct-1s}$				-0.029
				(0.031)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Observations	11,425	10,905	9,194	8,775

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth $DTFS_{cts}$is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). errors are clustered at the country-sector level. Statistical significance is represented * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table B.2. The impact of digitalisation of the financial sector on productivity – Additional results

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(log) DTFS$_{cts}$	0.010***	0.011***	0.012***	0.010***	0.009**	0.010***	0.014***
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)
Country-Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	Tang Cap Only	No	No	No
Capital Growth [Lagged]	No	No	Yes	No	No	No	No
Intang. and Tang. Capital Growth [Current]	No	No	No	No	InTang Cap Only	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	No	No	No	Yes
Observations	11,425	11,425	10,905	10,980	9,992	9,194	8,775

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table B.3. Contribution of digital finance adoption to productivity growth, growth accounting determinants – Additional results

	(1)	(2)	(3)	(4)
Dep. Variable: Labor Productivity Growth$_{cts}$	Lab. Produ Total	Lab. Compos. Contrib.	Capital contrib.	TFP contrib.
(log) DTFS$_{cts}$	0.01149***	-0.00014	0.00242	0.01057***
	(0.00371)	(0.00128)	(0.00194)	(0.00356)
Observations	10,883	10,496	10,635	10,291

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. Column 1 display results obtained using as dependent variable the labour productivity growth. Column 2 (3) [4] the dependent variable is the contribution of labour composition (capital) [TFP] to labour productivity growth productivity. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in ($Interm. Cons. of\ Financial\ Services_{cts}$). All specifications include country-year FEs, sector FEs and lagged capital growth. The discrepancy in observation counts across the various columns are due to different coverage of growth accounting variables in the EUKLEMS-INTANProd dataset. Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table B.4. Exploring the complementarity between the consumption and investment components of digitalisation of the financial sector

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
$(log)\ DTFS_{cts}^{\text{Consumption}}$	0.003	0.005	0.005	0.005
	(0.011)	(0.012)	(0.011)	(0.013)
$(log)\ DTFS_{cts}^{\text{Investment}}$	-0.000	0.003	0.001	0.004
	(0.010)	(0.012)	(0.011)	(0.013)
$(log)\ DTFS^{\text{Investment}} * (log)\ DTFS^{\text{Consumption}}$	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,407	10,887	9,182	8,763

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}^{Consumption}$ ($DTFS_{cts}^{Consumption}$) is consumption of digital technology (investment in digital technology) in the financial sector observed in the corresponding sector-country-year. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Annex C. Robustness Checks

Table C.1. Alternative exposure variable – Using current intermediate consumption observed in sector-country sc of financial services

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.007**	0.009***	0.009***	0.013***
	(0.003)	(0.003)	(0.003)	(0.004)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Exposure to Finance$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,425	10,905	9,194	8,775

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) current intermediate consumption of financial services. Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table C.2. Alternative exposure variable – Using pre-sample intermediate consumption

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.020***	0.022***	0.018***	0.021***
	(0.005)	(0.006)	(0.005)	(0.006)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	9,228	9,127	7,452	7,367

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 2001 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using sector-level specific exposure to finance using pre-sample values. Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table C.3. Alternative exposure variable – Using average intermediate consumption observed in sector-country sc of financial services up to year t-1

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.004	0.006*	0.007***	0.011***
	(0.002)	(0.003)	(0.003)	(0.003)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,425	10,905	9,194	8,775

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) average intermediate consumption of financial services observed up to the year t-1 in the corresponding country-sector. Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table C.4. Alternative exposure variable – Using total intermediate consumption rather than total output in Equation (3)

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.009***	0.012***	0.010***	0.014***
	(0.002)	(0.003)	(0.003)	(0.003)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,425	10,905	9,194	8,775

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question. (using total intermediate consumption instead of total output in the denominator of Formula 3). Standard errors are clustered at the country-sector level. Statistical significance is represented by * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table C.5. Using alternative fixed effects structure – Including sector-year fixed effects

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.010**	0.013***	0.006	0.011**
	(0.004)	(0.005)	(0.004)	(0.005)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector-Year FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,425	10,905	9,166	8,748

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table C.6. Using alternative fixed effects structure – Including country-sector fixed effects

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.008	0.004	0.011**	0.011*
	(0.005)	(0.006)	(0.005)	(0.006)
Country-Year FEs	Yes	Yes	Yes	Yes
Country-Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,407	10,883	9,182	8,759

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table C.7. Using alternative cluster-levels

