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Capital Dynamics, Global Value Chains, Competitiveness and Barriers to FDI and Capital Accumulation in the EU

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Abstract

The study analyses the relationships between capital dynamics, productivity, global value chains and foreign direct investment using panel data techniques. Among other results, we confirm the high importance of tangible and intangible ICT capital for productivity and GVC integration. We examine the extent of underinvestment in ICT in the EU relative to other major economies and identify bottlenecks for efficient capital allocation. The sluggish economic performance of the EU in the post-crisis period has been further challenged by the COVID-19 outbreak. Consolidating policy efforts to facilitate ICT investment, tackling the barriers to ICT adoption and broad-based digitalisation are critical for the EU in order to maintain a competitive edge and unlock new growth opportunities in the new normal.

Keywords: productivity, digitalisation, ICT capital, FDI, global value chains, barriers to ICT investments, intangible capital

JEL classification: F14, F15, F21, E22, O47

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Non-technical executive summary

The present study constitutes the final report of the CaDoVaC (Capital Dynamics, Global Value Chains and Competitiveness) research project and provides an overview of the key empirical results from the analysis, as well as policy conclusions focusing on the barriers to efficient capital accumulation in the EU. The research analyses the implications of capital accumulation, its composition and foreign direct investment (FDI) on economic competitiveness with a specific focus on the following issues:

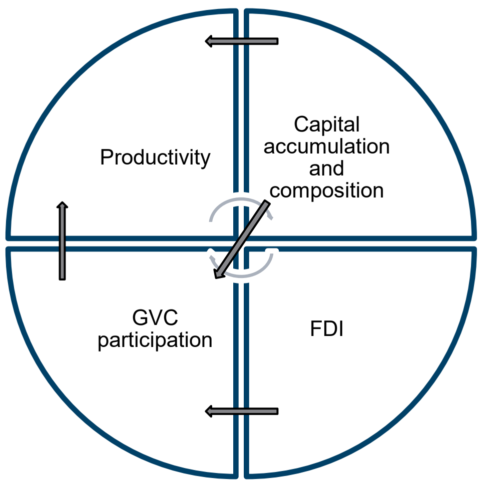
› interactions between changes in global value chains (GVCs), capital formation and foreign direct investment;

› interactions between productivity growth, changes in investment decisions, capital accumulation and capital stock composition;

› obstacles and barriers to an efficient allocation of capital across Europe.

Figure I provides a stylised combined representation of the relationships between the economic phenomena investigated in the project. While the analysis focuses on these linkages, other factors impacting each of the variables under consideration have naturally been taken into account as control variables.

Figure I / Conceptual framework: relationship between GVC, FDI, capital accumulation and productivity



Source: own elaboration.

The analysis is carried out at aggregate country and industry levels comparing the dynamics within the EU as well as with important peer economies – the US, Japan, China and South Korea – depending on the actually available data. To this end we constructed a consistent aggregate country- and sector-level database with capital accumulation, global value chain participation and FDI variables. The FDI variable has been cleaned from the effects of special purpose entities (SPEs) and adjusted to address the change in the statistical classification over the observed period (BPM5 to BPM6). In addition, the project took advantage of the newly available EU KLEMS data released in October 2019 (developed by wiiw; see Adarov and Stehrer, 2019a). This dataset introduced more detailed capital stock composition data, including a fine decomposition of capital stock into tangibles and intangibles as well as ICT and non-ICT capital, which allowed us to distinguish between the relative importance of tangible and intangible ICT capital (the latter is also referred to as the digital capital or the capital embedded in software and databases).

Summarising the analytical results, our research makes several contributions to the academic literature, as well as to the related policy debates concerning productivity, capital accumulation, foreign direct investment, digitalisation, global value chains and economic integration. In particular, as regards the analysis of the role of capital flows in the formation of global value chains, we show empirically that FDI constitutes an important driver of GVC participation and trade in value added. Inward FDI is especially conducive to the formation of backward linkages, while outward FDI facilitates forward GVC participation. Examining bilateral trade and investment relationships using the gravity model of trade, we find that both inward and outward bilateral FDI positively influences trade in value added. Pooled sectoral analysis confirms that both inward and outward FDI facilitates GVC integration and that inward FDI is especially important for both the backward and the forward integration of manufacturing sectors.

A closer look at the estimation results for individual sectors suggests that the positive impact of outward FDI on forward GVC participation is driven largely by high-tech manufacturing sectors – the machinery, transport and (especially) electrical equipment industries. A significant positive impact of inward FDI on backward GVC participation is found in the textile and clothing industry as well as in the agricultural and chemicals sectors. While the estimated marginal effects of inward FDI on backward linkages in high-tech manufacturing are sizeable, they are not statistically significant. Overall, the textile and clothing sector exhibits a particularly strong across-the-board response to FDI and capital formation in terms of both upstream and downstream integration.

ICT capital is generally positively associated with backward GVC participation and is especially instrumental for backward GVC integration of the electrical and transport equipment sectors as well as the chemical industry. At the same time, ICT capital appears to negatively impact forward GVC participation of the textile and clothing industry.

Focusing on the drivers of productivity, our analysis shows an important role of ICT capital accumulation in facilitating productivity, with an especially robust superior effect found for digital capital (as measured by SoftDB under the EU KLEMS capital asset classification used in the paper). In fact, digital capital appears to be the only capital asset type among the 14 capital asset types examined that manifests strongly as a driver of productivity across multiple empirical exercises at the sectoral and aggregate levels. Aggregate country-level estimates suggest that a 1 percentage point (pp) increase in the growth of real capital stock induces an increase in the growth of real labour productivity of about 0.06 pp in the case of tangible ICT capital and of 0.09 pp in the case of intangible ICT capital (SoftDB).

On closer sector-level examination we find a relatively stronger impact of ICT on the manufacturing sectors, particularly the textile and clothing, coke/refined petroleum and machinery manufacturing sectors in the case of intangible ICT capital and for the food processing and transport equipment sectors in the case of tangible ICT capital. Besides this, the estimates suggest that backward global value chain participation also fosters labour productivity as well as EU integration with the progressively increasing cumulative post-accession effect. However, in contrast to much of the literature, we find no strong evidence of the impact of FDI on labour productivity after netting out the impact of SPEs and outliers and controlling for labour services, capital composition and convergence effects.

Based on the empirical findings, a number of policy-relevant conclusions can be made as regards EU competitiveness and the implications of capital accumulation and composition. In particular, the issues associated with productivity performance in the EU have three important dimensions:

(i) the overall across-the-board slowdown of aggregate productivity growth in the post-crisis period (after the Great Recession) for all countries of the EU, including its frontier economies, mostly as a result of productivity slowdown across sectors (rather than a structural shift towards less productive sectors);

(ii) the core-periphery structure of the EU economy, with the lagging periphery countries struggling to converge towards the frontier EU countries in terms of productivity with an insufficient catch-up momentum (observed both before and particularly after the crisis);

(iii) as a result of the combined effect of (i) and (ii), the EU lags *on average* significantly behind the peer economies in terms of productivity, particularly the US. The lacklustre performance is observed both in terms of productivity levels and productivity growth rates.

In light of the challenges and the revealed importance of the role of ICT capital on productivity, it is therefore important to consolidate policy efforts to facilitate investment in ICT capital, both tangible ICT and digital capital, as an effective means to enhance the broad-based competitiveness of the EU economy. In terms of FDI inflows, the EU is currently already rather open, with relatively low regulatory restrictions and high volumes of inward FDI (although these differ significantly across the individual EU countries). However, as our research has demonstrated, the EU is lagging behind its peers, particularly the US, in the intensity of ICT investments, including both tangible and intangible ICT capital, as well as the effective utilisation of ICT investments.

The factors that hinder ICT investments are multiple and differ across the EU in terms of their relative importance. Roughly, the bottlenecks to ICT investment that the EU faces could be grouped into several broad categories, discussed in greater detail in this report:

(i) "Framework conditions" that are related to the overall macroeconomic stance of a country and broad socio-economic conditions that inhibit investments in general (including FDI); these include the business-cycle dynamics and long-run structural bottlenecks hindering investment in general, e.g. the gaps in institutions and infrastructure.

(ii) ICT investment-specific supply-and-demand factors that impact the ability or incentives of the private sector to engage in ICT investment and impact the efficiency of ICT; these include access to finance, labour market inefficiencies and other factors complementary to ICT use.

(iii) ICT-specific regulatory bottlenecks, including regulations that inhibit competition, lack of regulatory incentives, and financial and technical support to companies investing in ICT.

Taking this into consideration, it is important to recognise that the issues regarding ICT investment in the EU should also be considered in light of the existing intra-EU socio-economic asymmetries (the core-periphery structure of the EU that could be traced back to productivity differences, diverging economic specialisation patterns, quality of institutions and infrastructure etc.), which shape the relative importance of the barriers outlined. In this regard the slowdown of ICT investment, similar to the productivity patterns, is attributed to two distinct trends: (A) the slowing performance of the frontier EU economies and (B) the lack of convergence towards the frontier EU economies by the periphery EU countries, which have also historically been lagging behind in terms of competitiveness and productivity.

In light of the revealed importance of the role of ICT capital in accelerating productivity and taking into account the impediments discussed in the previous section, the following broad policy guidelines appear to be instrumental in facilitating ICT investments:

› Policies improving the general macroeconomic stability and addressing the structural impediments in lagging EU member states as a prerequisite to investment in general.
› Measures addressing the regulatory bottlenecks that hinder the efficient allocation of capital and the absorption of ICT capital, including pro-competition policies, measures fostering the further development of the EU single market in line with the four freedoms, policies regulating ICT-related areas (data privacy, digitalisation, intellectual property, technical standards).
› ICT-targeted policy incentives, including tax incentives, financial support, public procurement, provision of public infrastructure and other forms of financial and technical support, especially focusing on the support of small and medium-sized enterprises and innovative start-up companies, which experience greater difficulties in ICT absorption and scaling up in comparison with large multinational corporations.
› Policies fostering deeper financial markets and, in particular, advancing further efforts to establish sufficiently deep and efficient capital markets and create a broad-based environment that facilitates venture capital and other forms of start-up financing in ICT-intensive sectors.
› Policies facilitating the training of a skilled ICT workforce, including both higher education and vocational training, as well as addressing regulatory bottlenecks in labour markets as regards the skills mismatch, barriers to cross-country labour movements and adequate incentives to facilitate the retention of a skilled workforce in the EU.

The extra policy efforts targeted at the efficient adoption of ICT capital, both tangible and intangible, fostering technology absorption and broad-based digitalisation, are especially vital for the EU in light of its weak post-crisis growth performance, aggravated further by the new challenges posed by the deep and lasting negative impacts of the coronavirus disease.[1] As regards the latter, digitalisation proved to be instrumental in keeping much of the economic activities, both public and private, still running under the quarantine regimes, thereby alleviating the economic shock.[2] The issue is of even greater importance when looking further into the future, as the EU, with the exception of its several frontier

1 According to European Commission (2020a), as a result of the coronavirus disease (COVID-19) the EU has very likely entered the deepest economic recession in its history. The crisis will also lead to a reduction of the potential output and a protracted U-shaped recovery uneven across countries.

2 See, for instance, UNCTAD (2020) for a preliminary review of implication of digitalisation and related policy lessons in light of COVID-19.

economies, is falling behind not only the global leaders in digital innovation – the US and Japan – but also the rapidly developing new competitors from Asia, particularly China and South Korea. Gaining momentum in digital transformation via ICT capital investment may further aid the catching-up process of the lagging EU Member States, especially in light of the general purpose technology nature of ICT, thereby improving its internal cohesion and resilience as well as more generally strengthening the trust in the transformative power and net benefits the bloc may bring to its members, which has lost a lot of steam in the aftermath of the global crisis.

1. Introduction

Competitiveness nowadays is increasingly driven by the ability of countries to foster productivity. In turn, productivity is heavily influenced by capital intensity, information and communications technology (ICT), intangible capital and digitalisation. We analyse the implications of capital accumulation, its composition and foreign direct investment (FDI) on economic competitiveness with a specific focus on the following factors:

› interactions between changes in global value chains (GVCs), capital formation and foreign direct investment;

› interactions between productivity growth, changes in investment decisions, capital accumulation and capital stock composition;

› obstacles and barriers to an efficient allocation of capital across Europe.

The present study constitutes the final report of the CaDoVaC project and provides an overview of selected econometric results from the project in a consolidated form, as well as an assessment of the barriers to capital allocation (including foreign direct investment).

The detailed discussion of the results focusing on the drivers of GVC participation is presented in Adarov and Stehrer (2019b). The results pertaining to the analysis of productivity drivers are discussed in Adarov and Stehrer (2020). In the present report the key findings of the research are presented in Section 2, followed by an assessment of the possible barriers to capital accumulation in Section 3 and the discussion of policy implications in Section 4.

2. Overview of key research findings

2.1. DATA AND SAMPLE

For the purposes of econometric analysis we assemble a panel dataset that includes aggregate country- and sector-level variables of labour productivity, hours worked, labour composition, FDI, capital stocks and their composition by asset types, total factor productivity (TFP) estimates and other variables employed in the econometric analysis. The sample composition is largely determined by the availability of data in the key data sources, particularly the EU KLEMS database, which covers EU countries and, among non-EU countries, only the US and Japan. We deliberately drop Cyprus, Luxembourg, Malta, Ireland and the Netherlands from the sample, as these are the recognised as “tax offshore” countries (see, e.g. Hines, 2010 for a list of tax havens), as well as countries for which the data for the key variables of interest are missing or too short.[3] The resulting panel dataset covers 20 countries over the period 2000-2017 (Table 2.1.1).

Table 2.1.1 / Sample of countries

Country	ISO3 code	Country	ISO3 code
Austria	AUT	Greece	GRC
Belgium	BEL	Italy	ITA
Czech Republic	CZE	Lithuania	LTU
Germany	DEU	Latvia	LVA
Denmark	DNK	Portugal	PRT
Spain	ESP	Slovak Republic	SVK
Estonia	EST	Slovenia	SVN
Finland	FIN	Sweden	SWE
France	FRA	United States	US
United Kingdom	GBR	Japan	JPN

The FDI data are compiled using Eurostat and OECD data, depending on which source offers a longer series for a given country and bridging (to the extent possible) the gaps in the data. The OECD and Eurostat use a common framework for reporting FDI statistics, and thus the resulting data are internally consistent across the country-sector and time dimensions. In general, we follow the conventions and methods used by the Eurostat/OECD framework described in the 4th edition of the OECD Benchmark Definition of Foreign Direct Investment, BMD4. Importantly, our dataset excludes special purpose entities (SPEs) from the FDI data. SPEs are entities that primarily engage in holding activities and facilitate the internal financing of multinational enterprises (MNEs) but have little or no physical presence in the host economy, which severely distorts the FDI data and adversely affects economic inference in formal analysis, particularly for countries hosting financial centres. Together with dropping tax-haven countries, this approach allows us to focus only on the FDI dynamics with real economic relevance in the context of the productivity analysis.

[3] This mostly occurs when the capital asset data for certain asset type are not available.

In addition, given the change in the NACE classification during the period 2000-2017 in order to compile a dataset internally consistent across countries and sectors for the entire time period, we devised a sectoral classification (based on NACE Rev.2). More specifically, in the original Eurostat database the sectoral FDI data for the period 2000-2007 (for some countries 2009) are available according to BPM5 in NACE Rev.1; for 2008-2012 the data are available in BPM5 and according to NACE Rev.2; for 2013-2016 these data are according to BPM6 and NACE Rev.2. The resulting classification is reported in Table 2.1.2, listing the corresponding NACE Rev.2 codes and labelling conventions used in the paper.

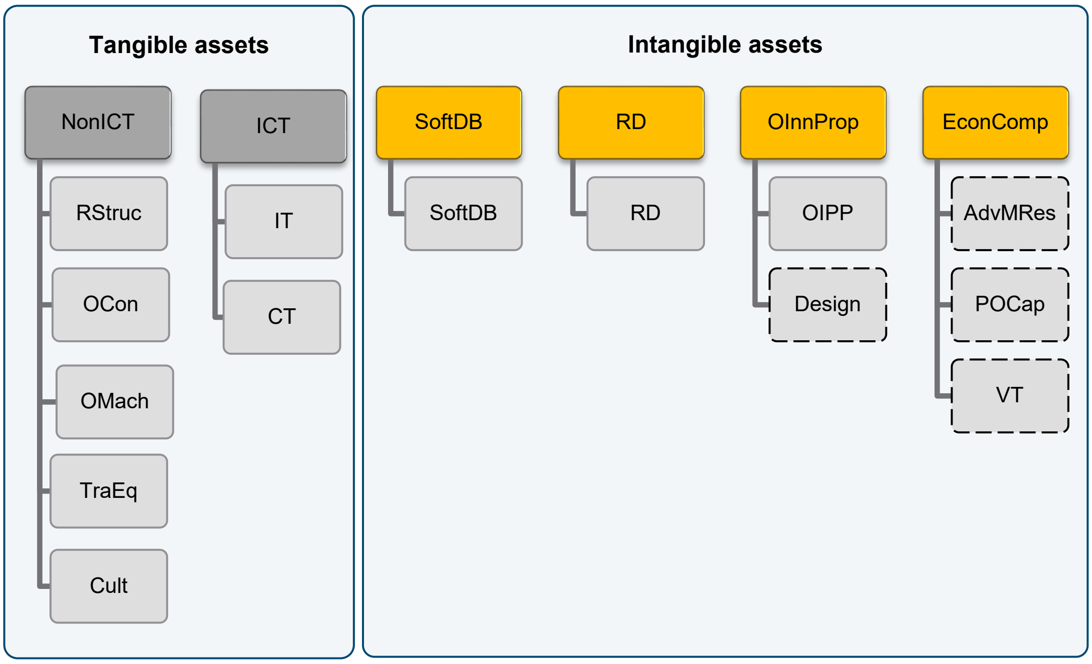
Table 2.1.2 / Classification of sectors

SEC	NACE Rev.2 codes	Sector description (based on NACE 2 classification)	Label
1	A	Agriculture, forestry and fishing	1_AGRI
2	B	Mining and quarrying	2_MING
3	10-12	Food products, beverages and tobacco	3_FOOD
4	13-15	Textiles, wearing apparel, leather and related products	4_TXTL
5	16-18	Wood and paper products; printing and reproduction of recorded media	5_WOOD
6	19	Coke and refined petroleum products	6_COKE
7	20-21	Chemicals and chemical products	7_CHEM
8	22-23	Rubber and plastics products, and other non-metallic mineral products	8_RUBB
9	24-25	Basic metals and fabricated metal products, except machinery and equipment	9_METL
10	26-27	Electrical and optical equipment	10_ELEC
11	28	Machinery and equipment n.e.c.	11_MACH
12	29-30	Transport equipment	12_TRAN
13	31-33	Other manufacturing; repair and installation of machinery and equipment	13_OMAN
14	D-E	Electricity, gas and water supply	14_GASW
15	F	Construction	15_CONS
16	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	16_TRMO
17	46	Wholesale trade, except of motor vehicles and motorcycles	17_WHTR
18	47	Retail trade, except of motor vehicles and motorcycles	18_RETR
19	49-52	Transport and storage	19_TRSR
20	53	Postal and courier activities	20_POST
21	I	Accommodation and food service activities	21_ACCO
22	J	Information and communication	22_INFO
23	K	Financial and insurance activities	23_FINA
24	L	Real estate activities	24_REAL
25	M-N	Professional, scientific, technical, administrative and support service activities	25_PROF
26	O-U	Community social and personal services	26_SOCI
100	TOT	Country total	100_TOTL

Note: the table shows the classification of sectors used in the paper with the numerical codes (SEC), corresponding NACE Rev. 2 codes, sector full name (based on NACE Rev.2) and short labels used for the brevity of exposition when discussing sectoral estimation results.
Source: own elaboration.

The data for capital stocks, their composition by asset types, labour productivity, TFP, hours worked and labour composition variables are obtained from the new EU KLEMS 2019 Release (see Adarov and Stehrer, 2019a for additional details about the database). Besides additional time coverage, the new EU KLEMS Release introduces an expanded capital asset type classification, in contrast to earlier iterations of the EU KLEMS database. It includes the ten asset types available from the national accounts capital data, which had already been included in the previous EU KLEMS data: Cultivated assets (Cult); Dwellings (RStruc); Other buildings and structures (OCon); Transport equipment (TraEq); Other machinery equipment (OMach); Computer hardware (IT); Telecommunications equipment (CT); Computer software and databases (SoftDB); Research and development (RD); and Other intellectual property products (OIPP). In addition, the database introduces four new “supplementary” intangible asset types, including Advertising and Market Research (AdvMRes), Design (Design), Purchased Organisational Capital (POCap) and Vocational Training (VT).

Figure 2.1.1 / Capital asset aggregates



Note: Dashed lines indicate asset types outside the boundaries of National Accounts.
Source: Own elaboration based on Haskel and Westlake (2018).

Therefore we distinguish 14 capital asset types. For the purposes of econometric analysis, in order to make the list of asset types more manageable and focused on the role of tangibles/intangibles and ICT/non-ICT capital, as well as to gain greater efficiency in the estimations given a relatively small sample size, in the baseline analysis we follow Haskel and Westlake (2018) and group the 14 asset types into six broader aggregates, as outlined in Figure 2.1.1

The data for GDP, institutional development and educational attainment are obtained from the World Bank's World Development Indicators and the Penn World Tables (PWT) 9.1 data. Based on the World Input-Output Database (WIOD), we compute measures of backward and forward global value chain participation (GVC participation) in line with Koopman et al. (2014). Additional technical details on the derivation of backward, forward and total GVC participation measures at the aggregate country and sectoral levels are discussed in Adarov and Stehrer (2019b) and Adarov and Stehrer (2020).

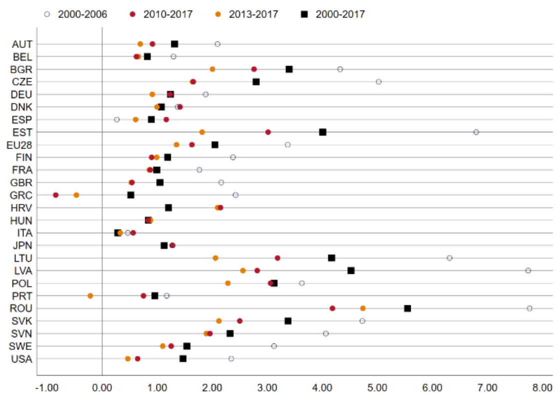
2.2. PRODUCTIVITY DYNAMICS IN EUROPE: A COMPARATIVE PERSPECTIVE

This section reviews the productivity dynamics in Europe over time and relative to peer economies. As a measure of labour productivity we use real output *per hour worked* (at the annual frequency), which better reflects the productivity concept in comparison with the alternative measure of labour productivity *per person employed*, as it is not prone to the bias associated with full-time versus part-time workers. In addition, we also review total factor productivity (TFP) dynamics based on the EU KLEMS and PWT 9.1 data. TFP conveys the combined productivity of labour and capital inputs and is estimated as a residual term of the production function.

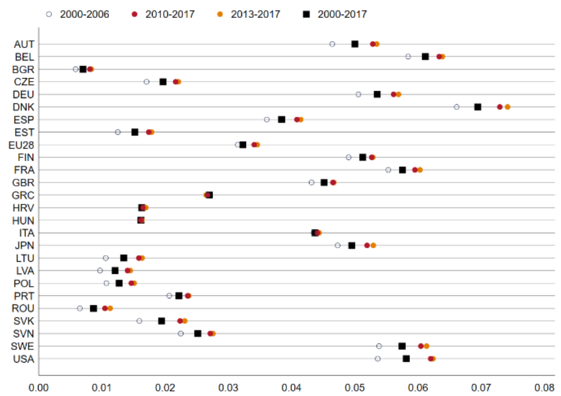
As reported in the literature, sluggish productivity growth has been a major challenge for many economies worldwide, particularly in the post-crisis period. As can be seen in Figure 2.2.1, most of the European countries suffered a major slowdown in labour productivity and TFP growth in the aftermath of the Great Recession, followed by a double-dip recession. The lacklustre productivity dynamics did not improve in the post-2013 period either – on the contrary, for most countries the slowdown persisted, and productivity is still hardly seen to be on the path to recovery. With the exception of Ireland, Spain, Italy and Denmark, labour productivity has decelerated further in the post-crisis period. Especially strong productivity losses were incurred by the Baltic countries and Romania, where the average productivity growth declined by more than 3 percentage points after the crisis.

Figure 2.2.1 / Productivity dynamics

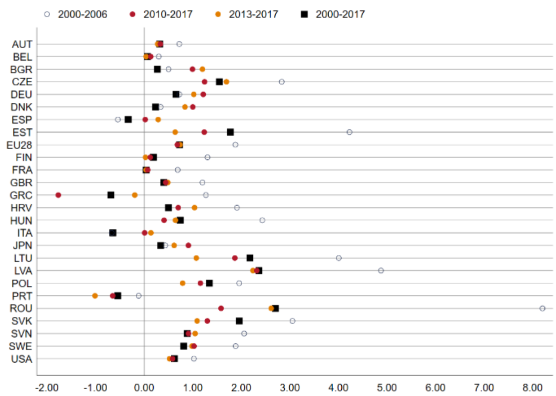
Labour productivity growth, year-on-year % change



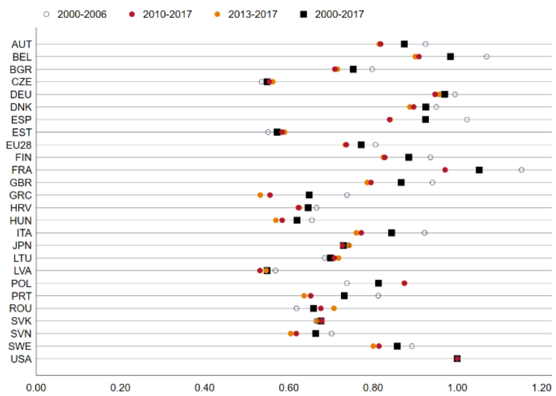
Labour productivity level (2010 USD million)



TFP growth, year-on-year, % change

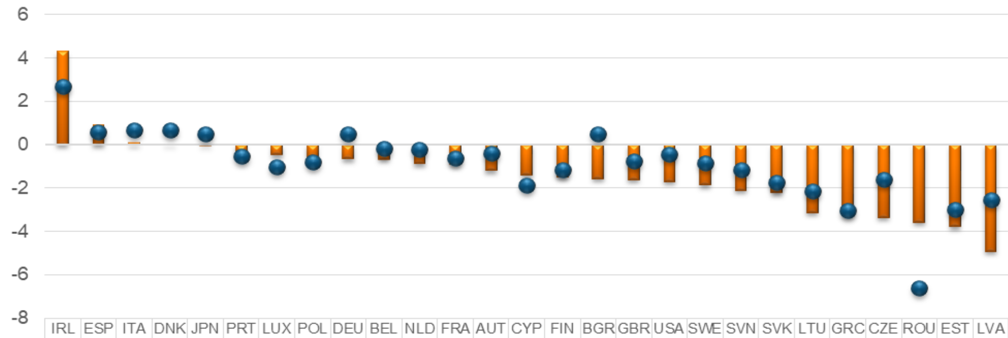


TFP level (US = 1)



Note: The figure shows real labour productivity (per hour worked) growth and real labour productivity level (in 2010 USD million), as well as TFP growth and TFP level (relative to the US). The figures indicate 2000-2017 averages along with the pre-crisis and post-crisis period averages (with and without the double-dip recession period). Countries are sorted by ISO3 in alphabetic order. EU28 indicates EU28 average values.
Source: Own computations based on the EU KLEMS 2019 and PWT 9.1 data.

Figure 2.2.2 / Pre-crisis and post-crisis labour productivity growth differential

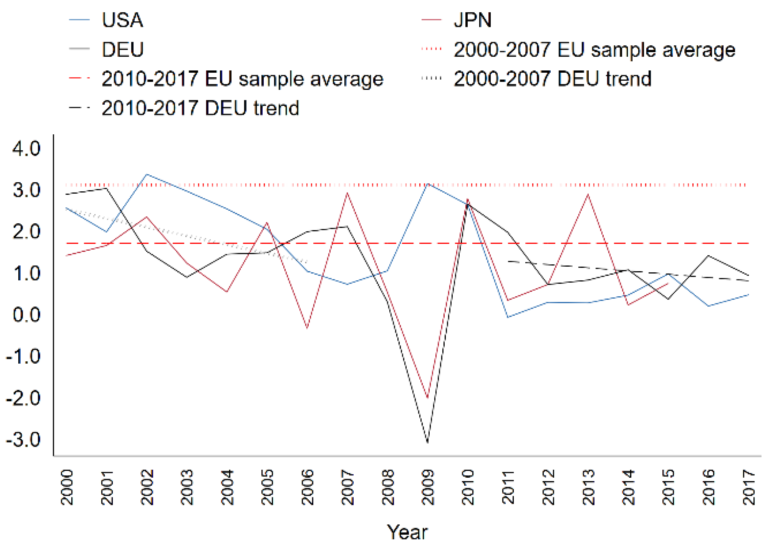


	IRL	ESP	ITA	DNK	JPN	PRT	LUX	POL	DEU	BEL	NLD	FRA	AUT	CYP	FIN	BGR	GBR	USA	SWE	SVN	SVK	LTU	GRC	CZE	ROU	EST	LVA
Labour productivity	4.3	0.9	0.1	0.0	0.0	-0.4	-0.5	-0.6	-0.6	-0.7	-0.9	-0.9	-1.2	-1.4	-1.5	-1.6	-1.6	-1.7	-1.9	-2.1	-2.2	-3.1	-3.3	-3.4	-3.6	-3.8	-4.9
TFP	2.7	0.6	0.7	0.7	0.5	-0.5	-1.0	-0.8	0.5	-0.2	-0.2	-0.6	-0.4	-1.9	-1.2	0.5	-0.8	-0.4	-0.9	-1.1	-1.8	-2.1	-3.0	-1.6	-6.6	-3.0	-2.6

Note: The figure shows the percentage-point difference between the average 2010-2017 and the average 2000-2006 growth rates of real labour productivity. The countries are sorted by the labour productivity growth differential.
Source: Own calculations based on the EU KLEMS 2019.

While the recent years were characterised by particularly lasting and sizeable productivity losses, it should be noted that the productivity slowdown was not a phenomenon observed in the post-crisis years only; rather, many European countries, both advanced and developing, suffered from productivity decelerations in the pre-crisis period as well. For instance, in Germany both labour productivity and TFP growth suffered a drop in the years 2002-2003 amid a generally long-run downward trend (Figure 2.2.3).

Figure 2.2.3 / Labour productivity trends, selected countries, 2000-2017



Note: The figure shows labour productivity growth over the period 2010-2017 of selected economies along with the pre- and post-crisis linear trend for Germany and sample pre- and post-crisis (simple) average growth rates.

Besides the common cyclical and structural issues underlying the productivity slowdown, the productivity dynamics are driven by economic convergence processes accelerated by economic integration, as countries with lower absolute productivity levels generally tend to enjoy a faster productivity growth rate than high-productivity economies (Figure 2.2.4). This has been a particularly important factor for Europe, as multi-speed EU integration facilitates institutional and infrastructural upgrading of the countries lagging behind – the transition economies and the Western Balkan countries. At the same time, a group of countries comprising Portugal, Greece, Croatia, Cyprus, and to a lesser extent Italy and Spain, nevertheless lag behind their comparable European peers and exhibit lower productivity dynamics than expected, based on the general statistical association between productivity levels and productivity growth rates as inferred from the scatterplots in Figure 2.2.4.

As a related matter, given the strong heterogeneity of European countries in terms of productivity levels and growth, the average productivity (for instance, the EU28 average plotted also for reference in Figure 2.2.1 for the pre-crisis, post-crisis and the full sample period) may be misleading as a characteristic of a general stance of the EU, particularly in comparison with peer non-European economies such as the US or Japan. However, in general most European countries tend to lag behind the US in terms of both labour productivity and TFP levels (particularly in the post-crisis period), and in many cases also in terms of productivity growth rates. There are only a few EU countries that are at or close to the global "productivity frontier" – the advanced countries like Germany, France, Austria, Belgium and Denmark. These countries, as noted, are naturally also characterised by lower productivity growth rates. The notable exception is Ireland, which has demonstrated an especially high level of productivity (both labour productivity and TFP) coupled with high productivity growth rates, which also proved to be resilient to the post-crisis growth malaise (the average post-crisis growth rate has increased relative to the pre-crisis period by 4.3 pp and 2.7 pp for labour productivity and TFP, respectively). In fact, Ireland has recently been the most productive country in the world. Its especially high productivity levels are attributed to the heavy presence of multinational corporations in the economy.[4]

With the exception of selected high-performance economies it is clear, however, that many EU countries tend to fall behind the US in terms of aggregate labour and TFP productivity, and in many cases also below the productivity levels of Japan. As a result of the combined effect of a broad-based slowdown in productivity across Europe as well as the lasting structural productivity issues faced by certain EU countries (in particular, protracted productivity convergence of the lagging economies of Central, East and Southeast Europe and macroeconomic issues associated with Italy, Portugal, Greece and Spain), the EU has fallen behind both the US and Japan. The US labour productivity *level* is almost twice as high as the EU average – a trend that persisted both before and after the recent crisis (see Figure 2.2.1). The EU suffered a major setback in its productivity growth rate as a result of the crisis, and although it still enjoys a productivity *growth rate* moderately above that of the US in the post-crisis period, bridging this gap appears to be an uphill struggle in light of the ongoing challenges faced by the EU.

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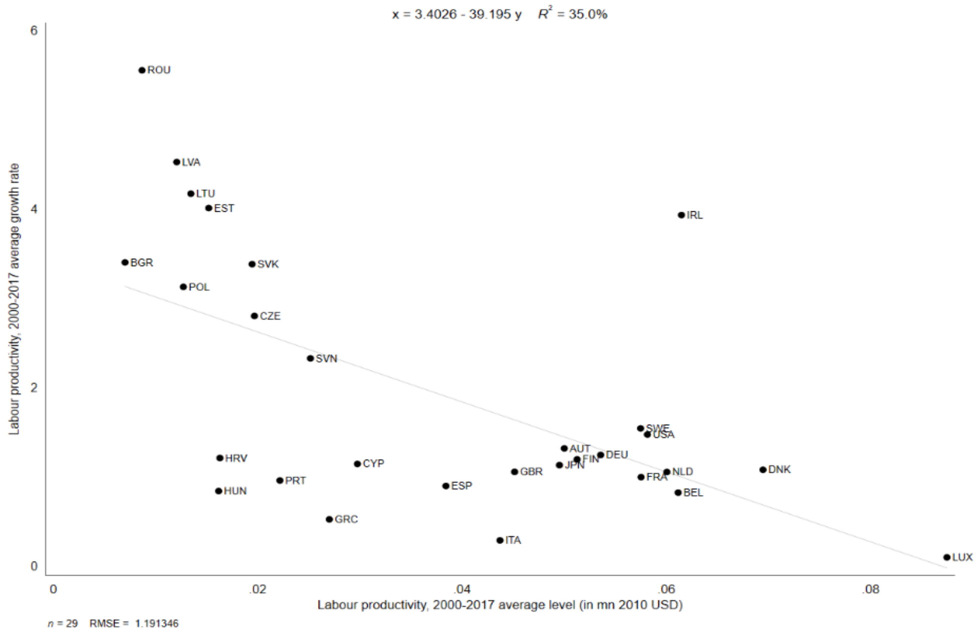
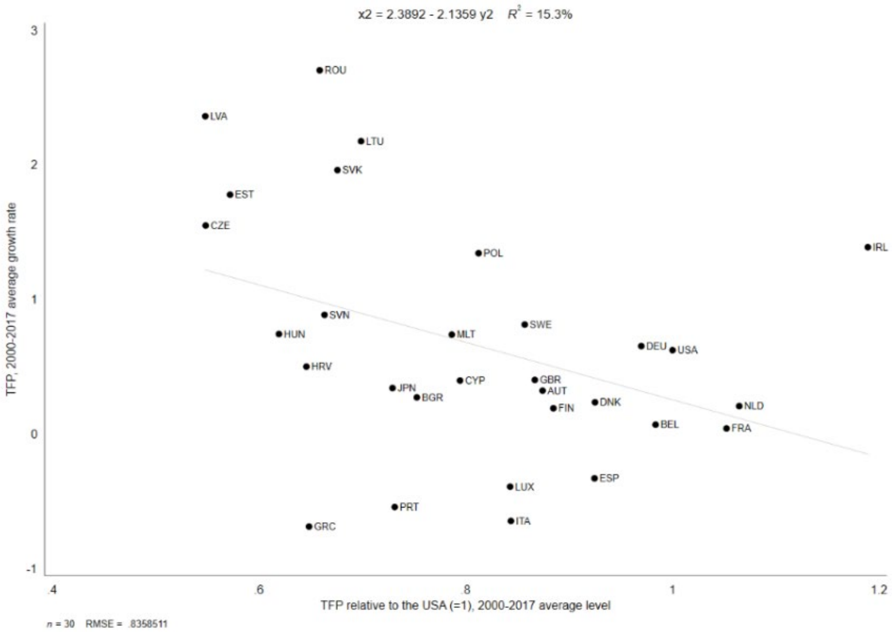
[4] Notably, while the multinational companies in Ireland are highly productive, the productivity of domestic enterprises is much lower (also below the OECD average). High productivity is associated with the relatively small number of frontier multinational companies operating in several foreign-dominated sectors, particularly the pharmaceutical, ICT and food sectors, as argued in the analytical report by the Irish National Competitiveness Council (2019).

Figure 2.2.4 / Long-run productivity convergence

Labour productivity



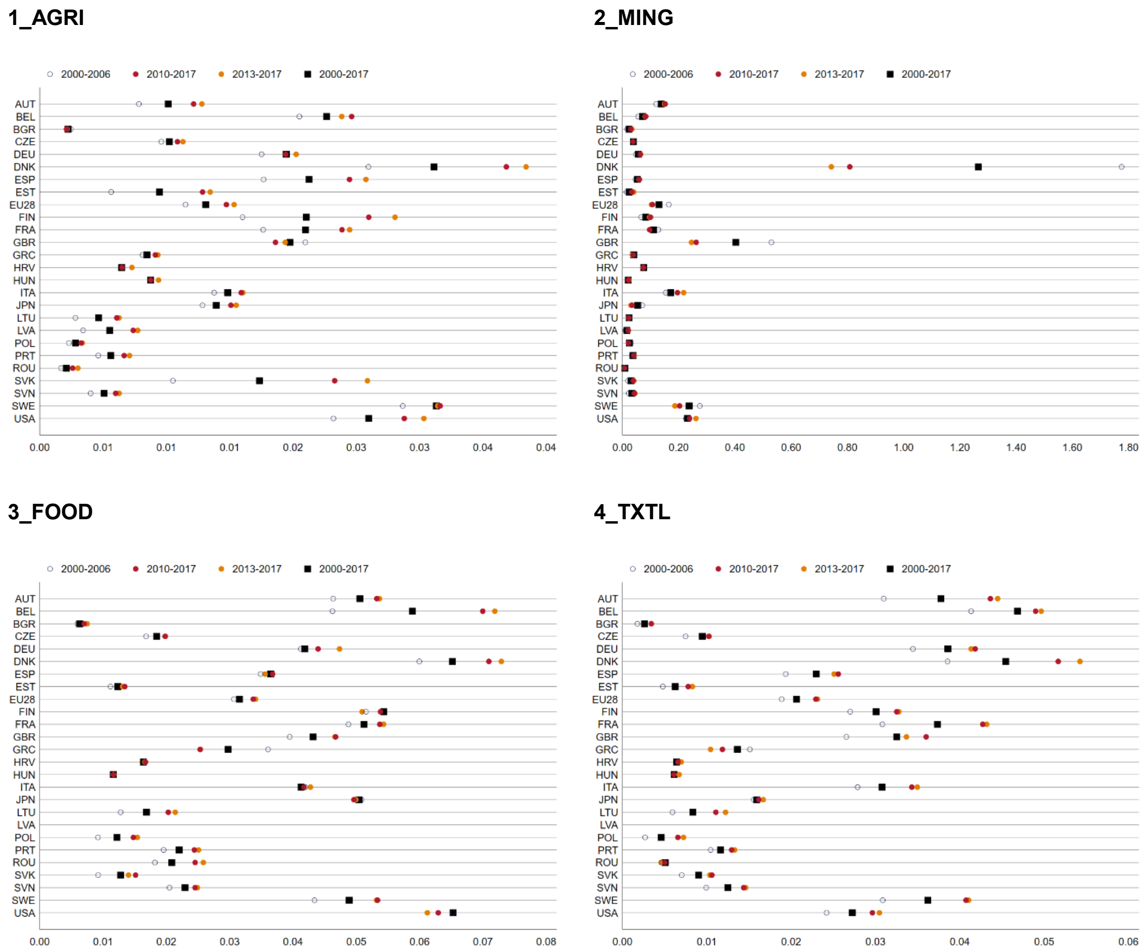
TFP



A comparative overview of sectoral labour productivity dynamics reported in Figure 2.2.5 for each of the 26 sectors as outlined in Section 2 reveals similar meagre patterns, with most EU countries lagging behind the US with the exception of selected frontier economies – Austria, Germany, Finland, Belgium, Denmark and other advanced industrialised economies (although the relative standing of countries differs across sectors). Inter alia, the productivity hold-up is visible in the high-tech manufacturing cluster (sectors 10_ELEC, 11_MACH, 12_TRAN): both Japan and the US surpass the average EU productivity in these sectors significantly, with the gap widening in the post-crisis period as the EU suffered major losses in the productivity growth dynamics in these sectors, especially in 10_ELEC and 11_MACH, which were the leaders in terms of productivity growth dynamics in the EU before the crisis (see Figure 2.2.6 for a comparative review of the average EU productivity by sectors before and after the crisis). In light of the observed concurrent weakening of productivity across multiple sectors, it is important to note that the decline in the *aggregate national* productivity therefore appears to be associated to a greater extent with common nationwide structural and cyclical challenges, rather than with the shift of the economic structure of European countries towards sectors with lower productivity growth rates (although the latter might still contribute to aggregate productivity slowdown).

In light of these developments in productivity as one of the key aspects of the project, we analyse the implications of capital accumulation and structure as well as FDI on productivity as the major factors of competitiveness. In addition, we explore the impact of capital and FDI on global value chains, which in turn also impacts productivity patterns. Selected results are discussed in the next subsections.

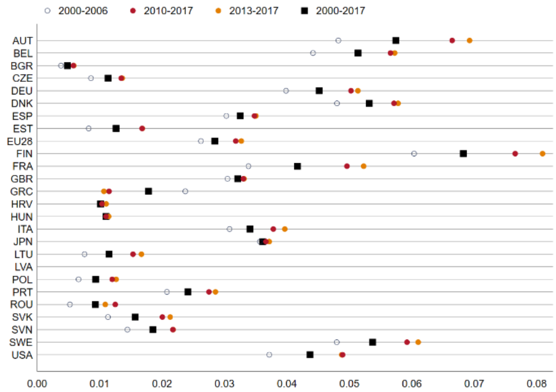
Figure 2.2.5 / Productivity dynamics by sectors (levels)



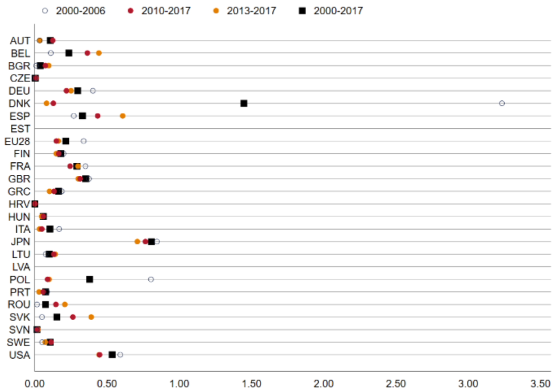
Source: Own computations based on the EU KLEMS 2019 data. ctd.

Figure 2.2.5 / (cont.)

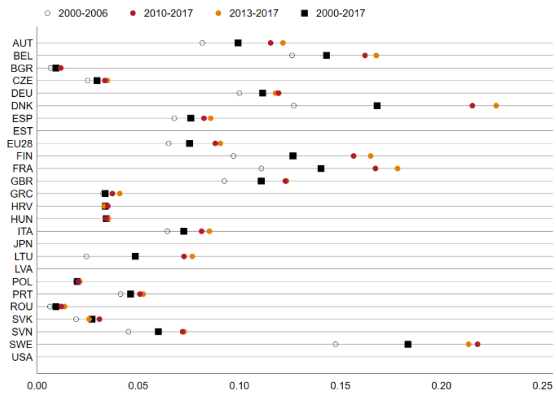
5_WOOD



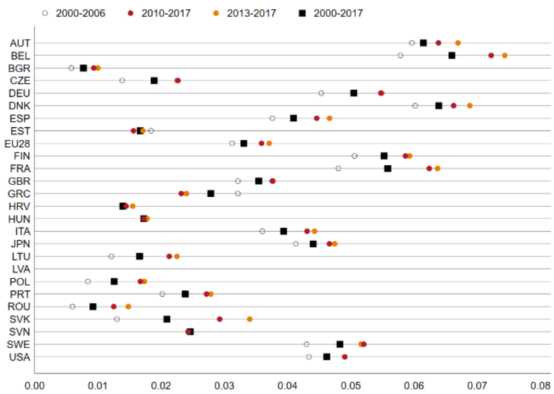
6_COKE



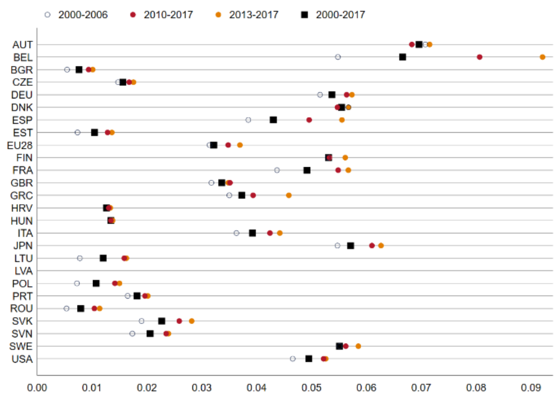
7_CHEM



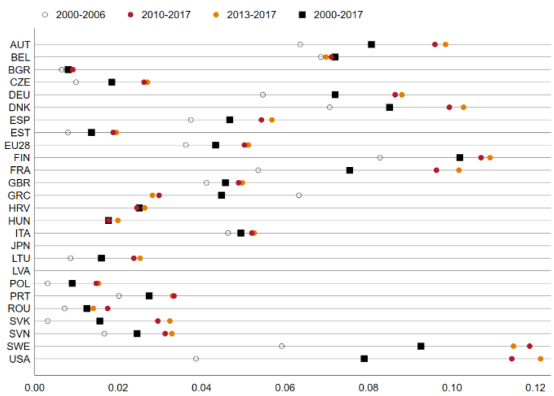
8_RUBB



9_METL



10_ELEC

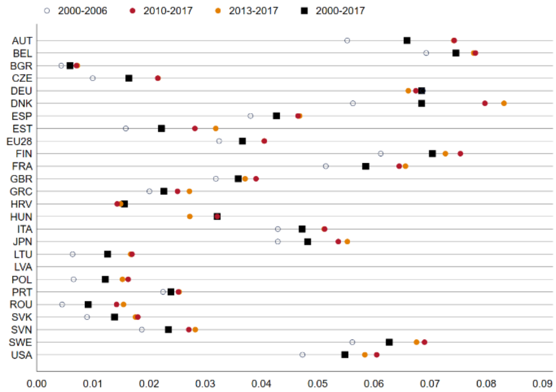


Source: Own computations based on the EU KLEMS 2019 data.

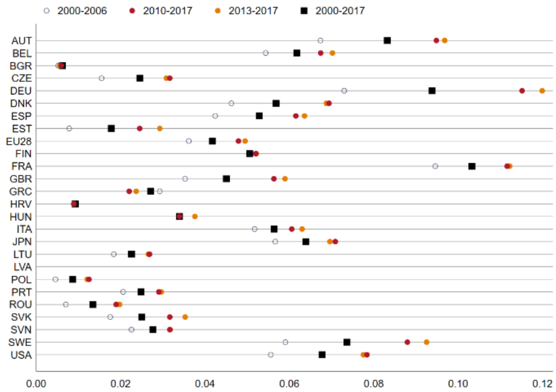
ctd.

Figure 2.2.5 / (cont.)