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.010***	0.012**	0.010**	0.014**
	(0.004)	(0.005)	(0.004)	(0.006)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,425	10,905	9,194	8,775

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question $(Interm. Cons. of\ Financial\ Services_{cts})$. Standard errors are clustered at the sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table C.8. Alternative samples – Drop one sector at the time

Dep. Variable: Labor Prod. $Growth_{cts}$	(1) All	(2) A	(3) B	(4) C10-C12	(5) C13-C15	(6) C16-C18	(7) C19	(8) C20	(9) C21
(log) $DTFS_{cts}$	0.0104***	0.00993***	0.0104***	0.0112***	0.0114***	0.0104***	0.00897***	0.0106***	0.0105***
	(0.00315)	(0.00317)	(0.00316)	(0.00331)	(0.00349)	(0.00318)	(0.00282)	(0.00318)	(0.00318)
Observations	11,425	11,035	11,057	11,085	11,084	11,085	11,110	11,130	11,154

Dep. Variable: Labor Prod. $Growth_{cts}$	(1) C22-C23	(2) C24-C25	(3) C26	(4) C27	(5) C28	(6) C29-C30	(7) C31-C33	(8) D	(9) E
(log) $DTFS_{cts}$	0.0103***	0.0104***	0.00846***	0.0100***	0.0105***	0.0101***	0.0101***	0.0108***	0.0104***
	(0.00318)	(0.00316)	(0.00311)	(0.00315)	(0.00317)	(0.00319)	(0.00319)	(0.00318)	(0.00316)
Observations	11,085	11,085	11,108	11,108	11,085	11,085	11,085	11,053	11,050

Dep. Variable: Labor Prod. $Growth_{cts}$	(1) F	(2) G45	(3) H49	(4) H50	(5) H51	(6) H52	(7) H53	(8) I	(9) J58-J60
(log) $DTFS_{cts}$	0.0104***	0.00987***	0.0100***	0.0112***	0.00935***	0.0101***	0.0105***	0.0106***	0.00983***
	(0.00315)	(0.00313)	(0.00319)	(0.00318)	(0.00299)	(0.00315)	(0.00316)	(0.00318)	(0.00331)
Observations	11,026	11,303	11,245	11,247	11,264	11,286	11,303	11,060	11,084

Dep. Variable: Labor Prod. $Growth_{cts}$	(1) J61	(2) J62-J63	(3) L	(4) M	(5) N	(6) O	(7) P	(8) Q	(9) R
(log) $DTFS_{cts}$	0.0107***	0.0105***	0.0113***	0.0105***	0.0102***	0.0104***	0.0125***	0.0107***	0.0102***
	(0.00316)	(0.00316)	(0.00367)	(0.00327)	(0.00320)	(0.00316)	(0.00369)	(0.00328)	(0.00318)
Observations	11,132	11,085	11,059	11,048	11,078	11,031	11,025	11,050	11,031

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. A table with all estimated coefficients is reported in Annex B. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). The first column in the first panel displays results obtained with the full sample. In the remaining columns, one sector at a time is removed from the sample (the sector is displayed at the top of each column). Estimates are obtained using the specification used in Column (1) of Table 2. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table C.9. Alternative samples – Drop one country at the time

Dep. Variable: Labor Prod. $Growth_{cts}$	(1) All	(2) AUT	(3) BEL	(4) CZE	(5) DEU	(6) DNK	(7) ESP	(8) FIN	(9) FRA	(10) GBR
(log) $DTFS_{cts}$	0.0104***	0.0112***	0.0112***	0.0109***	0.0102***	0.0108***	0.0104***	0.0103***	0.0107***	0.00966***
	(0.00315)	(0.00323)	(0.00327)	(0.00321)	(0.00335)	(0.00319)	(0.00336)	(0.00340)	(0.00326)	(0.00318)
Observations	11,425	10,621	10,758	10,604	10,753	10,638	10,830	10,630	10,735	10,735

Dep. Variable: Labor Prod. $Growth_{cts}$	(1) ITA	(2) JPN	(3) LTU	(4) LUX	(5) LVA	(6) NLD	(7) SVK	(8) SVN	(9) SWE	(10) USA
(log) $DTFS_{cts}$	0.0112***	0.0105***	0.0108***	0.0102***	0.0115***	0.0106***	0.00612**	0.0102***	0.00979***	0.00995***
	(0.00312)	(0.00320)	(0.00346)	(0.00316)	(0.00322)	(0.00326)	(0.00300)	(0.00319)	(0.00336)	(0.00322)
Observations	10,735	10,643	11,212	11,407	11,156	10,764	10,817	11,188	10,689	10,735

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. A table with all estimated coefficients is reported in Annex B. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). The first column in the first panel displays results obtained with the full sample. In the remaining columns, one country at a time is removed from the sample (the country is displayed at the top of each column). Estimates are obtained using the specification used in Column (1) of Table 2. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table C.10. Additional finance-related controls.