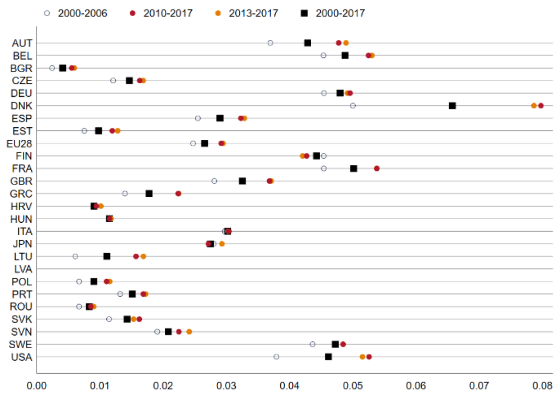
11_MACH



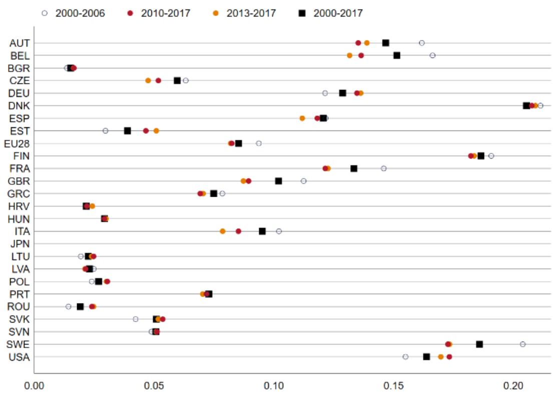
12_TRAN



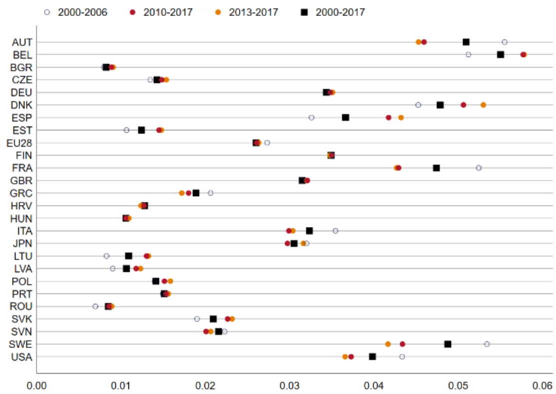
13_OMAN



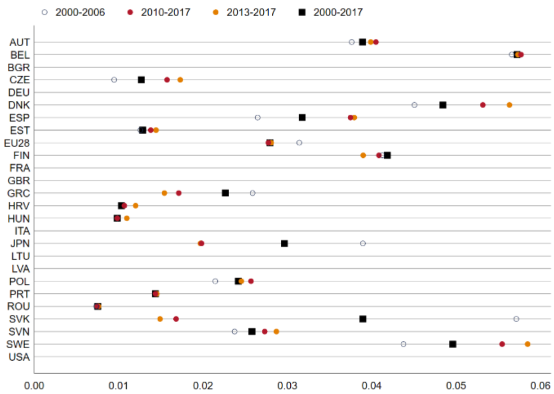
14_GASW



15_CONS



16_TRMO

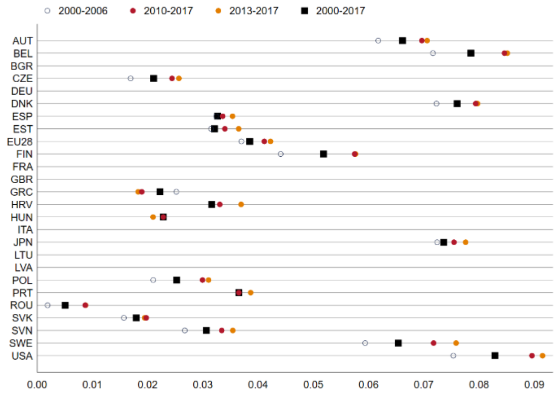


Source: Own computations based on the EU KLEMS 2019 data.

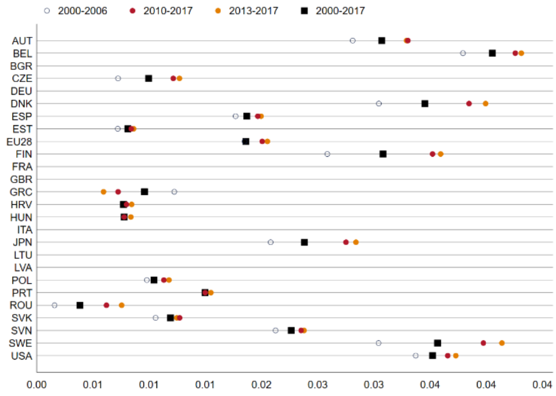
ctd.

Figure 2.2.5 / (cont.)

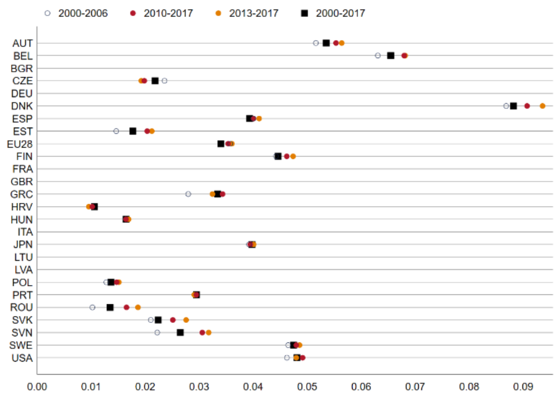
17_WHTR



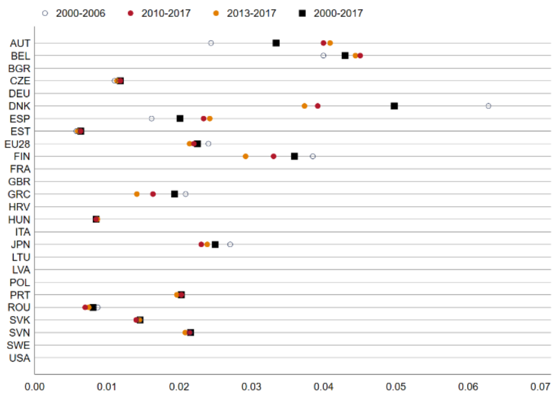
18_RETR



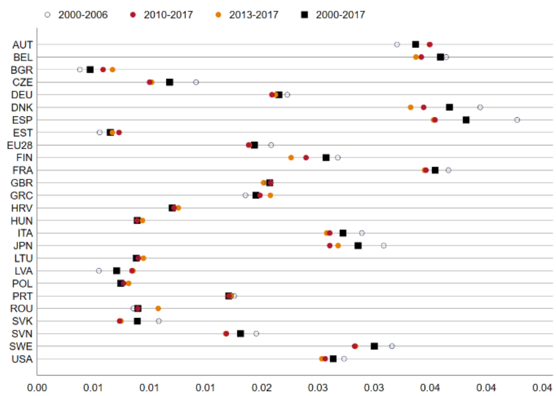
19_TRSR



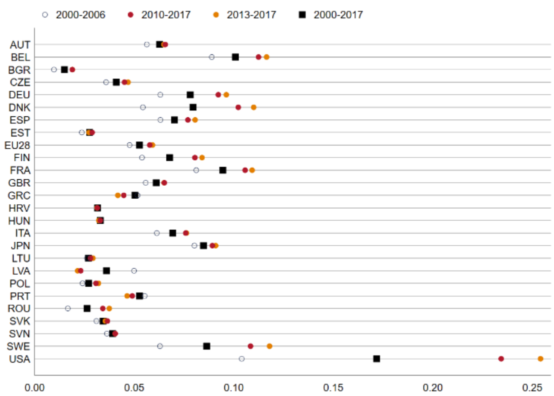
20_POST



21_ACCO



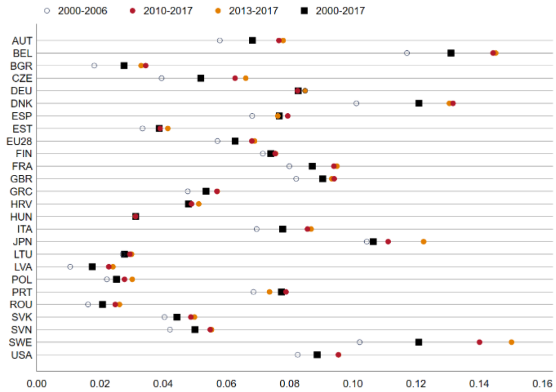
22_INFO



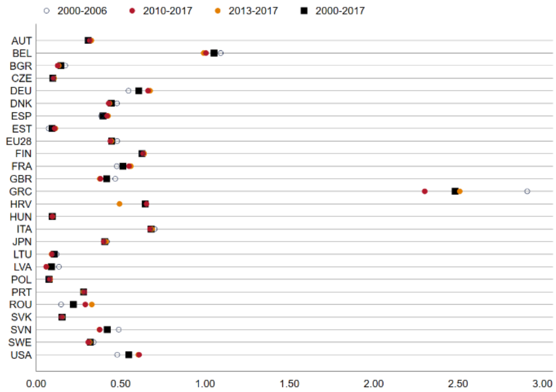
Source: Own computations based on the EU KLEMS 2019 data. ctd.

Figure 2.2.5 / (cont.)

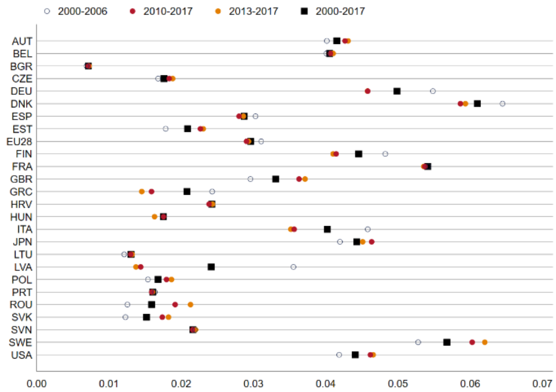
23_FINA



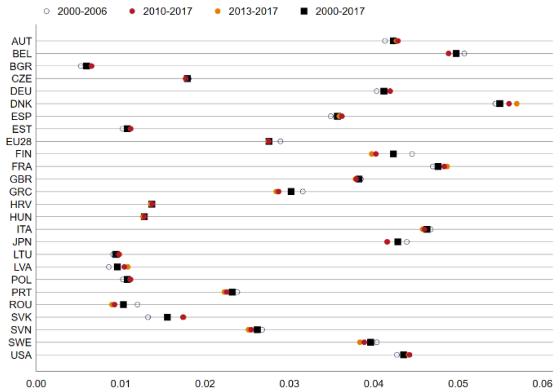
24_REAL



25_PROF

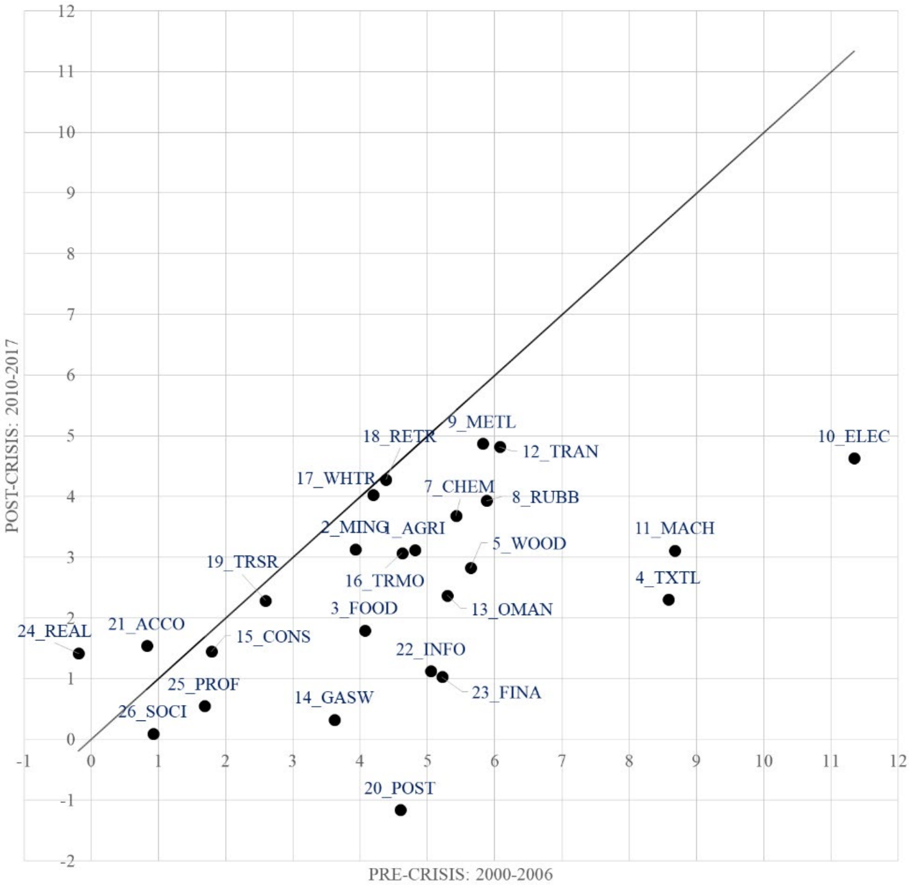


26_SOCI



Note: The figure shows real labour productivity levels in 2010 USD million for the 26 sectors as outlined in Table 2.1.2. The figures indicate 2000-2017 averages along with the pre-crisis and post-crisis period averages (with and without the double-dip recession period). Countries are sorted by ISO3 in alphabetic order. EU28 indicates average EU28 values.
Source: Own computations based on the EU KLEMS 2019 data.

Figure 2.2.6 / Labour productivity by sectors: EU28 average before and after the crisis



Note: The figure shows real labour productivity growth rates before and after the crisis along with the 45-degree line. Sector 6_COKE is omitted for clarity.
Source: Own computations based on the EU KLEMS 2019 data.

2.3. DRIVERS OF PRODUCTIVITY AND THE ROLE OF CAPITAL DYNAMICS AND COMPOSITION: EVIDENCE FROM THE ECONOMETRIC ANALYSIS

In this section we use panel data techniques to examine the impact of capital accumulation and structure on productivity at aggregate country and sectoral levels, controlling for the impact of other relevant factors, including global value chain participation and economic integration.[5] To this end the following specification is estimated:

$$\Delta\mathrm{lnPROD}_{ct} = \alpha_1\mathrm{lnPROD}_{ct-1} + \alpha_2\mathrm{lnL}_{ct} + \sum_{q\in Q}\beta_q\,\Delta\mathrm{lnK}_{qct} + \sigma\Delta\mathrm{lnFDI}_{ct-1} + \boldsymbol{\xi}\mathbf{X}_{ct} + \boldsymbol{\mu}_{c} + \varepsilon_{ct}$$

where $\Delta\mathrm{lnPROD}_{ct}$ is the measure of productivity in country c (real value added per hour worked), in log-differenced form (thus conveying its growth rate). The term lnPROD_{ct-1} is the lagged level of real labour productivity capturing the convergence effect. $\Delta\mathrm{lnL}_{ct}$ is the labour input: the growth of the labour

5 The chapter is based on the analysis reported in Adarov and Stehrer (2020).

services, which is used for baseline estimations, or a combination of the hours worked and the change in the labour composition, i.e. $\Delta \ln \mathrm{L_{ct}} = \Delta \ln \mathrm{LC_{ct}} + \Delta \ln \mathrm{H_{ct}}$.

The term $\Delta \ln \mathrm{K_{qct}}$ denotes the measure of capital inputs. The baseline model uses real capital stocks in log-differences distinguishing between several capital asset types (alternative specifications include capital services growth and the change in real capital stocks as a share of employed persons). In the baseline analysis we distinguish the six broader capital asset groups as defined in Section 2.1, i.e. the set Q = {SoftDB; NonICT; ICT; RD; OInnProp; EconComp}. In additional empirical exercises the 14 detailed capital asset types are included instead of the aggregate groups.

The variable $\Delta \ln \mathrm{FDI_{ct-1}}$ denotes a measure of foreign direct investment; the baseline model employs inward FDI growth (real inward FDI stock in log-differences),[6] alternative specifications use the change in the inward FDI stock as a share of GDP and the ratio of (real) inward FDI stock to the persons employed in log-differences. In order to address possible endogeneity issues, the FDI variable is lagged by one or more years.[7] In additional empirical exercises the model is further augmented by other explanatory variables of interest comprising constituting the vector $\mathbf{X_{ct}}$, including interaction terms of FDI with various variables conveying “absorptive capacity” – institutional variables (World Bank’s Worldwide Governance Indicators measuring government effectiveness and control of corruption), educational attainment, quality of infrastructure, financial development measured as private credit-to-GDP ratio and others. Other exercises also incorporate GVC participation measures and EU integration variables to measure the effects of deeper economic integration, which could be important for productivity gains. Finally, $\boldsymbol{\mu_c}$ denotes the vector of country and year fixed effects, capturing unobserved country heterogeneity and common year-specific shocks.

The model is estimated via fixed effects with standard errors clustered by country (“FE”) as the baseline estimator – the results are reported in Table 2.3.1 with the benchmark specification listed in column 1 (other specifications are reported for robustness). We drop outliers beyond 2 standard deviations from the mean for the key variables of interest (labour productivity growth, real capital stock growth by asset types and real FDI stock growth), which nevertheless retains 90% of the original data.

The analysis strongly suggests that investment in ICT capital is associated with the increase in labour productivity, consistent with the idea that advanced technology embodied in ICT effectively complements workers’ skills leading to productive efficiency gains. More generally, ICT capital, being a general-purpose technology, has multiple channels via which it may influence broad-based productivity at the country level, including faster and more efficient communication, better data management practices and enhanced data flow, thereby also reducing information inefficiencies and fostering knowledge creation and transfer. Notably, both tangible ICT (ICT) and intangible ICT (SoftDB) variables are statistically significant and imply sizeable economic effects: a 1 pp increase in the growth of real capital stock induces an increase in real labour productivity growth of about 0.06 pp in the case of the tangible ICT capital, and of 0.09 pp in the case of the intangible SoftDB capital. In fact, the impact of SoftDB is more profound relative to the ICT aggregate in terms of the magnitude and manifests itself more strongly across multiple specification and robustness checks, including alternative samples and models.

6 GDP deflators are used to compute FDI in constant prices.

7 In additional robustness exercises we also explore deeper lags of capital and FDI variables.

Contrary to expectations, no impact of FDI on productivity is found. In fact, the effect does not manifest at deeper lags of the FDI variable and after adjusting for the country's absorption capacity as proxied by institutional development, human capital and financial development measures. This implies that, after imposing a strict control over the sample, that is, removing the impact of strong outliers like Ireland and removing the bias associated with SPEs and controlling for other factors, the role of FDI as a booster of labour productivity may not be significant, at least not in the relatively short time spans of several years. This is, however, consistent with the idea that FDI is targeted at countries (or sectors) with already high levels of productivity (which is captured in the specification by the lagged labour productivity variable), but does not robustly contribute much per se to further productivity growth.

Table 2.3.1 / Aggregate country-level estimation results

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) POLS	(7) GMM
Ln (Labour productivity), lag	-0.122***	-0.119***		-0.135***	-0.106***	-0.010***	-0.117**
	(0.021)	(0.019)		(0.022)	(0.020)	(0.002)	(0.047)
ΔLn (Labour services)	-0.333***		-0.397***	-0.327***	-0.356***	-0.325***	-0.282*
	(0.073)		(0.079)	(0.079)	(0.068)	(0.059)	(0.166)
Labour composition growth		-0.028					
		(0.151)					
ΔLn (Hours worked)		-0.378***					
		(0.072)					
ΔLn (Inward FDI stock), lag	-0.012	-0.011	-0.012	-0.013		-0.004	-0.011
	(0.007)	(0.008)	(0.008)	(0.008)		(0.007)	(0.035)
ΔLn (EconComp, real capital stock)	-0.039*	-0.031	-0.040		-0.029	-0.012	-0.099
	(0.020)	(0.021)	(0.024)		(0.020)	(0.025)	(0.073)
ΔLn (ICT, real capital stock)	0.055**	0.061***	0.045**		0.040**	0.031**	0.030
	(0.021)	(0.021)	(0.021)		(0.017)	(0.013)	(0.059)
ΔLn (NonICT, real capital stock)	-0.037	0.018	-0.063		-0.006	-0.002	0.119
	(0.122)	(0.103)	(0.120)		(0.114)	(0.096)	(0.323)
ΔLn (OInnProp, real capital stock)	-0.002	-0.003	-0.021		0.013	0.008	0.026
	(0.050)	(0.047)	(0.054)		(0.049)	(0.054)	(0.098)
ΔLn (RD, real capital stock)	0.046	0.041	0.057		0.041	0.020	0.014
	(0.039)	(0.039)	(0.044)		(0.033)	(0.035)	(0.084)
ΔLn (SoftDB, real capital stock)	0.085**	0.085***	0.091**		0.083***	0.091**	0.105*
	(0.031)	(0.029)	(0.035)		(0.027)	(0.036)	(0.060)
ΔLn (Labour productivity), lag							-0.043
							(0.185)
Constant	-0.370***	-0.362***	0.016***	-0.425***	-0.326***	-0.018*	-0.347**
	(0.066)	(0.061)	(0.004)	(0.074)	(0.068)	(0.009)	(0.145)
Country FE	Yes	Yes	Yes	Yes	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	216	216	216	248	262	216	76
Adj. R-squared	0.581	0.593	0.521	0.495	0.589	0.468	

Note: The table shows the estimation results using fixed effects ('FE') with standard errors clustered by country (in parentheses), as well as pooled OLS ('POLS') and system GMM ('GMM') based on 3-year non-overlapping averages. The dependent variable is ΔLn (Labour productivity). *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

As expected, lagged labour productivity level is negative and significant throughout specifications, indicating strong convergence effects as countries with lower productivity levels generally enjoy a faster catch-up productivity growth. Introducing deeper lags of the real labour productivity variable as a robustness check yields very similar results. The growth of labour services is overwhelmingly associated with the decline in labour productivity. Decomposition of the labour services variable into its components – the hours worked and the labour composition (Column 2) reveals that this effect is entirely attributed to the negative impact of the growth in the hours worked, which confirms the conjecture of diminishing marginal returns to labour inputs.

We then test the impact of additional factors that may influence productivity dynamics, including the effects of GVC participation and European economic integration, and explore in more detail the implications of FDI for labour productivity, as the baseline estimation results did not reveal any significant impact despite expectations. The results are reported in Table 2.3.2.

Table 2.3.2 / The impact of GVC participation and EU membership

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln (Labour productivity), lag	-0.120***	-0.120***	-0.129***	-0.121***	-0.121***	-0.148***	-0.148***
	(0.025)	(0.026)	(0.026)	(0.027)	(0.021)	(0.029)	(0.029)
ΔLn (Labour services)	-0.339***	-0.339***	-0.336***	-0.347***	-0.334***	-0.342***	-0.342***
	(0.076)	(0.075)	(0.080)	(0.075)	(0.077)	(0.076)	(0.076)
ΔLn (EconComp, real capital stock)	-0.042	-0.042	-0.042	-0.044	-0.039*	-0.027	-0.027
	(0.028)	(0.028)	(0.026)	(0.028)	(0.020)	(0.022)	(0.022)
ΔLn (ICT, real capital stock)	0.043**	0.043**	0.043**	0.039*	0.055**	0.060**	0.060**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.021)	(0.021)	(0.021)
ΔLn (NonICT, real capital stock)	0.036	0.036	0.015	0.048	-0.034	-0.050	-0.050
	(0.131)	(0.131)	(0.128)	(0.123)	(0.124)	(0.126)	(0.126)
ΔLn (OInnProp, real capital stock)	-0.003	-0.002	-0.005	-0.005	-0.002	-0.002	-0.002
	(0.044)	(0.043)	(0.046)	(0.044)	(0.049)	(0.049)	(0.049)
ΔLn (RD, real capital stock)	0.056	0.056	0.054	0.053	0.046	0.036	0.036
	(0.040)	(0.040)	(0.039)	(0.041)	(0.040)	(0.037)	(0.037)
ΔLn (SoftDB, real capital stock)	0.075**	0.075**	0.082**	0.070**	0.085**	0.081**	0.081**
	(0.032)	(0.033)	(0.032)	(0.033)	(0.032)	(0.029)	(0.029)
FDI = ΔLn (Inward FDI stock), lag	-0.014*	-0.014*	-0.013	-0.009	-0.012	-0.012	-0.012
	(0.008)	(0.008)	(0.008)	(0.009)	(0.007)	(0.007)	(0.007)
Δ Backward GVC, lag	0.200**	0.204**		0.237**			
	(0.085)	(0.076)		(0.091)			
Δ Forward GVC, lag	-0.017		-0.139	-0.108			
	(0.155)		(0.146)	(0.179)			
FDI × Δ Backward GVC , lag				-0.083			
				(0.461)			
FDI × Δ Forward GVC, lag				1.664			
				(1.001)			
FDI × Transition economy DV, lag					0.003		
					(0.016)		
EU membership DV						0.015**	0.015**
						(0.006)	(0.006)
Years in the EU							0.006*
							(0.003)
Constant	-0.366***	-0.365***	-0.395***	-0.368***	-0.367***	-0.468***	-0.664***
	(0.079)	(0.081)	(0.080)	(0.083)	(0.067)	(0.096)	(0.163)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	193	193	193	193	216	216	216
Adj. R-squared	0.601	0.603	0.594	0.604	0.579	0.585	0.585

Note: The table shows the estimation results using fixed effects with standard errors clustered by country (in parentheses). The dependent variable is ΔLn (Labour productivity). *, **, *** indicate statistical significance at the 10, 5 and 1% levels, respectively. "FDI" in the interaction terms refers to real inward FDI stock in log-differences, i.e. ΔLn (Inward FDI stock).