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.016***	0.016***	0.014***	0.015***
	(0.005)	(0.005)	(0.005)	(0.006)
(log) Interm. Cons. of Financial Services$_{cst}$ *X LT Int. Rate*$_{ct}$	0.003	0.001	0.002	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	11,186	10,720	8,997	8,623

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. A table with all estimated coefficients is reported in Annex B. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm.Cons.of\ Financial\ Services_{cts}$). The first column in the first panel displays results obtained with the full sample. In the remaining columns, one sector at a time is removed from the sample (the sector is displayed at the top of each column). Estimates are obtained using the specification used in Column (1) of Table 2. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table C.11. Controlling for digital intensity of downstream sectors.

Dep. Variable: Labor Productivity Growth$_{cts}$	(1)	(2)	(3)	(4)
(log) DTFS$_{cts}$	0.010***	0.010***	0.009***	0.012**
	(0.003)	(0.004)	(0.003)	(0.004)
Country-Year FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes	Yes
Capital Growth [Current]	Yes	No	No	No
Capital Growth [Lagged]	No	Yes	No	No
Intang. and Tang. Capital Growth [Current]	No	No	Yes	No
Intang. and Tang. Capital Growth [Lagged]	No	No	No	Yes
Observations	10,873	10,379	8,756	8,358

Notes: The table reports OLS estimates. This table displays only estimates for the main variable of interest. A table with all estimated coefficients is reported in Annex B. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). The first column in the first panel displays results obtained with the full sample. In the remaining columns, one sector at a time is removed from the sample (the sector is displayed at the top of each column). Estimates are obtained using the specification used in Column (1) of Table 2. All estimates include controls for digitalisation of downstream sectors. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Annex D. Robustness of intangible-intensive results

Table D.1. Digital finance in intangible-intensive sectors

	(1)	(2)	(3)
Dep. Variable: Labor Productivity Growth$_{cts}$	All Sectors	Low Intang. Cap	High Intang. Cap.
(log) DTFS$_{cts}$	0.012***	0.006	0.014***
	(0.004)	(0.005)	(0.005)
Country-Year FEs	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes
Interm. Cons. of Financial Services$_{cts}$	Yes	Yes	Yes
Capital Growth [Lagged]	Yes	Yes	Yes
Observations	10,905	4,860	6,045

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question question ($Interm. Cons. of\ Financial\ Services_{cts}$). Column 1 displays results obtained with the full sample. Column 2 (3) displays results obtained using low (high) intangible sectors only. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table D.2. Digital finance in tangible intensive sectors

	(1)	(2)	(3)
Dep. Variable: Labor Productivity Growth$_{cts}$	All Sectors	Low Tang. Cap	High Tang. Cap.
(log) $DTFS_{cts}$	0.016***	0.016**	0.016*
	(0.006)	(0.006)	(0.009)
Country-Year FEs	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes
Exposure to Finance$_{cts}$	Yes	Yes	Yes
Capital Growth [Lagged]	Yes	Yes	Yes
Observations	10,905	5,913	4,992

Notes: The table reports OLS estimates. The unit of observation is the sector s in country c in year t. The sample includes all years between 1996 and 2018. The dependent variable is labour productivity growth. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding sector-country-year. The variable is computed as the product of the (log) digitalisation of the financial sector in country c in year t and the (log) intermediate consumption of financial services computed using average values across sectors and years but excluding the data for the specific country-sector-year in question ($Interm. Cons. of\ Financial\ Services_{cts}$). Column 1 displays results obtained with the full sample. Column 2 (3) displays results obtained using low (high) tangible sectors only. Standard errors are clustered at the country-sector level. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Annex E. Robustness of Mechanisms at work