Across all specifications the marginal effect of ICT and SoftDB remains significant. We first examine the impact of backward and forward GVC participation on productivity. While forward GVC integration does not reveal any impact, backward GVC participation enters significantly with the marginal impact of 0.2, which implies that an increase in backward GVC participation by 0.1 induces a 2 pp increase in aggregate labour productivity growth.[8] It is intuitive that participation in global value chains provides an opportunity for productivity gains owing to knowledge spillovers from MNEs and efficiency gains associated with greater specialisation in certain tasks. In this respect the results highlight the important difference in the relative gains associated with the mode of GVC participation, i.e. specialisation in relatively more downstream industries as picked up by the backward GVC participation measure, as firms are able to take advantage of imported inputs of superior quality and at lower costs and, in general, the greater available variety of foreign inputs.

GVC integration is closely related to FDI, as both are coordinated by MNEs. Therefore, we also assess the possible interaction between FDI and GVC participation. The impact of FDI is nevertheless not found to be significant, consistent with the baseline model results. Although the literature suggests that the impact of FDI may be conditional on the absorptive capacity of the host country, we also do not find support for this conjecture, as the inclusion of interaction terms (educational attainment variables, human capital, control of corruption, government effectiveness, financial development variables) does not yield statistically significant results.

Finally, we augment the model with the EU dummy variable that takes the value of unity if the country is an EU member in year t and is zero otherwise. Additionally, the variable measuring the total number of years in the EU of a given country is introduced to gauge the possible non-linear effects associated with the intensity of integration.[9] Notably, both variables enter statistically significantly, implying that EU membership boosts labour productivity growth by 1.5 pp, with each year in the bloc bringing an additional increase of 0.6 pp, ceteris paribus, i.e. in addition to the general convergence effects.

We then run similar estimations for each of the 26 sectors as outlined above. We find a relatively stronger impact in the case of the manufacturing sectors, particularly for the textile and clothing, coke/refined petroleum and machinery manufacturing sectors in the case of intangible ICT and for the food processing and transport equipment sectors in the case of tangible ICT capital (see Figure 2.3.1). However, consistent with aggregate country-level results, FDI does not reveal a statistically significant impact.

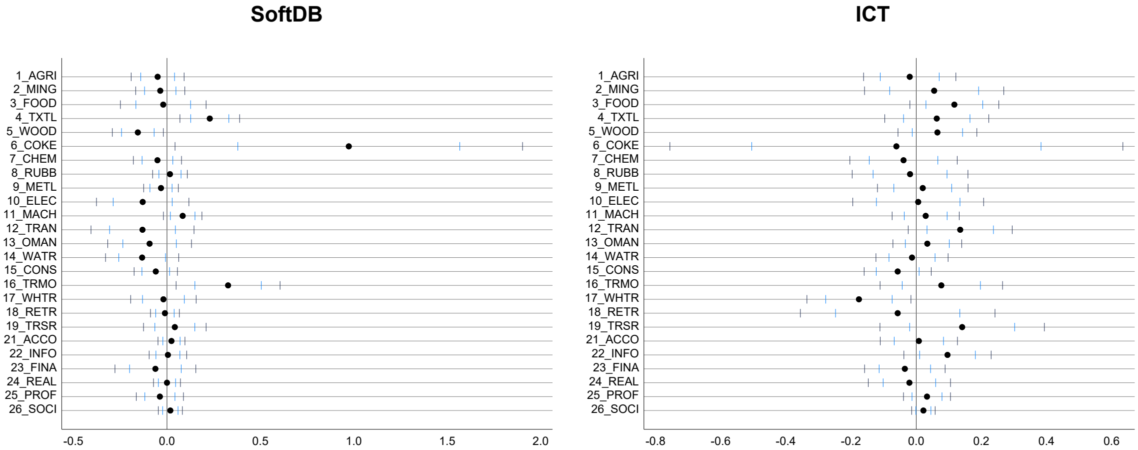
The positive impact of tangible ICT capital accumulation (ICT capital asset group) is found for sectors 3_FOOD and 12_TRAN. Among the services sectors, the significant effect (although only at the 10% level) is found for the sector 22_INFO, which is in line with expectations, as the provision of information and communications services relies heavily on tangible and intangible ICT capital. In all three cases the magnitude of the effect is about 0.1. At the same time, notably, the impact of intangible ICT capital (SoftDB capital asset group) is much more profound, with especially strong positive effects in terms of both statistical and economic significance observed in sectors 4_TXTL, 16_TRMO and 6_COKE. In the latter case the magnitude is particularly high, implying almost a 1-to-1 increase in labour productivity growth associated with the growth in the SoftDB capital. SoftDB capital also enters positively for the

8 For reference, backward GVC participation measure by construction is contained in the (0; 1) interval. In this respect a change in the backward GVC participation of the magnitude of 0.1 is a significant increase: de facto backward GVC participation for the sample under consideration varies from 0.09 (US) to 0.52 (Hungary); the sample year-on-year change in the backward GVC participation varies from -0.05 to +0.04 with the mean of 0.005.

9 To this end we use the year of entry for each country, starting from the Treaties of Rome (i.e. the year 1958) as listed by the European Commission on the EU portal: https://europa.eu/european-union/about-eu/countries_en#tab-0-1.

sector 11_MACH, but the effect is less significant statistically and in terms of economic significance (the estimate varies in the range of 0.08-0.1 across specifications). Surprisingly, intangible ICT also has a negative impact on sector 5_WOOD. Overall, the results observed across all specifications do not reveal strong systematic patterns across sectoral groups; while the high-tech sectors and sectors involved in the provision of information and communications services tend to exhibit more consistent positive response of productivity growth to ICT and RD capital, the impact of capital composition varies significantly and is specific to each sector.

Figure 2.3.1 / Marginal impact of FDI, ICT and non-ICT capital on labour productivity by sector



Note: The figure shows the average estimated marginal impact of ICT capital, along with the 90% and 99% confidence intervals (indicated light and dark blue bars, respectively).

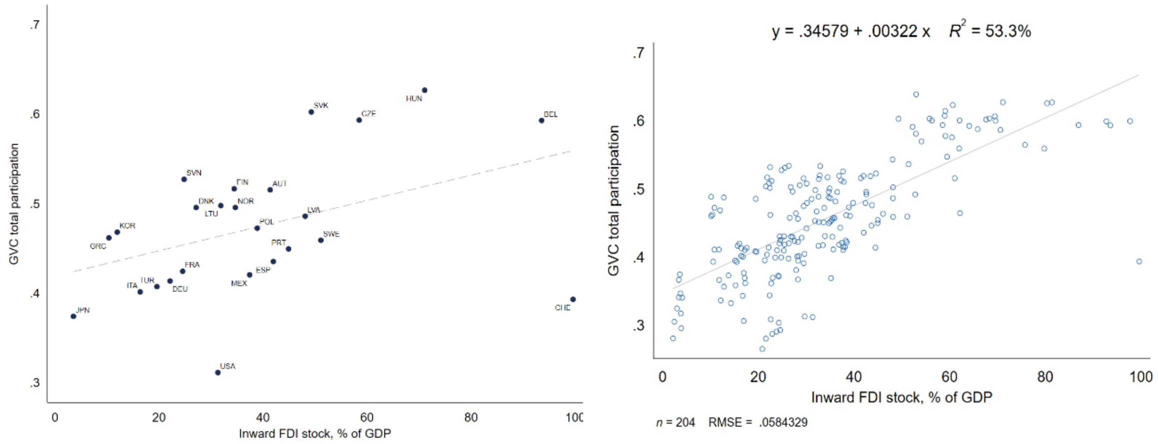
2.4. IMPLICATIONS OF FOREIGN DIRECT INVESTMENT, CAPITAL FORMATION AND ITS STRUCTURE FOR GLOBAL VALUE CHAINS

While we do not find a statistically significant impact of FDI on productivity directly, we identify a robust impact of FDI on GVC participation, which thereby also impacts productivity. In particular, we find that inward FDI is especially conducive to the formation of backward linkages, while outward FDI facilitates forward GVC participation, especially in high-tech manufacturing sectors. A particularly robust influence of FDI and capital accumulation on GVC integration is identified in the textile and clothing industry. While capital accumulation in general intensifies GVC linkages for most sectors, ICT capital appears to be especially instrumental for backward integration of the electrical and transport equipment sectors. This subsection discusses the key results from this analysis (for the full analysis see Adarov and Stehrer, 2019b).

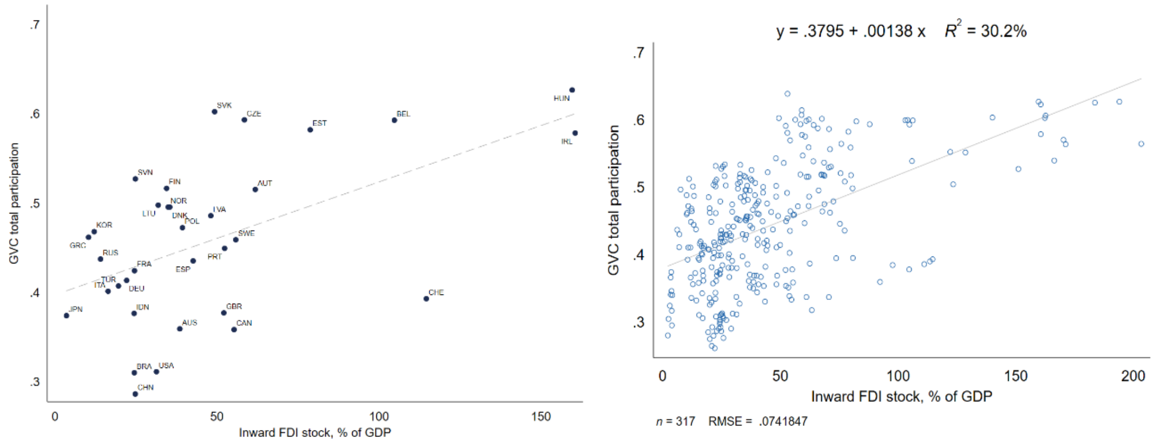
Figure 2.4.1 shows the general positive association between inward FDI and total GVC participation, as well as illustrates the extent to which the results could be biased with SPEs and outlier tax-haven countries included in the sample.

Figure 2.4.1 / Relationship between GVC participation and inward FDI adjusting for SPEs

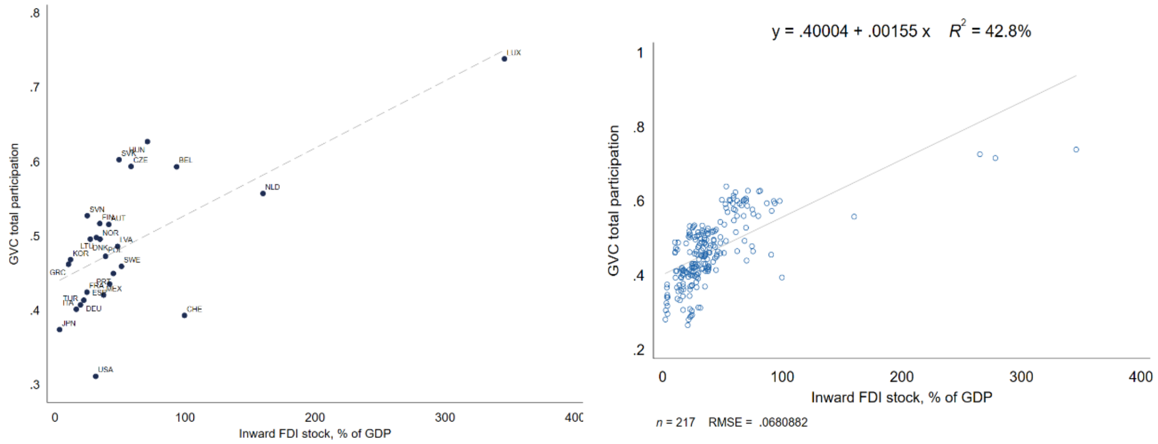
Excluding SPEs (excluding LUX and NLD)



Including SPEs (excluding LUX and NLD)



Excluding SPEs (with LUX and NLD)



Note: The left panels show the data for the year 2014. The right panels show the relationship for the panel data with the fitted linear regression line. The top panels report the data with FDI inward stocks excluding SPEs, the middle panels report the data with FDI inward stocks including SPEs (for clarity, outliers LUX and NLD are excluded in the top panels).

Following empirical literature and given the focus of our study on the role of FDI and capital as possible drivers of GVC participation, we estimate the following specification:

$$\mathrm{GVC}_{\mathrm{ct}} = \alpha + \beta \mathrm{FDI}_{\mathrm{ct-1}} + \gamma \mathrm{K}_{\mathrm{ct-1}} + \boldsymbol{\Psi}\mathbf{X}_{\mathrm{ct-1}} + \varepsilon_{\mathrm{ct}}$$

where GVC_{ct} denotes a GVC participation measure (forward, backward and total GVC participation variables used consecutively in alternative specifications); $\mathrm{FDI}_{\mathrm{ct-1}}$ is the FDI measure (alternative specifications employ inward FDI stock or outward FDI stock as a share of GDP); K_{ct-1} denotes real capital stock as a share of GDP. The FDI and capital variables thus convey the relative capital intensity of a country. In additional empirical exercises we also distinguish ICT and non-ICT capital, as well as disaggregate capital by asset types as discussed in the section above.

The vector of control variables $\boldsymbol{X}_{ct-1}$ includes a range of variables deemed to be important in the literature on GVC integration: real GDP as a measure of country size; real effective exchange rate (REER) in log differences; real GDP per capita as a general measure of a country's level of economic development; real labour productivity measured as value added per hour worked by persons engaged; share of manufacturing value added in GDP as a proxy for the overall level of industrialisation of a country; real GDP growth rate; average applied import tariff rate and institutional quality indicators (World Bank's Worldwide Governance Indicators of control of corruption, regulatory quality, government effectiveness). Some of the variables are, however, collinear (for instance, labour productivity, per-capita income and institutional quality) and are thus not included simultaneously in regressions.

We also introduce year fixed effects to control for common time-varying factors, e.g. the global or Europe-wide business cycle dynamics. In addition, we control for cross-country heterogeneity by introducing fixed effects or using time averages of continuous variables (discussed below).

As the dependent variables are bounded in the (0; 1) interval, one cannot use conventional linear panel data models. Therefore, as a baseline case we use fractional response models in line with Papke and Wooldridge (1996) and Papke and Wooldridge (2008), which develop an estimation framework based on generalised, linear-model quasi-likelihood estimators with the logit or probit link function. More specifically, as the baseline model we utilise fractional probit with standard errors clustered by country. For robustness, we also estimate fractional logit, panel fixed effects, random effects models and pooled OLS with the logistic transformation applied to the dependent variable as follows: $\mathrm{GVC}^{\mathrm{LTR}} = \ln\left[\frac{GVC}{1-GVC}\right]$.

At the same time, introducing cross-section dummy variables to control for unobserved time-invariant heterogeneity in the given model may lead to inconsistent estimates in small samples, particularly when T (time periods) is fixed and N (cross-section units) is large – the incidental parameters problem (Neyman and Scott, 1948). Therefore, in addition to fixed effects we also use the device developed by Mundlak (1978) and Chamberlain (1984) to impose some structure on the correlation between the unobserved effects and model variables, in line with the Papke and Wooldridge (2008) suggestions, also known as correlated random effects (CRE). In essence, the Mundlak-Chamberlain transformation controls for unobserved country heterogeneity by augmenting the regression with time averages of all continuous covariates for each country instead of fixed effects, while the variables are included as deviations from respective means.

Finally, in order to deal with potential endogeneity issues we lag explanatory variables by one period. In this regard, of particular concern for the hypothesis of interest is the potential (and likely) causal feedback from GVC participation to FDI variable. Therefore, for robustness, we also perform a range of additional estimations allowing for endogenous regressors via a two-stage estimation procedure in line with Wooldridge (2014), which involves regressing the FDI variable on model covariates in the first stage and augmenting the fractional probit model in the second step by first-stage residuals.

Estimations involving the baseline model (fractional probit) are reported in Table 2.4.1 for backward, forward and total GVC participation. Controlling for time-invariant country effects and thereby making use only of within-unit variation generally renders estimates for the key variables of interest (FDI and capital stock intensity) insignificant. As discussed in the methodology section, the use of country fixed effects to control for unobserved heterogeneity leads to inconsistent estimates in small samples. Yet the results from the Mundlak-Chamberlain CRE model (Table 2.4.3) also suggest insignificance of within-country variance in explaining the impact of FDI and capital dynamics on GVC participation (in this case only GDP and REER remain statistically significant). At the same time, examining time averages using estimation also allows to infer to some extent the role of within-country to between-country variation in explaining GVC participation. In fact, much of the variation in the key variables of interest (GVC participation, relative capital stock and FDI stock intensity) does not change significantly over time, and within-panel variation after removing time trend and common business cycle effects, particularly the impact of the late 2000s Great Recession, is much smaller than between-panel variation. Therefore, we focus primarily on estimation results of models that also make use of cross-country variation, for instance, reported in Table 2.4.1 (although it should be noted that these results may be driven by unobserved cross-country heterogeneity).

Table 2.4.1 / Drivers of GVC participation, country-level analysis, estimates

	Backward GVC participation		Forward GVC participation		Total GVC participation	
	(1)	(2)	(3)	(4)	(5)	(6)
Inward FDI stock, share of GDP	0.465*		0.062		0.502***	
	(0.252)		(0.181)		(0.156)	
Outward FDI stock, share of GDP		-0.017		0.255*		0.253*
		(0.205)		(0.132)		(0.144)
Real capital stock, share of GDP	0.135***	0.143***	-0.081***	-0.068***	0.066***	0.085***
	(0.024)	(0.021)	(0.024)	(0.023)	(0.019)	(0.017)
REER, log diff	0.026	0.057	-0.154	-0.092	-0.140	-0.048
	(0.104)	(0.158)	(0.113)	(0.122)	(0.101)	(0.120)
Labour productivity, log	0.175**	0.206*	-0.137**	-0.194***	0.045	0.015
	(0.082)	(0.113)	(0.055)	(0.066)	(0.048)	(0.074)
Real GDP, log	-0.058**	-0.074***	0.001	0.008	-0.045***	-0.052***
	(0.023)	(0.027)	(0.018)	(0.017)	(0.014)	(0.016)
Manuf. value added, % of GDP	0.010	0.012	0.004	0.005	0.010**	0.012*
	(0.007)	(0.009)	(0.004)	(0.003)	(0.005)	(0.006)
Constant	-0.291	0.070	0.004	-0.091	0.687**	0.946**
	(0.496)	(0.584)	(0.366)	(0.356)	(0.339)	(0.376)
Obs.	178	178	178	178	178	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-sq.	0.023	0.023	0.002	0.002	0.016	0.016

Note: The table shows the results of fractional regression estimations with probit link function. Standard errors clustered by countries are in parentheses. All explanatory variables are lagged by one period. *, **, *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

In Table 2.4.1 the results are listed for backward, forward and total GVC participation with inward and outward FDI included, along with the capital stock intensity variable. Overall, we find that inward FDI stock ratio is positively associated with backward GVC participation, while outward FDI is conducive to forward GVC participation. Both inward and outward FDI stock ratio estimates are positive and statistically significant at least at the 10% level in total GVC participation. Estimates suggest that the capital stock to GDP ratio positively affected backward and total GVC participation with high statistical significance.

Table 2.4.2 / Drivers of GVC participation, country-level analysis, predictive margins

	Backward GVC participation		Forward GVC participation		Total GVC participation	
	(1)	(2)	(3)	(4)	(5)	(6)
Inward FDI stock, share of GDP	0.157*		0.019		0.196***	
	(0.086)		(0.056)		(0.060)	
Outward FDI stock, share of GDP		-0.006		0.079*		0.099*
		(0.069)		(0.041)		(0.056)
Real capital stock, share of GDP	0.046***	0.049***	-0.025***	-0.021***	0.026***	0.033***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
REER, log diff	0.009	0.019	-0.047	-0.028	-0.055	-0.019
	(0.035)	(0.054)	(0.035)	(0.038)	(0.039)	(0.047)
Labour productivity, log	0.059**	0.070*	-0.042**	-0.060***	0.017	0.006
	(0.028)	(0.038)	(0.017)	(0.020)	(0.019)	(0.029)
Real GDP, log	-0.020**	-0.025***	0.000	0.003	-0.017***	-0.020***
	(0.008)	(0.009)	(0.005)	(0.005)	(0.005)	(0.006)
Manuf. value added, % of GDP	0.003	0.004	0.001	0.001	0.004**	0.005**
	(0.002)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)

Note: The table shows average marginal effects associated with the estimates reported in Table 2.4.1. Delta-method standard errors are in parentheses. *, **, *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

However, in the case of forward GVC participation the estimated impact is negative, although the magnitude of the effect is much smaller in comparison with the influence of capital stock on backward linkages. Additional estimations suggest that the result is driven largely by Poland and the UK, which are both characterised by a high degree of forward GVC integration and low capital-to-GDP ratios compared with the rest of the European sample, based on EU KLEMS real capital stock data.[10] In general, the results for forward GVC participation are less robust than those for backward GVC participation as regards sensitivity to the country sample composition, share of variance explained, significance and stability of estimates.

The use of probit-based models poses issues with the interpretation of the coefficients in terms of the magnitudes of the effects. Therefore, Table 2.4.2 provides the mean marginal effects computed for the respective estimates listed in Table 2.4.1. The results suggest that an increase in the inward FDI-to-GDP share by 0.1 increases backward GVC participation by about 0.016 (for reference, GVC_BWI values for most of the countries in the sample fall into the range of 0.18-0.52, and inward FDI stock as a share of GDP varies from 0.05 to 0.66). A unit-change in the capital intensity variable (the variable varies from 2.0 to 5.2 across the sample) induces an increase in backward GVC participation by about 0.05. The

[10] Re-estimating the model without Poland and the UK renders the impact of the capital-to-GDP ratio statistically insignificant.

marginal effect of outward FDI on forward linkages is weaker at 0.08, although one should note that forward GVC participation varies in a narrower range of 0.15-0.28. In the case of total GVC participation, the impact of FDI variables is slightly stronger and more statistically significant.

Table 2.4.3 / Alternative estimators, backward GVC participation.

	Frac probit	Frac logit	Mundlak CRE	2-st. endog	2-st. endog	FE	RE	POLS
	1	2	3	4	5	6	7	8
Inward FDI stock, share of GDP	0.465*	0.754*	0.016	-0.071	0.582*	0.080	0.023	0.748
	(0.252)	(0.428)	(0.158)	(0.184)	(0.350)	(0.284)	(0.230)	(0.429)
Real capital stock, share of GDP	0.135***	0.220***	-0.059	-0.048	0.143***	-0.076	0.154**	0.227***
	(0.024)	(0.041)	(0.046)	(0.047)	(0.022)	(0.088)	(0.073)	(0.044)
REER, log diff	0.026	0.062	-0.236***	-0.165***	-0.022	-0.370***	-0.534***	0.032
	(0.104)	(0.175)	(0.072)	(0.061)	(0.083)	(0.112)	(0.135)	(0.190)
Real GDP, log	-0.058**	-0.098***	-0.807***	-0.773***	-0.074***	-1.267***	-0.169***	-0.099**
	(0.023)	(0.038)	(0.171)	(0.185)	(0.023)	(0.298)	(0.049)	(0.040)
Labour productivity, log	0.175**	0.288**	0.600***	0.506***	0.196**	0.849***	0.267***	0.299*
	(0.082)	(0.138)	(0.156)	(0.168)	(0.080)	(0.220)	(0.092)	(0.145)
Manuf. value added, % of GDP	0.010	0.017	-0.011***	-0.008**	0.012*	-0.014*	0.004	0.016
	(0.007)	(0.011)	(0.004)	(0.003)	(0.007)	(0.007)	(0.015)	(0.012)
TA (Inward FDI stock, share of GDP)			0.657***					
			(0.139)					
TA (Real capital stock, share of GDP)			0.056***					
			(0.019)					
TA (REER, log diff)			11.784***					
			(1.528)					
TA (Real GDP, log)			-0.065***					
			(0.008)					
TA (Labour productivity, log)			0.227***					
			(0.024)					
TA (Manuf. value added, % of GDP)			0.006***					
			(0.002)					
Constant	-0.291	-0.396	-0.053	18.511***	0.098	30.762***	2.166	-0.453
	(0.496)	(0.830)	(0.205)	(4.568)	(0.507)	(7.581)	(1.361)	(0.861)
Obs.	178	178	178	166	166	178	178	178
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	Yes	No	Yes	No	No

Note: The table shows results from the fractional probit (baseline), fractional logit, Mundlak-Chamberlain correlated random effects, two-stage endogenous regressor models with and without country fixed effects, panel fixed effects, random effects and pooled OLS (the latter three models employ a logistically transformed GVC variable). In model 3: TA indicates panel time averages, variables enter the model as deviations from the respective panel means. Standard errors clustered by country are in parentheses. All explanatory variables are lagged by one period. *, **, *** indicate statistical significance at 10%, 5% and 1% levels, respectively.