Table E.1. Robustness digitalisation and credit environment

Dependent Variables:	(1) Non-performing loans (%)	(2) Δ Interest rate SMEs vs Large	(3) Collateral SMEs	(4) Long-term lending SMEs (% total)
(log) $DTFS_{ct}$	-0.656*	-0.838***	-7.978*	5.235**
	(0.366)	(0.310)	(4.351)	(2.305)
GDP $growth_{ct}$	-52.16***	-4.203**	-66.09*	9.083
	(13.36)	(1.896)	(34.88)	(18.62)
Private debt (% GDP) $_{ct-1}$	-0.000654	-0.00901**	-0.0242	-0.0209
	(0.00597)	(0.00420)	(0.0341)	(0.0272)
Share $SMEs_{ct}$	5.324	0.0599	28.35*	17.73
	(4.504)	(2.529)	(16.29)	(14.01)
Financial development $index_{ct}$	7.947**	4.805***	-27.39	-44.40***
	(3.111)	(1.773)	(32.17)	(14.29)
Observations	394	174	84	107

Notes: The table reports OLS estimates. The unit of observation is country c in year t. The dependent variable is displayed at the top of each column. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding country-year. Data on non-performing loans are sourced from World Bank Indicators, while variables related to access to credit by SMEs are obtained from the OECD SME Scoreboard. Robust standard errors are presented in parentheses. by * p<0.10, ** p<0.05, *** p<0.01.

Table E.2. Robustness digitalisation and credit environment

Dep. Var: Non-performing Loans (%)	(1) All	(2) 2007	(3) 2008	(4) 2009	(5) 2010	(6) 2011	(7) 2012
(log) DTFS	-0.664*	-0.702*	-0.707*	-0.788**	-0.713*	-0.605	-0.596
	(0.391)	(0.407)	(0.414)	(0.356)	(0.385)	(0.386)	(0.374)
Observations	436	418	418	418	417	417	417

Notes: The table reports OLS estimates. The unit of observation is country c in year t. The dependent variable is displayed at the top. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding country-year. The first column in the first panel displays results obtained with the full sample. In the remaining columns, one year at a time is removed from the sample (the year is displayed at the top of each column). Robust standard errors are presented in parentheses. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table E.3. Robustness digitalisation and credit environment

Dep. Var.: Δ Interest rate SMEs vs Large	(1) All	(2) 2007	(3) 2008	(4) 2009	(5) 2010	(6) 2011	(7) 2012
(log) DTFS	-0.816***	-0.841***	-0.780**	-0.732**	-0.707**	-0.909***	-0.838***
	(0.311)	(0.309)	(0.328)	(0.364)	(0.328)	(0.336)	(0.320)
Observations	187	174	172	172	171	171	171

Notes: The table reports OLS estimates. The unit of observation is country c in year t. The dependent variable is displayed at the top. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding country-year. The first column in the first panel displays results obtained with the full sample. In the remaining columns, one year at a time is removed from the sample (the year is displayed at the top of each column). Robust standard errors are presented in parentheses. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table E.4. Robustness digitalisation and credit environment

Dep. Var.: Collateral SMEs	(1) All	(2) 2007	(3) 2008	(4) 2009	(5) 2010	(6) 2011	(7) 2012
(log) DTFS	-7.757**	-7.911*	-7.843*	-7.643*	-8.365*	-6.952*	-7.600*
	(3.828)	(3.982)	(3.931)	(4.114)	(4.331)	(3.651)	(4.276)
Observations	87	85	85	84	80	79	78

Notes: The table reports OLS estimates. The unit of observation is country c in year t. The dependent variable is displayed at the top. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding country-year. The first column in the first panel displays results obtained with the full sample. In the remaining columns, one year at a time is removed from the sample (the year is displayed at the top of each column). Robust standard errors are presented in parentheses. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Table E.5. Robustness digitalisation and credit environment

Dep. Var. Long-term lending SMEs (% total)	(1) All	(2) 2007	(3) 2008	(4) 2009	(5) 2010	(6) 2011	(7) 2012
(log) DTFS	4.373*	3.562	4.204*	3.418	5.523**	4.954**	3.694
	(2.359)	(2.291)	(2.432)	(2.612)	(2.433)	(2.484)	(2.626)
Observations	108	102	102	102	100	100	99

Notes: The table reports OLS estimates. The unit of observation is country c in year t. The dependent variable is displayed at the top. $DTFS_{cts}$ is digital technology in the financial sector observed in the corresponding country-year. The first column in the first panel displays results obtained with the full sample. In the remaining columns, one year at a time is removed from the sample (the year is displayed at the top of each column). Robust standard errors are presented in parentheses. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Annex F. Robustness of policy and structural drivers of digitalisation of the financial sector

Table F.1. Policy and structural drivers of digitalisation of the financial sector – Robustness