The results imply that, at least in the case of backward and total GVC participation, domestic capital could work as a substitute for inward FDI at least in promoting downstream integration, particularly given that introducing an interaction term between FDI and capital intensity yields a statistically significant negative estimate.

We then examine the implications of capital structure for GVC participation. Similar to the previous empirical exercises, we estimate separate models for backward, forward and total GVC participation (based on gross exports) iterating between inward and outward FDI intensity variables (FDI stock as a share of GDP). The conditional marginal effects resulting from these estimations are summarised in Table 2.4.4. In the table, the estimations involving inward FDI are denoted as model I and those involving outward FDI are denoted as model II. As can be seen, while the results are mostly consistent across the two models, specifications with outward FDI tend to yield greater statistical significance and higher magnitudes for the capital asset type variables.

Table 2.4.4 / Impact of capital stock by asset types on GVC, country-level results (marginal effects)

Capital asset type	Code	Backward GVC participation		Forward GVC participation		Total GVC participation	
		(I)	(II)	(I)	(II)	(I)	(II)
Total non-residential investment	Ocon	0.046**	0.085***	-0.004	-0.013	0.046***	0.076***
Residential structures	RStruc	0.074**	0.061	-0.068***	-0.068***	0.012	-0.003
Transport equipment	TraEq	0.073	-0.010	-0.136	-0.132	-0.031	-0.118
Other machinery and equipment	OMach	0.171*	0.237**	0.074	0.054	0.249***	0.292***
Computing equipment	IT	2.473**	3.231***	-1.324*	-1.258*	1.264	2.068*
Communications equipment	CT	-0.052	0.362	-0.035	-0.016	-0.098	0.337
Computer software and databases	Soft_DB	0.669	1.753**	0.017	-0.077	0.660	1.618**
Research and development	RD	0.337	0.659***	-0.115	-0.132	0.206	0.471***
Cultivated assets	Cult	-0.404	-0.059	-0.262	-0.314	-0.781	-0.446
Other IPP assets	OIPP	-2.080**	-2.234***	0.652	0.696	-1.243***	-1.289**

Note: The table shows average marginal effects of real capital stock (taken as a share of GDP) by asset types in line with the EU KLEMS classification on GVC participation variables. *, **, *** indicate statistical significance at 10%, 5% and 1% levels, respectively. Columns (I) and (II) indicate alternative fractional probit models associated with the estimates: (I) includes inward FDI and (II) includes outward FDI stock as a share of GDP, in addition to other control variables (GDP, REER and year fixed effects are used in the baseline).

The most prominent result from the aggregate estimations is revealed for computing equipment, which yields estimates that are both statistically and economically significant – in fact, they are considerably higher than the effects for any other capital asset category. In particular, an increase in computing capital stock intensity by 10 pp boosts *backward* GVC participation by at least 0.25, ceteris paribus (for reference, GVC_BWI measure varies between 0.17 and 0.52 for the European sample of countries, excluding tax havens). In contrast, the impact of computing capital in the case of *forward* GVC participation is negative, albeit only marginally statistically significant. The impact of other machinery and equipment capital, oMach, is also significant and manifests itself both in backward GVC and total GVC participation measures. The estimates for capital embodied in residential and non-residential structures turn out significant statistically, but the magnitudes of the economic effect is minuscule.

Complementing the evidence from the aggregate country-level analysis, we also run estimations for individual sectors. The detailed discussion is available in Adarov and Stehrer (2019b). Here we provide a summary of the key results:

› The textile/clothing sector exhibits a particularly strong across-the-board response to FDI and capital formation in terms of both upstream and downstream integration.

› Outward FDI facilitates forward GVC participation in high-tech manufacturing sectors – machinery, transport and (especially) electrical equipment.

- A significant positive impact of inward FDI on backward GVC participation is found in the textile and clothing, agricultural and chemicals sectors. Sizeable marginal effects of inward FDI on backward GVC linkages in the high-tech manufacturing are not statistically significant.
- Capital intensity facilitates backward GVC participation. ICT capital is positively associated with backward GVC participation, especially for the electrical, transport equipment and chemicals sectors. ICT capital appears to negatively impact forward GVC participation of the textile and clothing industry.

In summary, the analysis reveals that inward FDI is especially conducive to the formation of backward linkages, while outward FDI facilitates forward GVC participation, especially in high-tech manufacturing sectors. A particularly robust influence of FDI and capital accumulation on GVC integration is identified in the textile and clothing industry. While capital accumulation in general intensifies GVC linkages for most sectors, ICT capital appears to be especially instrumental for backward integration of the electrical and transport equipment sectors.

3. Barriers to efficient capital allocation

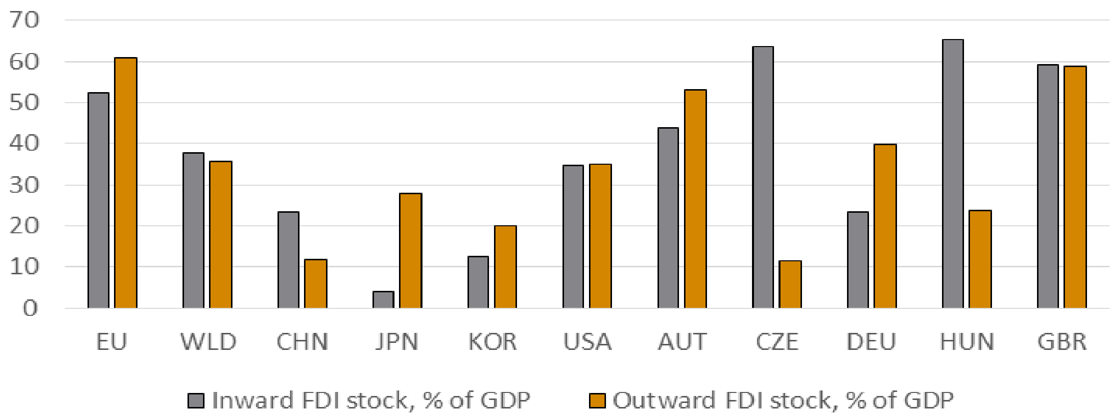
Given the empirical results suggesting the importance of FDI and ICT capital, we next examine the possible bottlenecks that could be behind the productivity challenges distinguishing (i) cross-border investment flows and (ii) capital accumulation with a focus on tangible and intangible ICT capital. As a first step we examine the recent and long-run trends in FDI, capital accumulation and its composition, taking a comparative perspective.

3.1. TRENDS IN FDI AND CAPITAL ACCUMULATION

As discussed in the data section, our analysis employs the FDI data compiled using the Eurostat and OECD datasets netting out investment associated with SPEs. We also exclude countries that are commonly acknowledged by experts as “tax havens”. This allows us to focus on the real economic implications pertinent to FDI conveying a lasting interest by an investor in one economy in an enterprise located in another economy.

Figure 3.1.1 shows the dynamics of FDI for the EU in comparison with the global FDI intensity and selected economies. The EU is characterised by a much higher FDI intensity relative to its peer economies – the US, China, Japan and South Korea in terms of both inward and outward FDI-to-GDP ratios. Despite a decline in the volume of FDI in the EU relative to 2017 (inward FDI stock decreased by 0.2% and outward FDI stock by 5.3%), FDI intensity in 2018 is high at 54.8% of GDP for inward FDI stock and 60.3% of GDP in the case of outward FDI stock. Overall, the post-crisis period has been characterised by a decline in FDI inflows for European countries (Figure 3.1.2).

Figure 3.1.1 / Inward and outward FDI stocks, 2014-2018 average

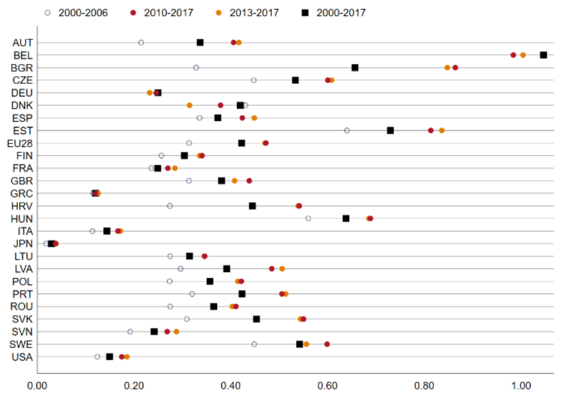


Note: The figure shows the 2014-2018 average for inward and outward FDI stocks as a percentage of GDP for the EU, the world economy (WLD) and selected economies. 2014-2017 average for South Korea.
Source: Computations based on OECD FDI database, 2019.

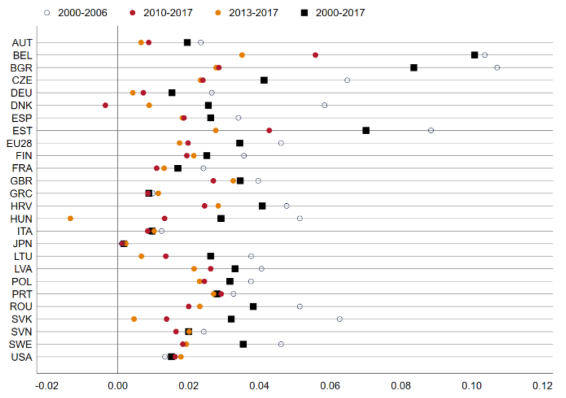
While aggregate capital intensities vary significantly across European countries (Figure 3.1.2), in terms of the absolute levels of real capital stock and capital-to-labour ratios, European countries generally lag behind their peers (e.g. the US and Japan).

Figure 3.1.2 / FDI and capital accumulation before and after the Great Recession

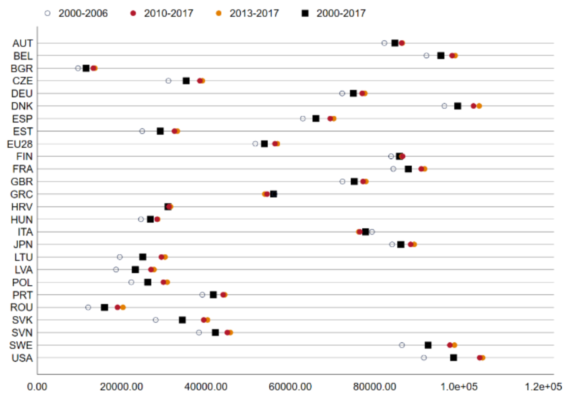
Inward FDI stock, share of GDP (ex. tax havens)



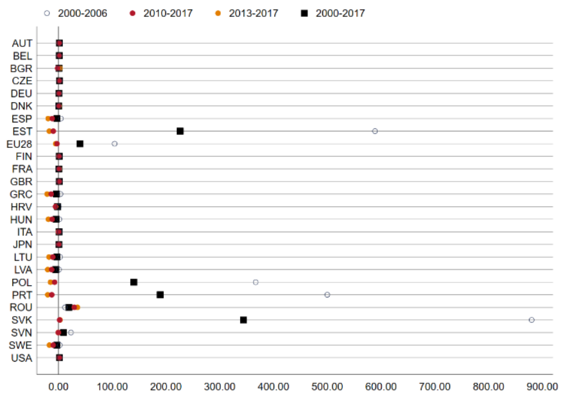
FDI inflow, share of GDP (ex. tax havens)



Real capital stock, share of employed



Real capital stock, year-on-year growth



Note: The figure shows inward FDI stocks and flows, real capital stock growth and real capital-to-labour ratios. 2000-2017 averages along with the pre-crisis and post-crisis period averages (with and without the double-dip recession period). Countries are sorted by ISO3 in alphabetic order.
Source: own computations based on Eurostat, OECD and EU KLEMS 2019 data.

Of equal importance is the composition of capital stocks, in particular the share of ICT capital and intangible assets, which have recently been seen as important new factors of economic growth and productivity. In Figures 3.1.3 and 3.1.4 we outline the share of individual capital asset aggregates in total capital stocks and intensities with respect to the labour employed and also examine the changes between the pre- and post-crisis periods (for the countries for which the detailed capital asset composition is available in the EU KLEMS 2019). Most of the capital stock value (about 90%) is attributed non-ICT capital. In this regard Japan stands out from the rest of the sample with a smaller share of non-ICT capital and particularly high shares of ICT, SoftDB and RD capital in the total capital stock; however, as a share of employed, these capital asset aggregates are in line with other countries. European countries exhibit significant heterogeneity in terms of capital composition. While no significant changes are observed in the shares of tangible and intangible ICT capital in total capital stocks (there is a marginal increase in the share of SoftDB along with a slight decrease in the share of tangible ICT in total capital stock), their per-employed intensities have increased notably, despite the decline in the real capital stock growth (Figure 3.1.5). Among the European countries, Austria, Sweden and Denmark appear to be the leaders at the digital capital frontier as measured by the importance of ICT and SoftDB relative to both total capital stock and the persons employed (also France for SoftDB, but not tangible ICT).

Figure 3.1.3 / Composition of capital stocks by asset groups

Note: The figure shows the share of an asset group in the total capital stock, averages over the period 2000-2006 and 2010-2016. Countries are listed by ISO3 in alphabetic order.
Source: Own computations based on EU KLEMS 2019.

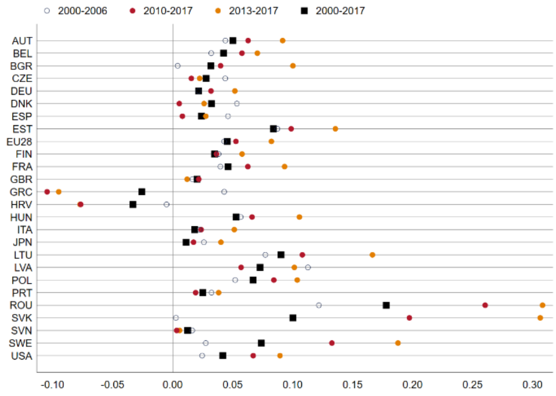
Figure 3.1.4 / Capital stocks per person employed by asset groups, USD million

Note: the figure shows real capital stock per person employed (in USD million) by asset group; averages over the period 2000-2006 and 2010-2017. Countries are listed by ISO3 in alphabetic order.
Source: Own computations based on EU KLEMS 2019 data.

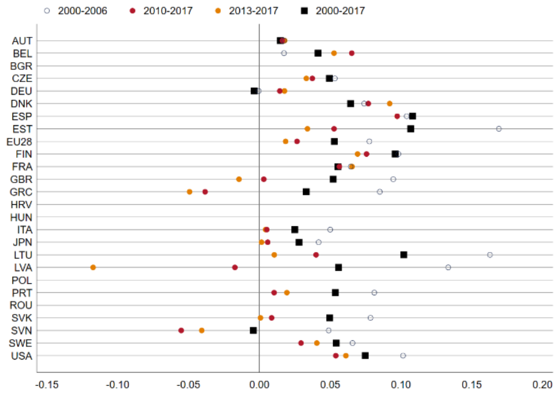
As a rough assessment of the relationship between capital structure and labour productivity, Figure 3.1.6 shows the scatterplots based on the full panel data (country aggregates). Although for all capital assets the relationship appears to be positive, it is clear that at least to some extent the results are clearly influenced by outlier points, which prompts a careful control for outliers in addition to controlling for other factors influencing productivity via a robust econometric analysis – discussed in the next section.

Figure 3.1.5 / Capital dynamics by broad asset groups (real capital stocks in log-differences)

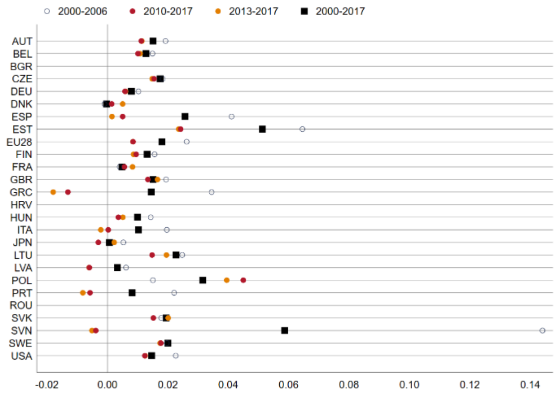
EconComp



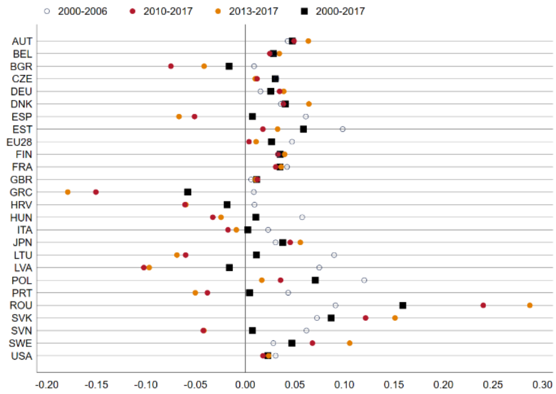
ICT



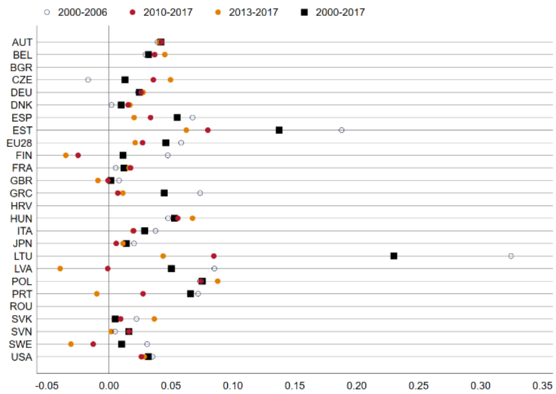
NonICT



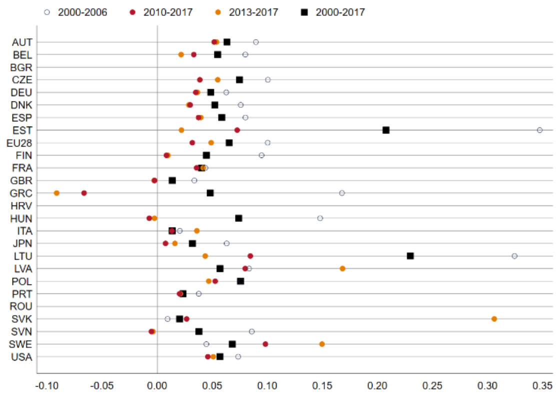
OInnProp



RD

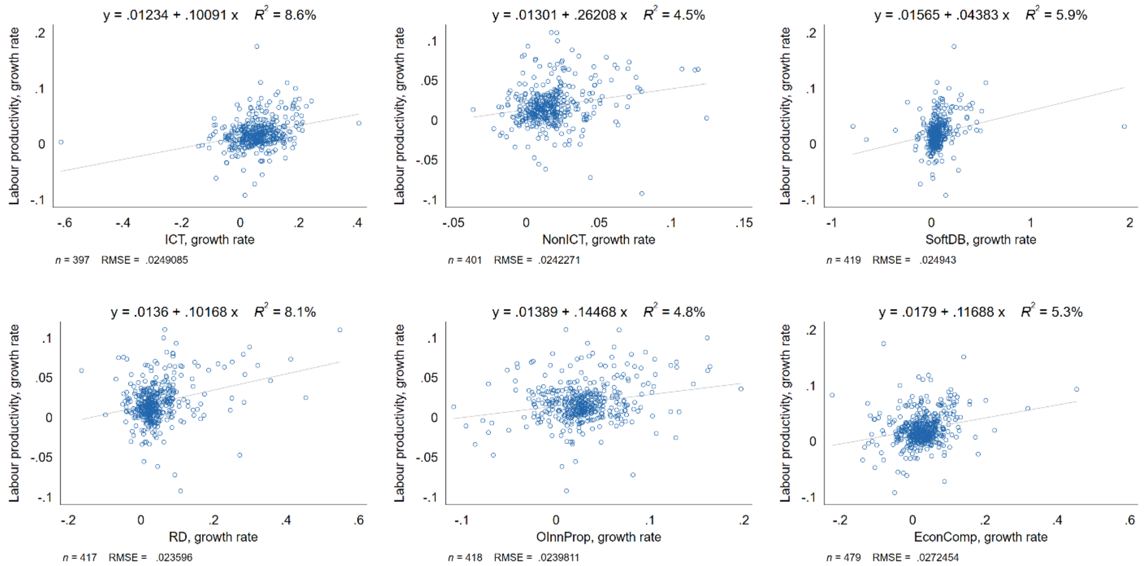


SoftDB



Source: Own computations based on EU KLEMS 2019 data.

Figure 3.1.6 / Scatterplots: labour productivity growth vs growth of capital asset aggregates



Source: Own elaboration based on EU KLEMS 2019 data.

3.2. BARRIERS TO FDI

The focus of our analysis is FDI that is targeted at real economic activity rather than at capital flows associated with holding activities, transfer pricing and tax minimisation activities. The literature on the drivers of FDI is quite extensive. As regards the factors that facilitate inward FDI, a range of host country-specific characteristics related to the cost of production, proximity to large markets, as well as other macroeconomic and regulatory factors has been consistently identified in the literature.

Among the most widely known frameworks of FDI is the OLI-framework by Dunning (1993), which recognises three types of advantages that attract FDI: ownership (firm-specific advantages of the investing firm like technological superiority, marketing and promotion), location (country characteristics that make it attractive for FDI) and internalisation advantages (the benefits of production by the company itself, rather than outsourcing to another firm). Testing the significance of the specific factors empirically, such factors as geographical proximity, a common language, economic openness, quality of institutions and infrastructure have been commonly identified as relevant for FDI (see Shatz and Venables, 2000; Antonakakis and Tondl, 2012; Campos and Kinoshita, 2008; Bénassy-Quéré et al., 2007). The cost of production in the host economy, access to natural resources, the cost of labour, human capital, access to technology, quality of infrastructure, regulatory quality and strong institutions, tax burden, trade openness and macroeconomic stability are also identified as relevant factors. Furthermore, the importance of FDI-specific regulatory restrictions is reported in Mistura and Roulet (2019), Fournier (2015), Ghosh et al. (2012) and Nicoletti et al. (2006).

It is clear that in the context of the EU, both market-seeking and efficiency-seeking motives of FDI are relevant, as the EU constitutes the largest market in the world. Significant socio-economic heterogeneity of the EU countries allows for diverse specialisation patterns in different sectors and tasks along global and regional value chains owing to country-specific competitive advantages. The general “framework” conditions related to business-cycle dynamics and long-run structural characteristics (quality of institutions, infrastructure, human capital and other factors directly related to economic competitiveness) are of critical importance in facilitating FDI inflows. These factors shape the investment environment in general and are discussed in more detail in the next section, which focuses on impediments to ICT investments.

In addition to the general macroeconomic conditions, regulatory frameworks targeting cross-border capital flows affect the ability of a country to attract FDI. The OECD FDI Regulatory Restrictiveness Index quantifies the extent to which countries impose barriers to FDI. The index measures statutory restrictions on foreign direct investment across 22 economic sectors. The discriminatory nature of measures, i.e. when they apply to foreign investors only, is used as the central criterion for scoring. Four types of restrictiveness measures are reported on a 0 (open) to 1 (closed) scale, including:

I) Foreign equity limitations

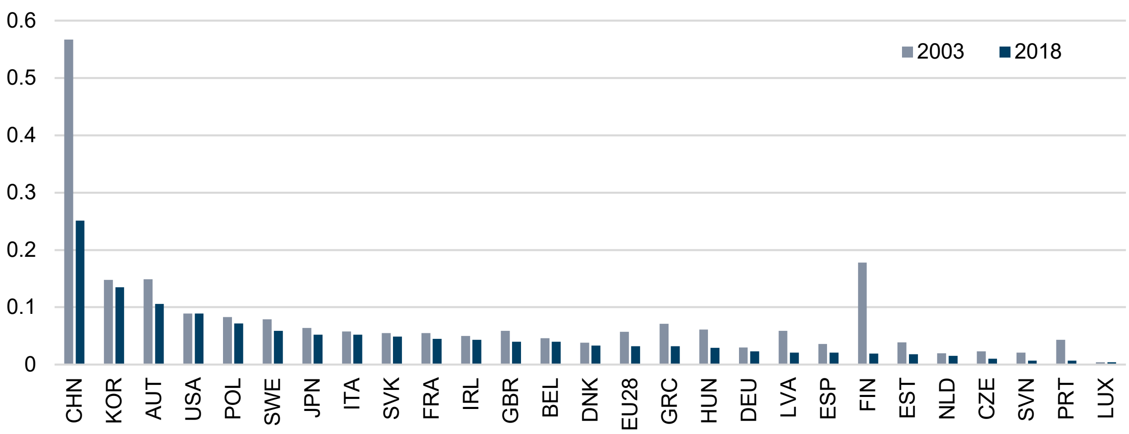
II) Discriminatory screening or approval mechanisms;

III) Restrictions on the employment of foreigners as key personnel;

IV) Other operational restrictions, e.g. restrictions on branching and on capital repatriation or on land ownership by foreign-owned enterprises.