	Policy drivers		*Structural drivers*		*Combined*	
Dep. variable: (log) $DTFS_{ct}$	(1) PMR	(2) Research	(3) Workforce	(4) Infrastructure	(5)	(6)
PMR Communications (log)	-0.0324				-0.0359*	
	(0.0199)				(0.0186)	
Gross domestic spending on R&D (as % GDP) [GERD]		0.345***			0.0156	0.238***
		(0.0855)			(0.0451)	(0.0720)
Tertiary level enrolment rate			0.000149		0.00798***	-0.000186
			(0.00261)		(0.00164)	(0.00247)
Share of tertiary enrolments in STEM subjects			0.0371***		0.00928*	0.0208***
			(0.00711)		(0.00544)	(0.00615)
Proportion of workers who are well matched			0.00402		0.00115	0.00363
			(0.00769)		(0.00453)	(0.00721)
Relative size of youth population			0.0623***		0.0349***	0.0422***
			(0.0142)		(0.00818)	(0.0111)
Secure Internet servers (per 1 million people)				4.17e-06**	2.04e-06*	9.98e-07
				(1.65e-06)	(1.17e-06)	(1.72e-06)
Fixed broadband subscriptions (per 100 people)				0.0327***	0.00383	0.0217***
				(0.00739)	(0.00276)	(0.00528)
(log) $DT \neq DF_{ct}$	0.596***	0.740***	0.903***	0.864***	0.598***	0.913***
	(0.0550)	(0.100)	(0.126)	(0.0963)	(0.0594)	(0.104)
Observations	359	460	412	460	335	412

Notes: The table reports OLS estimates. Country and year FEs are include in all columns and a variable (log) $DTFS_{ct}$ combining intermediate consumption of digital services and investment in ICT assets both at constant prices per hour worked, for the entire economy excluding financial services. The dependent is (log) $DTFS_{ct}$ and corresponds to the digital technology in the financial sector observed in the corresponding country-year. Columns 1 and 5 include the variable ComFin that corresponds to the ratio between the intermediate consumption of telco services in the financial sector and the total value added of the financial sector. Robust standard errors are reported in parenthesis. Statistical significance is represented by * p<0.10, ** p<0.05, *** p<0.01.

Annex G. Data

SOURCE	DATASET NAME	VARIABLES USED	COUNTRIES USED	YEARS
OECD	Financing SMEs and Entrepreneurs Scoreboard	Interest rate spread SMEs - large firms (% points)	AUT, BEL, CZE, DNK, ESP, FIN, FRA, GBR, ITA, LTU, LUX, LVA, NLD, PRT, SVN, SWE, USA	2007-2018
OECD	Financing SMEs and Entrepreneurs Scoreboard	Long-term loans, SMEs as % of total	AUT, BEL, CZE, DNK, ESP, FIN, FRA, ITA, LVA, NLD, PRT, SVK, SVN, SWE	2007-2018
OECD	Financing SMEs and Entrepreneurs Scoreboard	Collateral, SMEs (% needing collateral)	BEL, ESP, FIN, FRA, GBR, ITA, LTU, NLD, PRT, SVK, USA	2007-2018
OECD	Main Science and Technology Indicators	Gross Domestic Expenditures in R&D (as % GDP) [GERD]	AUT, BEL, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LTU, LUX, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2018
OECD	World Indicators of Skills for Employment	Tertiary level enrolment rate	AUT, BEL, BGR, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LTU, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2013
OECD	World Indicators of Skills for Employment	Proportion of workers who are well matched	AUT, BEL, BGR, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, LTU, LVA, NLD, PRT, ROU, SVK, SVN, SWE	2000-2013
OECD	World Indicators of Skills for Employment	Share of tertiary enrolments in STEM subjects	AUT, BEL, BGR, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LTU, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2013
OECD	World Indicators of Skills for Employment	Relative size of youth population	AUT, BEL, BGR, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LTU, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2013
OECD	Product Market Regulation Database	PMR in E-communications	AUT, BEL, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LUX, NLD, PRT, SVK, SVN, SWE	2000-2018
WORLD BANK	World Development Database	Fixed broadband subscriptions (per 100 people)	AUT, BEL, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LTU, LUX, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2018
WORLD BANK	World Development Database	Secure Internet servers (per 1 million people)	AUT, BEL, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, LTU, LUX, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2018
WORLD BANK	World Development Database	Bank nonperforming loans to total gross loans (%)	AUT, BEL, CZE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, LTU, LVA, NLD, PRT, ROU, SVK, SVN, SWE, USA	2000-2018