The overall FDI restrictiveness index is then computed as an average of the sectoral scores. Figure 3.2.1 shows the aggregate FDI Restrictiveness Index for the EU countries and selected peer economies. As can be seen, the EU is characterised by a rather open investment regime relative to its peers. Over the period 2003-2017 the EU average FDI restrictiveness index has also declined by about half. At the same time, there is significant heterogeneity across European countries. Within the EU, as of 2017, Austria is reported to have the most restrictive FDI regime, while the lowest level is observed in Luxembourg, where virtually no obstacles to foreign investors are reported. Most EU countries also have a much lower degree of regulatory obstacles to FDI compared with the US, Japan and China, with the latter having an especially high level of FDI restrictions.

Figure 3.2.1 / OECD FDI Regulatory Restrictiveness Index

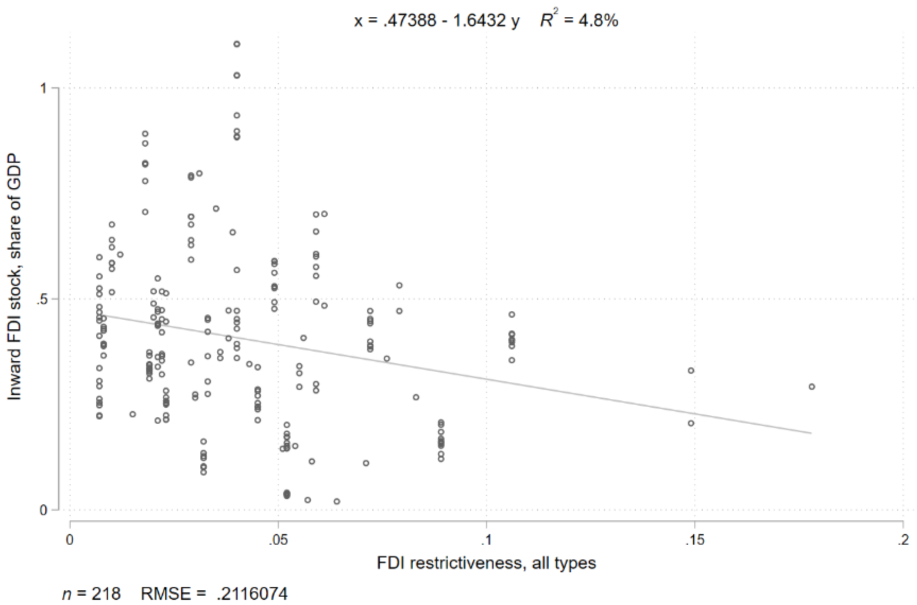


Source: OECD, own calculations.

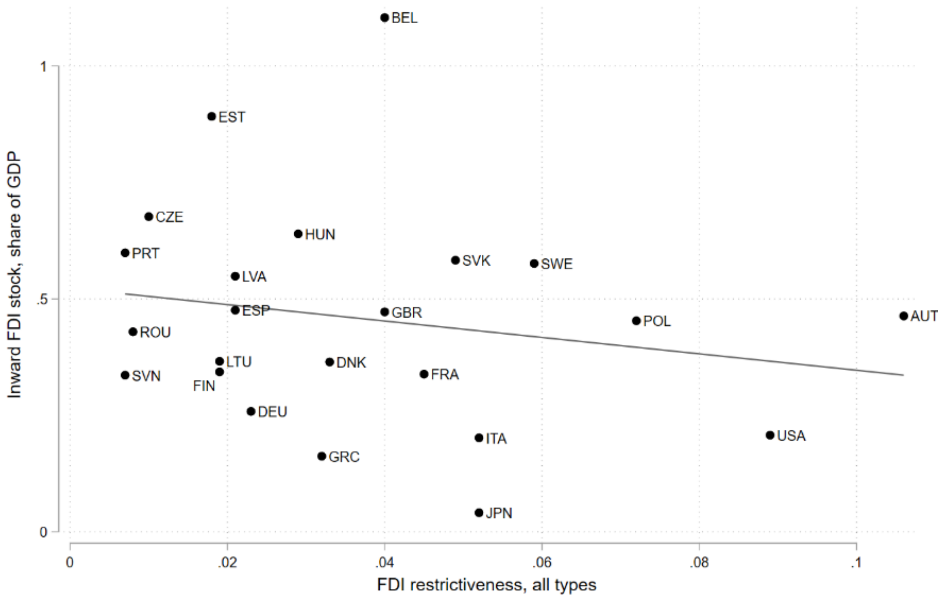
As can be seen from Figure 3.2.2, FDI regulatory restrictions appear to have a strong negative effect on FDI inflows. Looking at the specific components of the FDI Restrictiveness Index (Figure 3.2.3), the regulatory measures are mostly associated with equity restrictions. Other types of restrictions are sizeable only in some countries in the sample (China, Sweden, Japan, Belgium and Croatia).

Figure 3.2.2 / FDI restrictiveness vs inward FDI

Panel A. Panel data

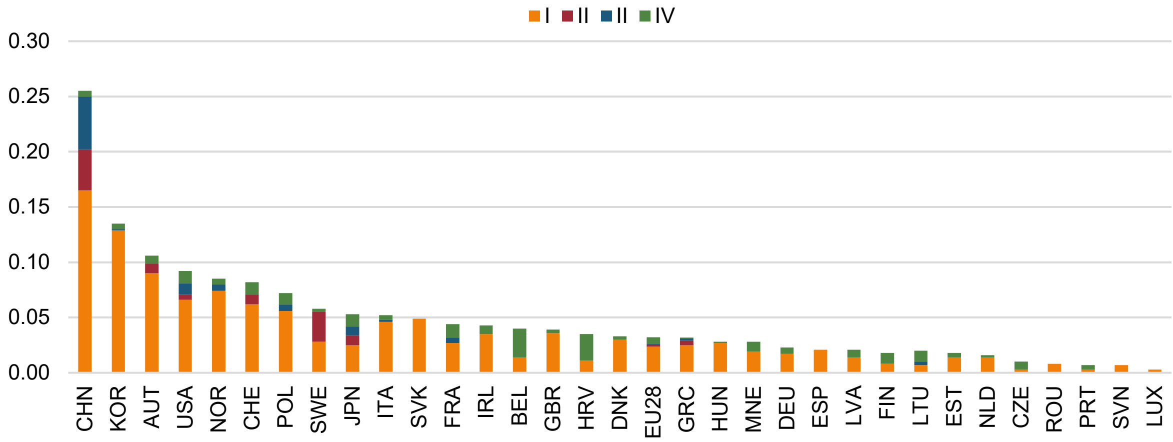


Panel B. 2017



Source: Own calculations.

Figure 3.2.3 / FDI regulatory restrictiveness by components, 2018



Note: The legend specifies the following: (I) Foreign equity limitations; (II) Discriminatory screening or approval mechanisms; (III) Restrictions on the employment of foreigners as key personnel; (IV) Other operational restrictions on FDI.
Source: OECD.

While the importance of a robust macroeconomic framework, strong institutions and a solid infrastructure are obvious, the need for statutory restrictions on FDI in the EU is a more complicated case. On the one hand, restrictions on inward FDI hinder the benefits the host country receives from FDI in the form of additional capital, technology spillovers, development of global value chains and job creation. On the other hand, there are concerns being voiced over heightened vulnerabilities to external shocks and foreign control over strategic European assets that may come with greater inward FDI.[11] The latter has become a notable source of anxiety for EU policymakers in recent years, particularly with regard to the acquisition of EU assets by Chinese companies. This has led to the development of policy proposals seeking to introduce screening of FDI in “strategic” sectors. In particular, the initiative on the screening of FDI into the EU was presented by the European Commission on 13 September 2017 and officially entered into force on 10 April 2019.[12] The initiative seeks to empower EU member states to screen FDI from non-EU countries on the grounds of security or public order and to impose mitigating measures or prevent a foreign investor from acquiring or taking control of a company.

As the EU is on average relatively open to FDI, according to the FDI Regulatory Restrictiveness Index, and has been a significant recipient of FDI, these measures, although distortionary and protectionist, are justified if applied pragmatically only to the sectors that are indeed sensitive from a national security perspective (including ICT sectors, national defence, public infrastructure) rather than exploited to provide an unfair advantage to domestic companies over foreign competitors.

[11] See also European Parliament (2017) for an overview of related issues and FDI screening mechanisms.

[12] See the related documents on https://ec.europa.eu/commission/presscorner/detail/en/IP_19_2088

3.3. BARRIERS TO ICT CAPITAL ACCUMULATION

In light of our empirical results reported earlier, suggesting that ICT capital (and especially intangible ICT) is an important productivity driver, we next discuss the barriers to capital accumulation with a focus on ICT capital in the EU context. As has already been noted in Section 3.1, the meagre productivity growth in the EU in the post-crisis period relative to past historical trends and in comparison with peer economies is related to a lack of investment in ICT capital. The insufficient ICT investment in the EU is a rather complex issue in light of the high socio-economic heterogeneity of the EU and a multitude of factors that influence the efficiency of ICT capital allocation. The variety of these factors could be roughly grouped in three broad categories:

(i) "Framework conditions" that are related to the overall macroeconomic stance of a country and broad socio-economic conditions that inhibit investments in general (including FDI), which include the business cycle dynamics and long-run structural bottlenecks hindering investment in general, e.g. the gaps in institutions and infrastructure.

(ii) ICT investment-specific supply and demand factors that impact the ability or incentives of the private sector to engage in ICT investment and impact the efficiency of ICT; these include access to finance, labour market inefficiencies and other factors complementary to ICT use.

(iii) ICT-specific regulatory bottlenecks, including regulations that inhibit competition, lack of regulatory incentives, and financial and technical support to companies investing in ICT.

Besides this, these impediments can also be considered from another perspective. As noted, the EU is highly asymmetric in terms of the economic development of its member states and has a core-periphery structure with the frontier economies significantly outperforming the developing countries in terms of economic development, competitiveness, productivity and ICT capital growth. Therefore, these issues are related to (A) the slowing performance of the frontier EU economies (Germany and other advanced EU economies as described in Sections 2.2 and 3.1), and (B) the lack of convergence towards the frontier EU economies by the periphery EU countries, which have historically been lagging behind in terms of competitiveness and productivity.

These factors, however, are intertwined and in many cases mutually reinforcing, and thus the relative importance of each one for specific countries is difficult to discern. Below we discuss the most important factors from the EU perspective.

Macroeconomic environment

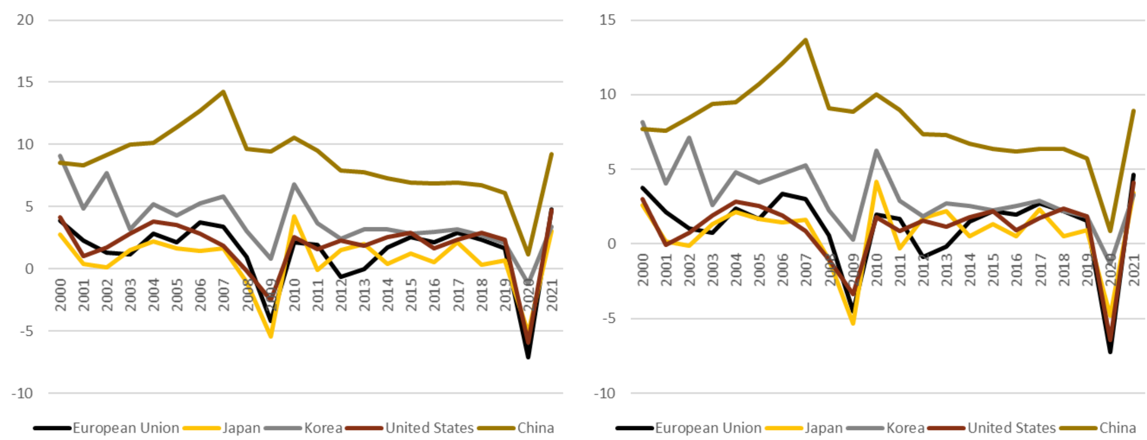
Among the key bottlenecks inhibiting broad-based technological diffusion and the resulting productivity gains is the complex interplay between such factors as infrastructure gaps, low business dynamism, overregulation in some sectors and countries, the challenges in the regulatory and real convergence of the periphery EU countries towards the frontier economies, and other impediments for the efficient allocation of capital and labour, along with the lack of absorptive capacity by the "follower" firms unable to take advantage of ICT investments, digitalisation and technological advances made by the "leader" firms in the same industry.

These lasting structural issues have been further aggravated by the recent crisis, and in particular the much deeper adverse impact of the global financial crisis and the subsequent recession on Europe in comparison with the US. While the latter has recovered relatively quickly, the EU has suffered a much more prolonged crisis – in fact, a double-dip recession followed by continued stagnant economic growth (see Figure 3.3.1). This has resulted in the EU economy suffering greater damage via the hysteresis effects and the lasting losses of production capacity (i.e., the decline in potential GDP rather than the transitory business cycle shock associated with a “normal” V-shaped economic crisis). The crisis gave rise to the political and institutional challenges the EU has been facing, with new challenges posed by the rise of anti-integration sentiment, including Brexit, and the resulting uncertainties reflecting negatively on forward-looking investment sentiment.

Investment is rather sensitive to business-cycle fluctuations, and in this respect the macroeconomic conditions in the EU have been significantly less advantageous in the recent decade as a result of the double-dip recession and a lasting lower real GDP growth trend relative to the pre-crisis period. Over the period 2010-2019 in terms of real economic growth the EU performed worse relative to its peer economies (except for Japan): average real GDP growth in the EU was 1.67%, compared with 2.29% in the US, 3.29% in South Korea and 7.66% in China. Looking ahead, the expected deep downturn as a result of the COVID-19 disease will be a major factor hindering investment in general.[13]

Figure 3.3.1 / Real economic growth in the EU relative to peer economies

Real GDP growth, % | **Real GDP per capita growth, PPP-adjusted, %**



Source: IMF WEO April 2020.

Intra-EU heterogeneity and real convergence challenges

As regards the general background framework conditions, as already noted, the EU is highly heterogeneous, with a handful of advanced economies that are close to the global productivity frontier countries (Germany and other advanced countries) and a large number of countries that are on the periphery and experience difficulties with catch-up growth and convergence. The latter include the developing/transition economies as well as advanced economies that encountered macroeconomic challenges over the past decade (Italy, Greece). Among others, the EU countries differ significantly in

[13] See also European Commission (2020a) for an outlook of growth and investment prospects in the EU context.

terms of economic development levels, the quality of infrastructure, institutions and other dimensions, which together result in differing levels of competitiveness across the EU. The countries that lag behind slow down the progress in ICT investment and utilisation of the EU in general, prompting additional policy action to facilitate real economic convergence and internal cohesion.[14]

As a related problem, the fragmentation of the EU markets still remains a factor that inhibits a more effective ICT capital allocation in the EU in comparison with its peers, e.g. the US. Despite deep integration already achieved by the EU, a single market in terms of the so-called four freedoms, implying free movement of goods, services, capital and labour, is still a "work in progress" and bottlenecks remain. This is also related to achieving a single market and arriving at a common effective regulatory framework in ICT-relevant areas (e.g. data privacy, cybersecurity). Related issues contributing to the de facto fragmentation of the EU market are the lack of harmonisation of national standards in the areas not covered by the common EU frameworks (e.g. national technical requirements and standards, tax systems, commercial dispute resolution frameworks), informal barriers to market entry created by incumbents, cross-country language differences hindering ICT use and maintenance, "home bias" in the goods and services and labour markets, and other factors.[15]

The intra-EU heterogeneity in terms of structural background conditions has led to strong specialisation trends across the EU countries. These trends, for instance, are evidenced by the specialisation patterns in certain sectors within the global value chain networks of EU countries (see Figures A.2 and A.3 in the Appendix for the sectoral specialisation patterns as regards backward and forward global value chain participation). A case in point is the European automotive cluster involving the cross-border production sharing of the German automobile industry in Central European countries, which strongly influences their production as well as foreign trade and the labour market.[16] As countries become locked into certain parts of global and regional value chains, the deepening economic specialisation in these sectors and tasks determines also the demand for capital inputs, including, inter alia, ICT capital. This implies that some countries find themselves in a relatively disadvantaged position, specialising in low value-added activities and, as one of the externalities, demanding less ICT capital (see also Section 3.1 for a review of the relative ICT capital intensity by sectors). While these sectoral specialisation patterns may be optimal for the EU as a whole, for individual countries this outcome may not be desirable, and certainly not every country in the EU will be able to specialise in knowledge-based industries that are heavy on ICT capital use. Economic openness and deeper integration may magnify these cross-country differences. (For a broader perspective on the inequality and development risks associated with the geographical localisation of value-added activities, e.g. specialisation of low-income countries in commodities and low value-added tasks and goods, see, for instance, UNCTAD, 2019.)

Complementary factors of ICT capital accumulation: financial markets

As noted above, the protracted economic crisis was accompanied by a major investment slowdown in the EU and, as a result, unsatisfactory capital deepening across all European economies. The decline in the credit supply on account of the crisis was also aggravated by less efficient financial markets in comparison to the US, in particular by the "bank bias" in Europe (the dominance of the banking sector in

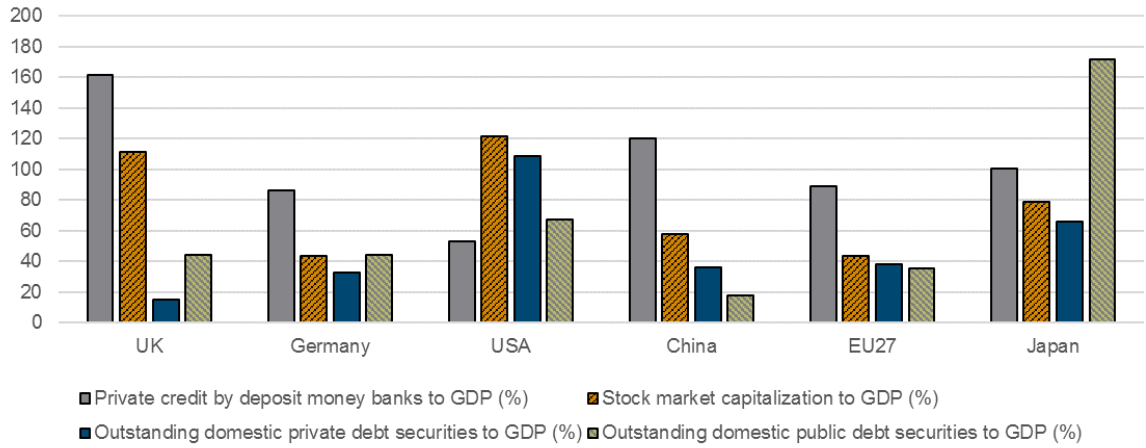
14 See also Bachtler et al, 2017 or Darvas et al, 2019 for a recent review of European cohesion policies and challenges.

15 See also European Commission (2020) for a recent review of barriers to the Single Market as of March 2020.

16 For additional discussion of GVC participation patterns and implications see Adarov and Stehrer, 2019b, 2020. See also Landesmann and Stoellinger (2020) for a policy brief on related industrial policy issues in the EU.

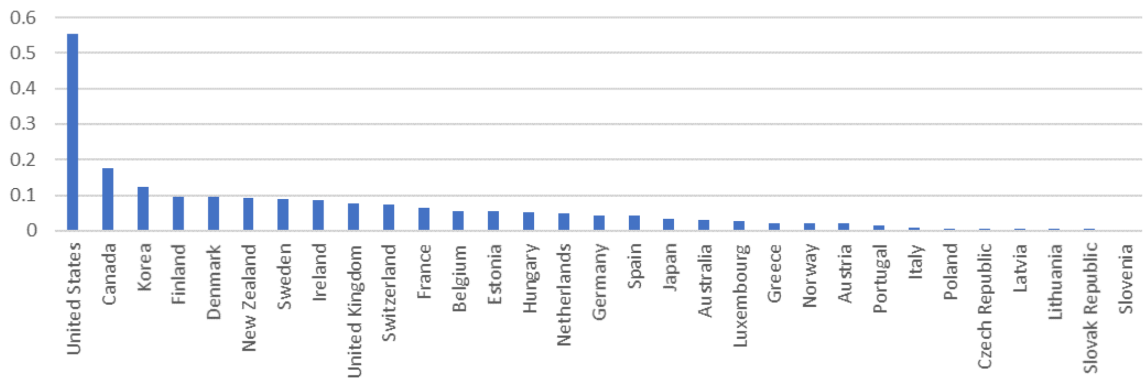
financial intermediation, while the capital markets remain less developed – see Figure 3.3.2 for a comparative review of the composition of financial markets). Lack of diversified financial resources and shallow capital markets have been an impediment to boosting investments in the EU in general.

Figure 3.3.2 / Composition of financial markets, 2007-2017 average



Source: Own calculations based on the World Bank's Global Financial Development Database.

Figure 3.3.3 / Venture capital investments, % of GDP, 2018



Note: Japan and Canada – 2017 data.
Source: OECD.

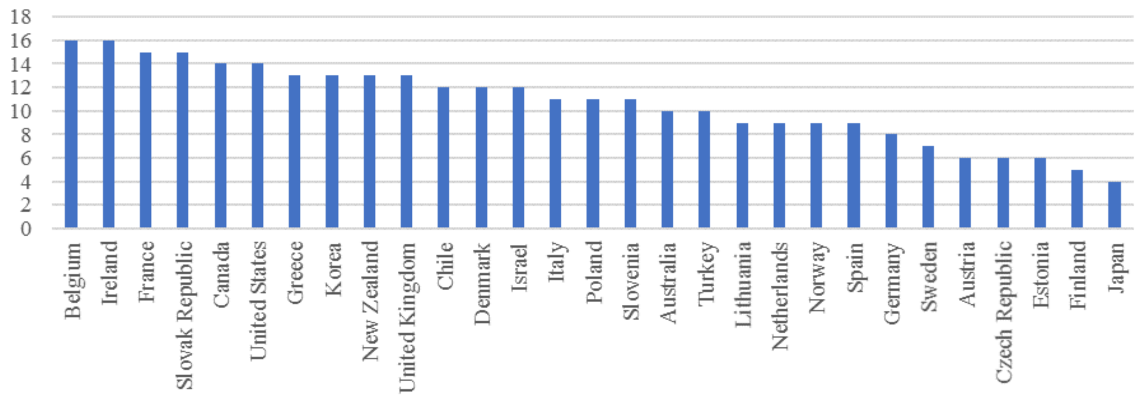
Moreover, industries that heavily exploit ICT capital, and particularly knowledge-based sectors engaging in extensive innovations, face an additional constraint in the form of the inherently higher risks and uncertainty of their investments, as innovative activity is naturally prone to higher risks with uncertain returns and possibly longer break-even points. In this respect banks may not always be willing to finance such projects because of their higher investment project risk profiles and lack of collateral, and alternative ways of raising funds are needed. The bank bias in Europe may therefore hinder access to finance for more risky projects that are intensive in ICT capital. The importance of access to finance, particularly in the context of intangible capital, is outlined, for instance, in Montresor and Vezzani (2014) and OECD (2017). These articles also suggest the development of alternative sources of finance as a viable solution to the problem: venture capital, crowd-funding and public-private co-financing such as provided in the European Fund for Strategic Investment (EFSI).

Such alternative funding mechanisms are particularly important for innovative start-ups intensive in ICT capital. Among the essential factors for such start-ups, besides a research base to foster idea generation, entrepreneurial talent and a technically skilled labour force, is the availability of initial venture capital. As Figure 3.3.3 indicates, EU countries, including frontier EU economies, severely lag behind the US in venture capital investments. Other sources of funding for such companies, such as crowdfunding, are also limited in the EU in comparison with the US.[17]

Complementary factors of ICT capital accumulation: labour markets

Effective ICT capital utilisation is conditional upon complementary factors that are taken into account by firms when planning ICT investments. Among the most important factors for ICT is complementary labour, which is needed to make use of ICT capital and enable economic value creation. Human capital and workplace organisation are shown to be important for ICT, as discussed, for instance, in Black and Lynch, 2004; Bresnahan et al., 2002; Bugamelli and Pagano, 2004. There is evidence to suggest that skills mismatch could be another relevant bottleneck for effective ICT absorption (OECD, 2015, 2018; Andrews et al. 2018).

Figure 3.3.4 / Share of population with tertiary education in the science, mathematics and computing area



Note: Based on surveys with reference years 2012-2015.
Source: OECD Educational attainment and labour market outcomes by skills.

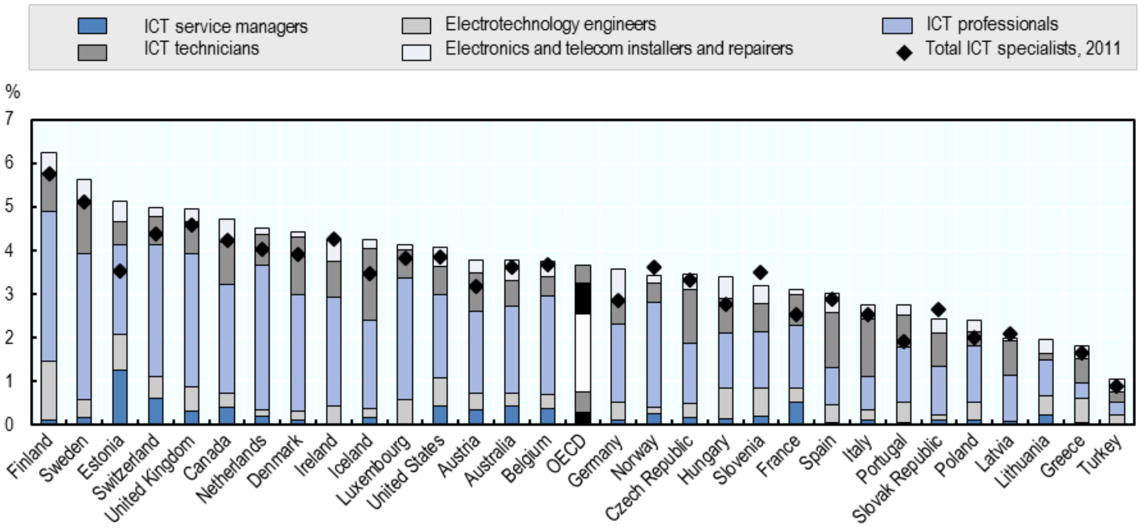
Extending these arguments further, the issue can be broken down along several interrelated dimensions: the training of ICT specialists, the demand for ICT specialists (supply of relevant ICT jobs) and labour market inefficiencies that hinder the effective allocation of workers in the EU. As regards the former, the system of higher education in the EU is in general of a very high standard, resulting in an adequate supply of ICT specialists, although, when looking at the share of the population with training in

17 The issues with the underdeveloped crowdfunding market in the EU relative to major peer economies is recognised by the European Commission and there a number of initiatives developed to address the related bottlenecks: see the dedicated portal by the European Commission at https://ec.europa.eu/info/business-economy-euro/growth-and-investment/financing-investment/crowdfunding_en

ICT-related areas, most of the EU countries are lagging behind the US (Figure 3.3.4). At the same time Belgium, Ireland, France and Slovakia are ranked more highly, with the share of the population with a tertiary education in areas such as science, mathematics and computing exceeding 14%. Similarly, when looking at the share of ICT graduates in the total number of graduates (Appendix Table A2), one may notice a significant heterogeneity across the EU, as countries like Germany and Finland are on par with the US, while others (Italy, Portugal) lag significantly behind. In the EU context, however, this appears to be a minor issue, as the labour market is sufficiently well integrated and skilled ICT labour generally does not face obstacles in finding jobs across the EU.

Apparently, there is high heterogeneity across countries in Europe, and the lack of ICT skills and inadequate matching of workers to relevant ICT jobs as a factor for a less than optimal technology adoption – and as a result insufficient ICT investment – differs across the EU. In general, developing EU countries tend to employ fewer ICT specialists (see Figure 3.3.5) than countries such as Finland and Sweden. These patterns, however, are also influenced by the specialisation patterns of countries in sectors with varying levels of needed ICT intensity, as noted previously.

Figure 3.3.5 / Employment of ICT specialists across the economy, 2016, % of total employment

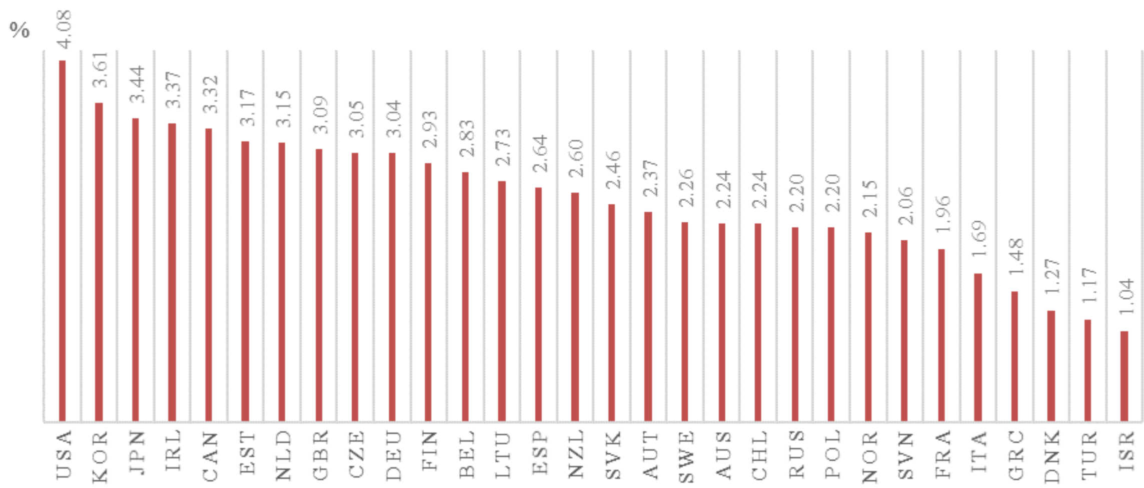


Source: OECD Digital Economy Outlook 2017.

At the same time, the challenge is not only to develop the needed ICT labour force, but also to have a supply of sufficiently attractive jobs relative to peer countries and the ability to ensure the long-run retention of skilled workers in the EU. Given the higher gross salaries paid in the US for high-skilled experts and especially high marginal income tax rates in the EU, the job market in the latter remains less competitive than that in the US for skilled labour, ceteris paribus. Another measure related more specifically to ICT-intensive labour and tasks is the average returns for ICT tasks, measured as a percentage change in hourly wages for a 10% increase in the ICT task intensity of jobs (Figure 3.3.6). This shows the clear dominance not only of the US but also of South Korea and Japan over the EU countries in marginal monetary rewards for ICT tasks.

The literature also suggests that not only ICT specialists are needed as a complementary factor for ICT investment, but also adequate managerial capital and organisational skills. Brynjolfsson et al. (2002) and Abramovsky and Griffith (2009) emphasise the latter two as important factors for the restructuring of business models towards more competitive ICT-intensive states. Inefficient management can result in a lack of awareness about the effectiveness of ICT capital for productivity growth and competitiveness. This can be further aggravated by market inefficiencies and a lack of intensive market competition in overregulated sectors or sectors with high market concentration and low business dynamism. A related issue is the lack of trust in innovative business models, particularly by SMEs, as a result of a lack of knowledge of the ICT market and data privacy concerns in such applications as cloud computing, cybersecurity issues, etc. These are closely related to the general market competition, business dynamism and related regulations discussed below.

Figure 3.3.6 / Average returns to ICT tasks, 2017

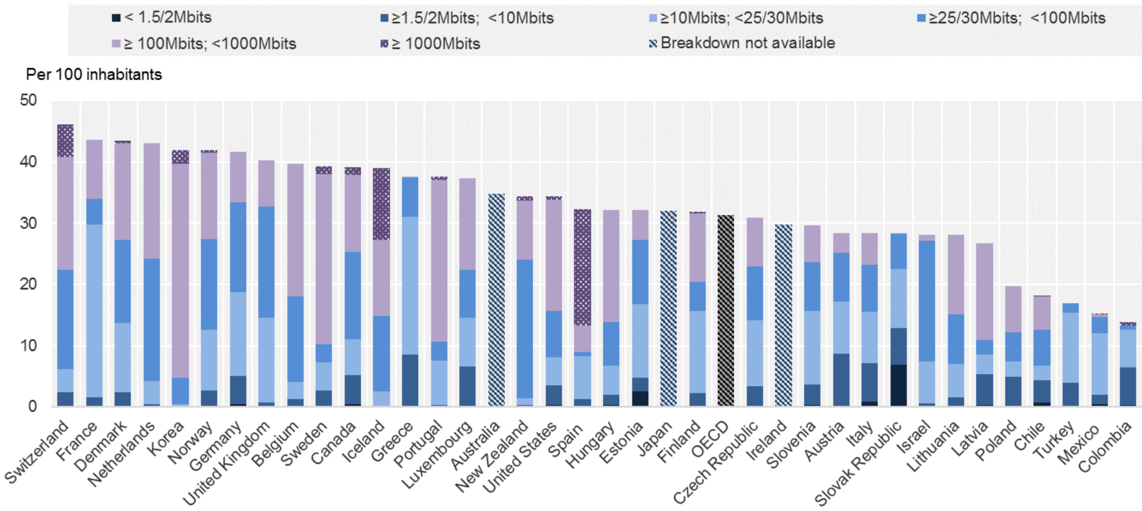


Note: Percentage change in hourly wages for a 10% increase in ICT task intensity of jobs (at the country mean)
Source: OECD.

Complementary factors of ICT capital accumulation: market structure, infrastructure and other factors

One of the complementary factors that facilitate further ICT investment is the established quality infrastructure that enables the effective use of ICT by businesses. This involves high-speed broadband connectivity infrastructure, including high-speed mobile broadband. While the EU in general is highly developed in terms of the overall ICT infrastructure, the quality differs across EU member states. For instance, fixed broadband penetration as measured by the number of subscribers per 100 inhabitants differs across the EU countries (Figure 3.3.7). While the EU countries are ranked highly in terms of broadband penetration rates relative to peer economies, there is room for improvement in many EU countries (including advanced economies like Germany and France) with a move to ultrafast broadband access, which is needed for businesses operating with large data transfers.

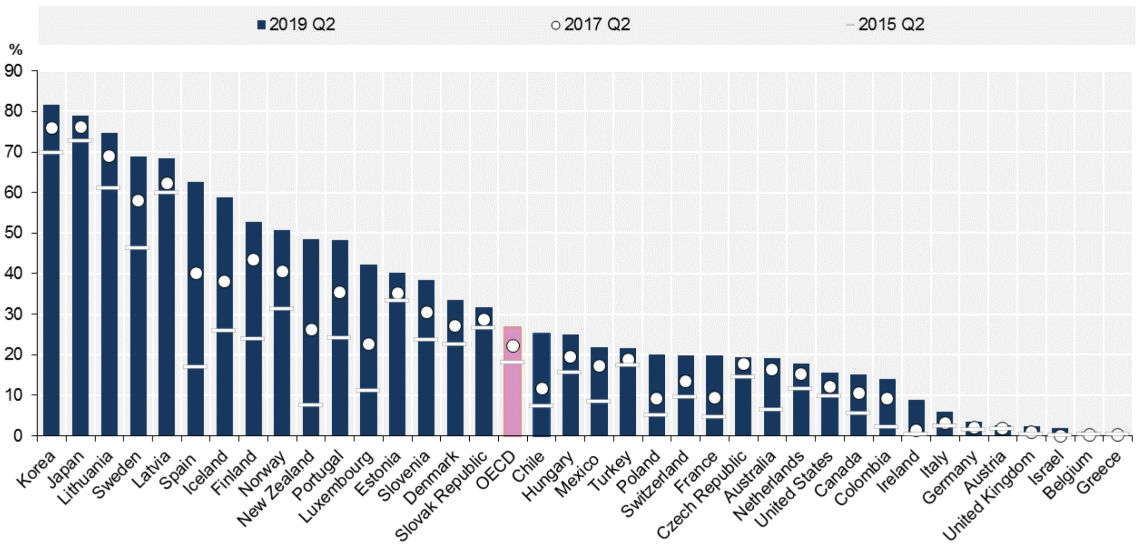
Figure 3.3.7 / Fixed broadband subscriptions per 100 inhabitants, per speed tiers, 2019



Source: OECD.

Similarly, looking at the relative share of modern high-speed fibre in internet connections (Figure 3.3.8), the EU countries lag behind the long-time leaders – South Korea and Japan, which have a share of fibre connection exceeding 75%. At the same time, Lithuania, Latvia and Spain have been catching up in recent years (OECD attributes this to progress made in boosting market competition, better regulation and infrastructure investment).

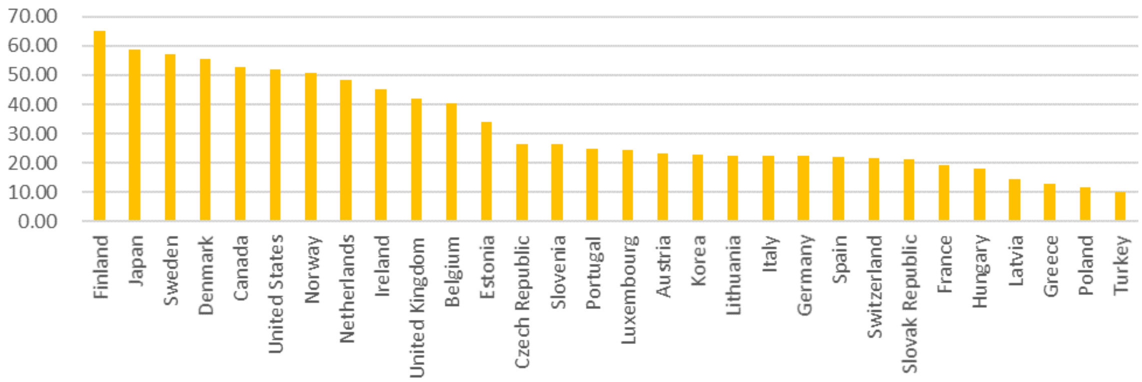
Figure 3.3.8 / Percentage of fibre connections in total fixed broadband, 2019



Source: OECD.

As regards the general utilisation of basic ICT services in daily business operations (Table 3.3.1), the EU countries are generally in line with their peer economies, and no strong patterns are visible within the EU in terms of the intensity of common uses of ICT capital, e.g. e-mail, internet or text processing software. However, when it comes to the more advanced uses of ICT technology involving remote data storage and processing (see, for instance, Figure 3.3.9 for the intensity of the use of cloud computing services), with the exception of the Nordic countries European countries were generally lagging behind the US as of 2018. It can be conjectured that these observed patterns are the outcome of multiple factors, including those discussed in the present report, e.g. sectoral specialisation patterns of countries, perceived and real ICT security risks, regulatory gaps and inefficiencies, and relevant complementary labour skills. However, the relative importance of these factors remains an open question requiring further research.

Figure 3.3.9 / Businesses purchasing cloud computing services, 2018, %



Source: OECD.

Additional possible issues are related to the dominant market structure in the EU (this, however, differs significantly across EU countries and sectors). In the EU, SMEs are relatively more important for job creation, whereas in the US employment by big companies is dominant. At the same time, bigger firms are much more likely to undertake massive investments in ICT capital. As discussed earlier, smaller firms in innovative ICT-intensive sectors in the EU – particularly those focusing on financial research and development and other risky business activities – besides deficient internal funding sources also face challenges with raising external funding as a result of lacking collateral and undeveloped capital markets in the EU. The incentives for technology adoption could be weakened as a result of less competitive pressures (Decker et al., 2016). Investment in ICT capital is associated with strong economies of scale, which contribute to the problem of market concentration and may give rise to a handful of “superstar” MNEs and raise market entry barriers (De Loecker and Eeckhout, 2017).

Table 3.3.1 / Frequency of use of information and communications technologies at work

	Daily use of e-mail at work			Daily use of the Internet at work			Daily use of word processors at		
	Below upper secondary education	Upper secondary education or post-secondary non-tertiary	Tertiary education	Below upper secondary education	Upper secondary education or post-secondary non-tertiary	Tertiary education	Below upper secondary education	Upper secondary education or post-secondary non-tertiary	Tertiary education
Austria	48	69	80	31	44	58	30	38	53
Czech Republic	25	65	87	30	51	74	20	35	60
Denmark	54	71	85	30	43	62	26	35	57
Estonia	44	58	85	30	46	68	15	23	45
Finland	53	59	86	25	29	54	14	14	39
France	57	64	85	23	28	53	25	30	56
Germany	39	61	80	18	36	52	23	41	57
Greece	20	44	68	18	41	62	5	28	51
Ireland	50	64	79	35	38	59	28	38	60
Italy	55	72	83	37	49	70	26	50	64
Japan	39	42	61	24	31	51	18	18	35
Korea	8	37	62	16	39	62	6	24	46
Lithuania		49	84	39	46	76		27	57
Netherlands	67	79	91	37	46	66	32	47	68
Norway	64	71	89	29	39	56	19	27	55
Poland	29	48	76	18	41	65		26	54
Slovak Republic	16	55	81	23	38	65		38	62
Slovenia	36	67	93	27	50	80	8	33	69
Spain	46	66	80	31	50	65	21	44	59
Sweden	52	69	89	25	36	53	10	27	46
United States	40	61	88	30	43	67	14	30	56

Source: OECD.

Regulatory environment

The quality of the regulatory environment is of high importance for ICT investment. In the context of EU the issues are manifold, stemming from overregulation in some business areas, lack of regulation or slow legislation and implementation in certain frontier digitalisation-related areas, and lack of harmonisation in the areas regulated by national standards. The issues are, however, well noted and are being addressed; in particular, the importance of regulatory and other barriers in the EU market context and possible solutions have been pointed out in a recent survey-based report by the European Commission (2020b).

As already noted, one of the risks associated with broader ICT use that eventually translates into lower than desired levels of ICT investment by businesses is related to the lack of trust in data sharing, cloud services, digital security risks, privacy issues and intellectual property rights (OECD, 2015, 2016; European Commission, 2020b). The EU-wide regulatory environment which mitigates these risks is therefore of high importance.

Flexible product market regulations are needed to ensure business dynamism and competition, which, in turn, stimulate businesses to seek more effective modes of operation and, among others, invest in ICT capital. The importance of increased competitive pressures as a necessary stimulus for innovative activity and ICT adoption has been documented in the literature (Conway et al., 2006; Aghion et al., 2008, Bourles et al., 2010; Andrews and Criscuolo, 2013; OECD, 2016b). In particular, as one dimension of this issue, lower entry regulations for new businesses, while not desired by incumbent firms, greatly facilitates ICT adoption as one of the instruments to maintain a competitive edge in the market. New firms typically are more aggressive in trying to find their market niche and expand their market share, and therefore tend to employ new technologies more intensively as a means of maintaining a competitive edge. Explicit and implicit barriers to a new firm's entry in the form of excessive bureaucratic procedures to register and start new business or activities could thus hinder ICT capital investment. On aggregate, as can be seen in Table 3.3.2, in the EU on average the costs of starting a new business are relatively high in comparison with peer economies in terms of time required to start a business, procedures and costs. Overregulation and bureaucracy are also listed in business surveys among the bottlenecks to business operation in general.[18]

While the regulations intend to achieve optimal social outcomes, related inefficiencies in their development and actual implementation also increase the costs and delays that hamper the development and adoption of new technologies, which is critical for innovative sectors. In the EU context the issue is further multiplied by the need for the lengthy coordination and approval processes of policy proposals and the different stages of interim evaluation and implementation across multiple EU institutions and member states. This puts the EU in a relatively disadvantaged position relative to the more dynamic peer frontier economies and possibly hinders the competitiveness of EU businesses relative to their peers in highly dynamic sectors.

The need for policies supporting ICT sectors are emphasised in OECD (2019). In particular, it is noted that the policies need to be continuously modernised to keep pace with technological change. The EU should find the appropriate balance between removing anti-competitive product market regulations and effectively enforcing competition law. Excessive market regulation by the government inhibits the catch-up process in productivity, hinders competition and firm entry and thereby reduces the efficient resource allocation towards more productive firms, especially in ICT-using sectors (Nicoletti and Scarpetta, 2003).

Table 3.3.2 / Regulatory burden to start a business, 2019

	Start-up procedures to register a business (number)	Time required to start a business (days)	Cost of business start-up procedures (% of GNI per capita)
European Union	5.3	11.9	8.1
United States	6.0	4.2	0.0
Japan	8.0	11.2	0.0
South Korea	3.0	8.0	0.0
China	4.0	8.6	0.0

Source: World Bank's WDI, Doing Business.

As a related matter, labour market regulations may also have a negative impact on ICT investment and the benefits firms can obtain from it. Labour market regulations inhibit the possibly more efficient reorganisation of business processes in favour of a greater utilisation of ICT capital replacing labour. For instance, Van Reenen et al. (2010) suggest that labour market regulations reduce productivity gains from ICT by approximately 45%. One should note, however, that while viewed strictly from the business perspective such regulations may hinder efficiency and competitiveness, they are still optimal in the aggregate country socio-economic contexts.

18 See, for instance, European Commission, 2020; World Banks's Doing Business surveys, OECD Product Market Regulation surveys.

4. Policy implications

The sluggish economic performance of the EU in the post-crisis period, both by international standards and relative to its past historical trends, has given a renewed impulse to the debate on the drivers of productivity. As discussed in this paper, the issue is two-fold: the across-the-board slowdown of productivity growth (along with lagging behind peer economies in terms of productivity levels) in the frontier EU economies in the post-crisis period, and the structural impediments faced by the periphery European economies that led to the slow convergence and catch-up of the EU frontier economies. Together, these two issues resulted in the overall meagre average productivity dynamics of the EU aggregate.

In light of the important revealed role of ICT capital in accelerating productivity and taking into account the impediments discussed in the previous section, the following broad policy guidelines appear to be instrumental to facilitate ICT investments:

› Policies improving the general macroeconomic stability and addressing the structural impediments in lagging EU member states as a prerequisite to investment in general.

› Measures addressing the regulatory bottlenecks that hinder the efficient allocation of capital and absorption of ICT capital, including pro-competition policies, measures fostering further development of the EU single market along the four freedoms, policies regulating ICT-related areas (data privacy, digitalisation, intellectual property, technical standards).

› ICT-targeted policy incentives, including tax incentives, financial support, public procurement, provision of public infrastructure and other forms of financial and technical support, especially focusing on the support of small and medium-sized enterprises and innovative start-up companies, which experience greater difficulties in ICT absorption and scaling up in comparison with large multinational corporations.

› Policies fostering deeper financial markets, and, in particular, advancing further the efforts to establish sufficiently deep and efficient capital markets and establishing a broad-based environment that facilitates venture capital and other forms of start-up financing in ICT-intensive sectors.

› Policies facilitating the training of a skilled ICT workforce, including both higher education and vocational training, as well as addressing regulatory bottlenecks in labour markets as regards the skills mismatch, barriers to cross-country labour movements, and adequate incentives to facilitate the retention of a skilled workforce in the EU.

Expanding further on the pro-ICT policies, given the importance of financing constraints for ICT capital investment, the development of capital markets and special funding instruments (venture capital, crowdfunding, etc.) is especially relevant for innovative start-ups that are particularly intensive in ICT capital. In this regard, the European Capital Markets Union and the Banking Union initiatives and, in general, the further development of sustainable and diverse financial markets are highly welcome as a means to finance start-ups and enable the scaling up of companies. Overall, this is also important for the more efficient channelling of financial capital across EU countries and sectors and fostering overall gross fixed capital formation.

In general, the EU's gross tax burden on both labour and businesses is rather heavy. Along with less competitive gross salaries offered for skilled labour force, this translates into lower net labour compensation and disposable incomes for skilled labour in the EU, also in the ICT sector, thereby potentially making high-skilled jobs in the EU less attractive relative to the US. However, ICT-relevant labour supply does not appear to be a major challenge in the EU context at present. Focusing specifically on ICT investments and tax incentives, accelerated depreciation rates on ICT capital could provide additional incentives to invest in ICT capital. Similarly, further efforts to stimulate tax incentives to promote education and training in ICT areas – for instance, tax allowances for education or training expenditures – or a tax credit against relevant spending or tax exemption may also contribute to ICT absorption and, as a result, greater ICT intensity, because skilled ICT specialists are important complementary factors, as discussed previously (see also CEDEFOP, 2009).

Pro-competitive regulations and policies aimed at the reduction of barriers to new firm entry can provide incentives to adopt new technologies and invest in ICT capital, thereby contributing to the development of the necessary start-up ecosystem that may eventually lead to an EU equivalent to Silicon Valley. In addition to easing the bottlenecks associated with overregulation, firm entry barriers and cross-country regulatory harmonisation, however, this requires a massive complementary public infrastructure investment in addition to the policy measures outlined above to remain on a par with similar initiatives in the US or in Asian countries.

As noted, addressing the EU regulatory gaps in the area of digitalisation is of great importance as well, and given the fast pace of technological progress, delays in the regulatory frameworks adversely affect the businesses concerned. In this respect, the Digital Single Market strategy in the EU should gain greater momentum. Following the 2014–2019 Digital Single Market strategy, on 19 February 2020, the European Commission released further documents discussing the envisioned digital regulations in the EU focusing on digitalisation, data regulations and artificial intelligence.[19] The key idea is to establish Europe as a leader in the digital world.

In considering viable options the EU should take advantage of the related strategies undertaken in frontier economies that have been successful in boosting ICT diffusion. OECD (2019) lists a range of policies that have already been considered and implemented in OECD countries. In particular, among the most frequently mentioned policy measures to strengthen the ICT sector are subsidies for companies to undertake further investment in infrastructure or research and development, or to encourage exports. In addition, direct government funding programmes focusing on ICT investment and government-sponsored training programmes are also commonly considered as viable policy instruments that enhance the competitiveness of domestic firms in the ICT domain. More exotic policy tools include innovative strategies focusing on the support of start-ups via business incubators and providing state guarantees to start-ups to enable them to access to bank credit.

The EU has been running the risk of falling behind not only the current global leaders in digital innovation – the US and Japan – but also the rapidly developing new competitors in Asia, particularly

19 The documents include the "White Paper on Artificial Intelligence A European approach to excellence and trust"; "Communication: A European strategy for data"; "Shaping Europe's digital future".

China and South Korea. Gaining momentum in digital transformation via ICT capital investment may further aid the catching-up process of the lagging EU Member States, especially in light of the general purpose technology nature of ICT, and thereby improve its internal cohesion and resilience, as well as, more generally, strengthening the trust in the transformative power and net benefits the bloc may bring to its members, which has lost much steam in the aftermath of the global crisis.

5. Concluding remarks

Accelerating productivity growth has been a major challenge in the post-crisis period. It is an especially important issue in the context of the feeble economic growth in the EU and is increasingly seen by policymakers as a means to foster sustainable long-run economic development. The double-dip recession resulted in a deep structural slowdown in the growth dynamics. The new, much more profound socio-economic challenges associated with the COVID-19 crisis have halted the recovery and obstructed the macroeconomic outlook at least in the medium run, hindering, inter alia, investment prospects. At the same time, the new challenges have already underscored the importance of digitalisation and ICT capital and will clearly prompt further search for more effective and resilient ways to organise economic activities and boost economic growth and competitiveness.

Our research has empirically confirmed the important role that ICT capital, both tangible and intangible, as well as FDI play in facilitating the competitiveness of modern economies by boosting productivity or supporting GVC participation. Consequently, fostering the infrastructure that is necessary to facilitate a more efficient allocation of investment with an emphasis on ICT capital, both tangible and intangible, thereby facilitating technology absorption and digitalisation by the real economy, seems to be a pragmatic way forward in the efforts to improve structural conditions. This applies not only to the EU but more generally also to both advanced and developing economies. This is even more important given that ICT is a general purpose technology, in the sense that it leads to broad-based positive spillover effects for the entire economy rather than only benefiting some firms and industries, and that it is capable of inducing far-reaching changes in human society, similar to the deep transformations that the steam engine and electricity brought in the past.

While not the direct focus of the study, our analysis also supports the important transformational impact of EU integration on productivity growth, which may work through multiple channels, including regulatory convergence and the upgrading of institutions, co-funding of infrastructure, and efficiency gains due to a more efficient cross-border reallocation of productive resources. This underscores the importance of tackling the bottlenecks that still exist in Europe concerning regulatory inefficiencies along with high cross-country heterogeneity in the capacity to improve the necessary “framework conditions” preventing the effective generation of innovation and adoption of new technologies. Digitalisation represents a significant opportunity for the EU to accelerate its lacklustre productivity growth and thereby potentially also its (structural) economic growth. At the same time it is clear that it also represents a challenge, given the global nature of competition and the rise of highly competitive peer economies. Today the EU is facing multiple challenges associated with geopolitical tensions and unresolved macroeconomic issues, and in terms of innovation and digitalisation technology it has already been lagging behind not only the US and Japan but also the rapidly developing new competitors from Asia – China and South Korea. While Europe seems to have all the necessary ingredients to boost innovation and innovation-driven productivity, including a skilled workforce, research infrastructure and strong institutions, more efforts are clearly needed to mobilise and channel them into the real economy to avoid falling behind its peers in the new era of Industry 4.0.

References

Abramovsky, L. and R. Griffith (2009), “ICT, corporate restructuring and productivity”, IFS *working papers* 09,10, http://hdl.handle.net/10419/47484.

Adarov A. and R. Stehrer (2019a). Tangible and Intangible Assets in the Growth Performance of the EU, Japan and the US. Vienna Institute for International Economic Studies (wiiw) *Research Report*, No. 442, Vienna, October 2019.

Adarov A. and R. Stehrer (2019b). Implications of Foreign Direct Investment, Capital Formation and its Structure for Global Value Chains. Vienna Institute for International Economic Studies (wiiw) *Working Paper*, No. 170, Vienna, November 2019.

Adarov A. and R. Stehrer (2020). New productivity drivers: revisiting the role of digital capital, FDI and integration at aggregate and sectoral levels. Vienna Institute for International Economic Studies (wiiw) *Working Paper* No. 178, April 2020.

Aghion, P., R. Burgess, S. Redding, and F. Zilibotti (2008), “The Unequal Effects of Liberalization: Evidence from Dismantling the License Raj in India”, American Economic Review 2008, 98:4, 1397–1412, https://www.aeaweb.org/articles.php?doi=10.1257/aer.98.4.1397

Andrews D., G. Nicoletti and C. Timiliotis (2018), “Going digital: What determines technology diffusion among firms?”, OECD *Economics Department Working Paper*, 2018.

Andrews D. and Chiara Criscuolo (2013). "Knowledge-Based Capital, Innovation and Resource Allocation," OECD *Economics Department Working Papers* 1046, OECD Publishing.

Alam, A. and S.Z.A. Shah, (2013). Determinants of foreign direct investment in OECD member countries, *Journal of Economic Studies*, Vol. 40(4), pp. 515 – 527

Antonakakis, Nikolaos & Tondl, Gabriele (2012). "Do determinants of FDI to developing countries differ among OECD investors? Insights from Bayesian model averaging," Discussion Papers 1/12, Europa-Kolleg Hamburg, Institute for European Integration.

Bachtler, J., I. Begg, D. Charles and L. Polverari (2017) ‘The long-term effectiveness of EU cohesion policy. Assessing the achievements of the ERDF, 1989–2012’, in J. Bachtler, P. Berkowitz, S. Hardy and T. Muravska (eds) EU cohesion policy. Reassessing performance and direction, Routledge, available at https://www.taylorfrancis.com/books/10.4324/9781315401867

Bénassy-Quéré, A., M. Coupet, T. Mayer (2007). Institutional Determinants of Foreign Direct Investment, The World Economy, Vol. 30(5), pp. 764-782.

Black Sandra E. & Lisa M. Lynch (2004). "What's driving the new economy?: the benefits of workplace innovation," Economic Journal, Royal Economic Society, vol. 114(493), pages 97-116, February.

Bourlès Renaud, Gilbert Cette, Jimmy Lopez, Jacques Mairesse and Giuseppe Nicoletti (2013). "Do Product Market Regulations In Upstream Sectors Curb Productivity Growth? Panel Data Evidence For OECD Countries," The Review of Economics and Statistics, MIT Press, vol. 95(5), pages 1750-1768, December.

Borensztein, E., J. Gregorio, J. Lee (1998), “How does Foreign Direct Investment Affect Economic Growth?”, Journal of International Economics, 45(1): 115-135

Bresnahan Timothy F. & Erik Brynjolfsson & Lorin M. Hitt (2002). "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence," The Quarterly Journal of Economics, Oxford University Press, vol. 117(1), pages 339-376.

Brynjolfsson E., L.M. Hitt and S. Yang (2002), “Intangible assets: Computers and organizational capital”, Brookings papers on economic activity (1), 137-198.

Bugamelli Matteo & Patrizio Pagano (2004). "Barriers to investment in ICT," Applied Economics, Taylor & Francis Journals, vol. 36(20), pages 2275-2286.

Campos, N. and Y. Kinoshita (2008). Foreign Direct Investment and Structural Reforms: Evidence from Eastern Europe and Latin America. IMF *Working Paper* WP/08/29, pp. 38.

CEDEFOP (2009) Using tax incentives to promote education and training, https://www.cedefop.europa.eu/files/5180_en.pdf

Chamberlain, G. (1984). Panel data. Volume 2 of *Handbook of Econometrics*, pp. 1247–1318. Elsevier.

Darvas, Z., A.M. Collin, J. Mazza and C. Midoes (2019) Effectiveness of cohesion policy: Learning from the project characteristics that produce the best results, Study prepared for the European Parliament’s Committee on Budgetary Control

Decker, R.A., J. Haltiwanger, R.S. Jarmin, and J. Miranda (2016), “Declining Business Dynamism: What We Know and the Way Forward”, *American Economic Review*, 106 (5): 203-07.

De Loecker, J. and J. Eeckhout (2017), “The Rise of Market Power and the Macroeconomic Implications”, NBER *Working Paper*, No. 23687.

Dunning, J.H. (1993). Multinational Enterprises and the Global Economy. Wokingham, England: Addison-Wesley Publishing Company.

European Commission (2020a). European Economic Forecast Spring 2020. *Institutional paper* 125. May 2020.

European Commission (2020b). Identifying and addressing barriers to the Single Market. Brussels, 10.3.2020 COM(2020) 93 final. SWD(2020) 54 final. March 2020.

European Parliament (2017). Foreign direct investment screening. A debate in light of China-EU FDI flows. European Parliament Briefing. May 2017.

Fournier, J. M. (2015), "The negative effect of regulatory divergence on foreign direct investment", OECD *Economics Department Working Papers* No. 1268, OECD Publishing, Paris.

Ghosh, M., Syntetos, P. and Wang, W. (2012), “Impact of FDI restrictions on inward FDI in OECD countries”, Global Economy Journal, Vol 12(3).

Haskel, J. and S. Westlake (2018), Capitalism Without Capital. The Rise of the Intangible Economy, Princeton&Oxford: Princeton University Press.

Koopman, Robert, Zhi Wang and Shang-Jin Wei (2014). “Tracing Value-Added and Double Counting in Gross Exports.” *American Economic Review*, 104(2), 459–94.

Landesmann, M. and R. Stoellinger (2020). The European Union’s Industrial Policy: What are the Main Challenges? *wiiw Policy Notes and Reports* No. 36, January 2020

Montresor, S., Vezzani, A. (2014): Intangible investments and innovation propensity. Evidence from the Innobarometer 2013. European Commission's Joint Research Centre - IPTS Working Papers on Corporate R&D and Innovation – No 03/2014.

Mistura Fernando & Caroline Roulet (2019). "The determinants of Foreign Direct Investment: Do statutory restrictions matter?," OECD *Working Papers on International Investment* 2019/01, OECD Publishing.

Mundlak, Y. (1978). On the pooling of time series and cross section data. Econometrica 46(1), 69–85.

National Competitiveness Council (2019). NCC Productivity Statement 2019. Ireland, November 2019.

Neyman, J. and E. L. Scott (1948). Consistent estimates based on partially consistent observations. Econometrica 16(1), 1–32.

Nicoletti, G., Hajkova, D., Vartia, L. and Yoo, K.-Y. (2006), “Taxation, Business Environment and FDI Location in OECD Countries”, OECD *Economics Department Working Papers* No 502, OECD Publishing: Paris.

Nicoletti, Giuseppe & Scarpetta, Stefano, 2003. "Regulation, productivity, and growth: OECD evidence," *Policy Research Working Paper Series* 2944, The World Bank.

OECD (2013). Interconnected Economies: Benefiting from Global Value Chains, OECD Publishing, Paris.

OECD (2019). ICT Investments in OECD countries and partner economies. Trends, policies and evaluation. OECD digital economy papers. April 2019 No. 280

OECD (2016a), Skills for a Digital World (Policy Brief on the Future of Work), OECD Publishing, Paris

OECD (2018), Maintaining competitive conditions in the era of digitalisation, G-20 FWG mimeo.

OECD (2016b) Stimulating digital innovation for growth and inclusiveness: The role of policies for the successful diffusion of ICT. OECD Draft background report for Ministerial panel 1.2. DSTI/ICCP(2015)18/FINAL

OECD (2015), Inquiries into Intellectual Property’s Economic Impact, OECD Publishing, Paris, https://www.oecd.org/sti/ieconomy/intellectual-property-economic-impact.htm.

OECD (2017). Unlocking Investment in Intangible Assets. OECD Discussion paper 047 May 2017.

Papke, L. E. and J. M. Wooldridge (1996). Econometric methods for fractional response variables with an application to 401(k) plan participation rates. Journal of Applied Econometrics 11(6), 619–632.

Papke, L. E. and J. M. Wooldridge (2008). Panel data methods for fractional response variables with an application to test pass rates. Journal of Econometrics 145(1–2), 121–133.

Shatz, H. and Venables, A.J. (2000). The geography of international investment, World Bank Policy Research Working Paper No. 2338

UNCTAD (2019). Trade Policies for Combating Inequality: Equal opportunities to firms, workers and countries. September 2019.

UNCTAD (2020). The COVID-19 Crisis: Accentuating the Need to Bridge Digital Divides. Digital Economy Update. April 2020.

Van Reenen, J., Bloom, N., Draca, M., Kretschmer, T. & Sadun, R. (2010). The Economic Impact of ICT SMART No. 2007/0020. London: Enterprise LSE.Wooldridge, J. M. (2014). Quasi-maximum likelihood estimation and testing for nonlinear models with endogenous explanatory variables. Journal of Econometrics 182, 236–234.

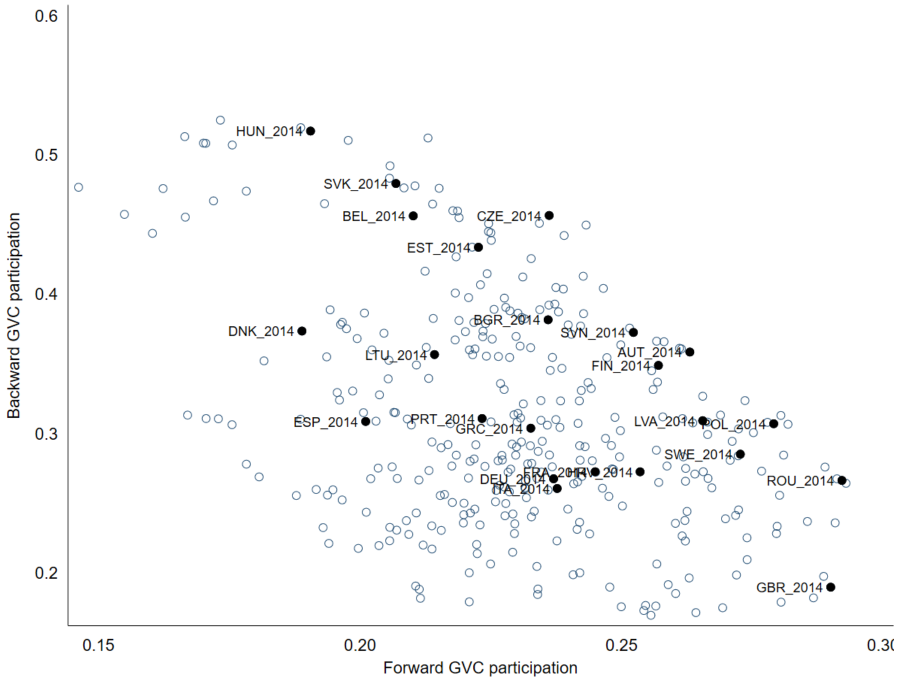
Appendix

Table A.1 / Classification of sectors

SEC	NACE Rev. 2 codes	Sector description (based on NACE 2 classification)	Label
1	A	Agriculture, forestry and fishing	1_AGRI
2	B	Mining and quarrying	2_MING
3	10-12	Food products, beverages and tobacco	3_FOOD
4	13-15	Textiles, wearing apparel, leather and related products	4_TXTL
5	16-18	Wood and paper products; printing and reproduction of recorded media	5_WOOD
6	19	Coke and refined petroleum products	6_COKE
7	20-21	Chemicals and chemical products	7_CHEM
8	22-23	Rubber and plastics products, and other non-metallic mineral products	8_RUBB
9	24-25	Basic metals and fabricated metal products, except machinery and equipment	9_METL
10	26-27	Electrical and optical equipment	10_ELEC
11	28	Machinery and equipment n.e.c.	11_MACH
12	29-30	Transport equipment	12_TRAN
13	31-33	Other manufacturing; repair and installation of machinery and equipment	13_OMAN
14	D-E	Electricity, gas and water supply	14_GASW
15	F	Construction	15_CONS
16	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	16_TRMO
17	46	Wholesale trade, except of motor vehicles and motorcycles	17_WHTR
18	47	Retail trade, except of motor vehicles and motorcycles	18_RETR
19	49-52	Transport and storage	19_TRSR
20	53	Postal and courier activities	20_POST
21	I	Accommodation and food service activities	21_ACCO
22	J	Information and communication	22_INFO
23	K	Financial and insurance activities	23_FINA
24	L	Real estate activities	24_REAL
25	M-N	Professional, scientific, technical, administrative and support service activities	25_PROF
26	O-U	Community social and personal services	26_SOCI
100	TOT	Country total	100_TOTL

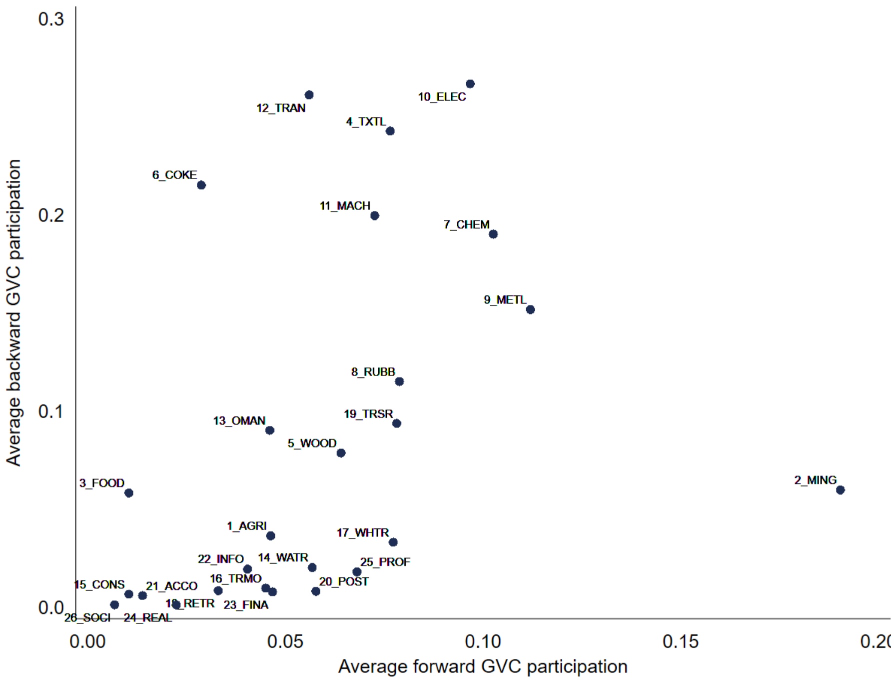
Note: the table shows the classification of sectors used in the paper with the numerical codes (SEC), corresponding NACE Rev. 2 codes, sector full name (based on NACE Rev. 2) and short labels used for the brevity of exposition when discussing sectoral estimation results.
Source: own elaboration.

Figure A1 / Backward and forward GVC participation in Europe



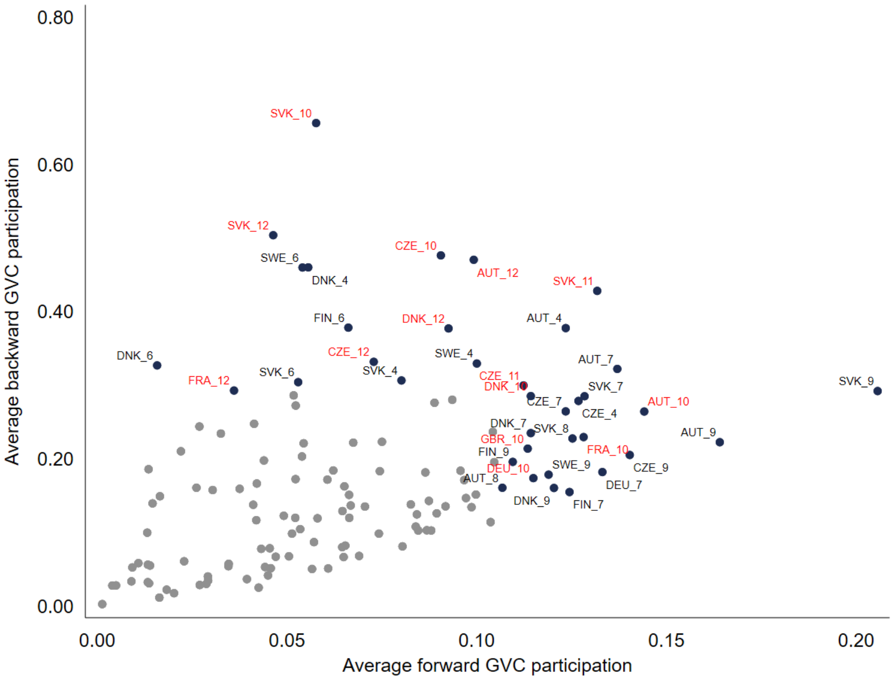
Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for the sample of European countries (excluding tax haven countries) for the period 2000-2014. The data for 2014 is labelled.
Source: own elaboration based on WIOD 2016 release

Figure A2 / Average backward and forward GVC participation of sectors



Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for the sectors (GVC participation based on gross output), averaged across the sample of countries and the period 2000-2014.
Source: own elaboration based on WIOD 2016 release

Figure A3 / Countries and sectors with high GVC participation



Note: the figure shows the scatterplot of backward GVC participation against forward GVC participation for countries and sectors (GVC participation based on gross output), averaged across the sample of countries and the period 2000-2014. High-tech sectors are highlighted.
Source: own elaboration based on WIOD 2016 release.

Table A.2 / Share of ICT graduates, 2017

	B.A. degree		M.A. degree	
	share of total graduates, %	persons	share of total graduates, %	persons
Australia	3.3	7,350	6.7	5,803
Austria	4.4	1,299	3.8	987
Belgium	2.8	1,822	0.8	310
Canada	2.3	4,498	3.4	2,113
Czech Republic	5.3	2,270	4.9	1,617
Denmark	3.4	1,491	6.7	1,761
Estonia	7.8	471	6.8	223
Finland	6.1	2,237	6.6	1,168
France	3.0	7,867	3.5	10,062
Germany	5.0	16,461	4.4	9,297
Greece	2.6	1,299	3.6	616
Hungary	5.1	1,980	2.6	507
Iceland	8.1	243	1.0	14
Ireland	8.4	3,728	7.0	1,491
Italy	1.3	2,566	0.5	762
Korea	4.8	17,172	3.0	2,493
Latvia	4.6	340	4.2	176
Lithuania	2.9	579	2.3	173
Luxembourg	3.6	22	2.8	19
Netherlands	2.7	2,738	2.2	992
Norway	4.0	1,326	3.6	561
Poland	3.9	12,836	2.9	5,375
Portugal	1.3	609	1.1	261
Slovak Republic	4.3	951	2.6	669
Slovenia	3.8	337	2.4	123
Spain	2.5	4,399	1.9	2,519
Sweden	4.1	1,418	2.0	534
Switzerland	2.8	1,659	1.6	393
Turkey	0.2	810	0.6	360
United Kingdom	4.1	16,800	2.8	6,698
United States	3.9	76,720	5.2	47,666

Source: OECD.

Table A.3 / Proficiency, use and need of information and communication technologies at work

	Manufacturing : Use of computer at work	Manufacturing : Moderate or complex ICT skills required at work	Manufacturing : Good ICT and problem-solving skills
Australia	66	41	29
Austria	72	47	38
Belgium	74	51	36
Canada	69	44	32
Chile	40	18	11
Czech Republic	58	34	29
Denmark	86	61	40
Estonia	49	32	16
Finland	84	55	42
Germany	72	46	36
Greece	46	30	12
Ireland	69	43	30
Israel	68	49	29
Japan	74	49	43
Korea	60	39	26
Lithuania	33	23	12
Netherlands	74	54	38
New Zealand	71	48	38
Norway	85	61	36
Poland	43	28	17
Slovak Republic	43	28	25
Slovenia	57	35	17
Sweden	84	54	42
Turkey	29	13	9
United States	77	49	30

Note: based on reference years 2012-2015.
Source: OECD.

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