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Investment composition and growth: the role of intangible and tangible ICT capital in the EU and other economies

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Abstract

This paper examines whether differences in the composition of investment help explain economic growth disparities in the EU and other advanced economies from 1996 to 2021. While overall investment levels in the EU and the US are broadly similar, the EU invests less in intangible and tangible ICT capital. This difference in composition is associated with part of the EU's productivity gap with the US. Employing panel fixed effects and local projection methods, we find that intangible and tangible ICT investments -particularly in communications equipment, R&D, and other intellectual property products- are associated with higher GDP per capita growth than other forms of investment. To quantify these differences, we construct a novel investment efficiency ratio that relates the estimated economic growth contribution of each asset to its share in total investment. The results are robust across empirical methods, country samples, and time periods, and reveal substantial heterogeneity: the growth association of ICT-related investment is stronger in countries with higher income levels and greater human capital. Overall, the findings suggest that improving the allocation and efficiency of investment, rather than simply increasing its volume, is key to enhancing long-term growth.

Keywords: Investment efficiency; Intangible investment; Tangible ICT investment; Human Capital; Panel Data

JEL codes: E22; O47; O50; J24; C23

Non-technical summary

Europe's persistently low long-term growth, especially relative to the United States, often leads to calls for higher investment. However, our analysis, which examines the relationship between investment and economic growth across the European Union (EU) and other advanced economies (the United States, the United Kingdom, and Japan) from 1996 to 2021, shows that the issue is not simply the quantity of investment. In fact, the total amount of investment relative to GDP is comparable between the EU and the US. Instead, the returns on investment are consistently lower than those in the US, indicating an underlying problem with the efficiency of investment in the EU. This suggests that merely increasing the total capital stock would be insufficient to significantly narrow the productivity gap with the US.

Our analysis identifies the composition of investment as a key factor for growth performance. Using data from EUKLEMS, our empirical results from panel fixed effects and panel local projections demonstrate that investments in intangible and tangible Information and Communication Technology (ICT) -including R&D, communications equipment, and other intellectual property products- are associated with higher GDP per capita growth compared to other forms of investment. The US has prioritized these high-technology sectors, while the EU has historically concentrated a larger share of capital on traditional, mid-tech tangible investments. This divergence in investment patterns is a key reason for the observed productivity gap between the two regions.

Furthermore, we find that the relationship between investment and economic growth is not uniform across countries. Differences emerge when countries are grouped by their income levels and human capital. Economies with higher education levels and stronger skills experience a stronger GDP growth effect from intangible and tangible ICT investments, as human capital is linked to higher productivity gains in the presence of knowledge-intensive investments. Conversely, in lower-income EU member states, other tangible investments are more closely associated with growth than intangible and tangible ICT investment, underscoring the critical role of investment complementarities.

Overall, our findings underscore the benefits for European policymakers to shift their focus from the volume of investment to its composition and efficiency. Improving the framework conditions to incentivise investment in intangible and tangible ICT capital is crucial for closing the productivity gap. To illustrate the potential impact, our simulations suggest that if the EU

were to match the same growth rates in high-efficiency investment types as the US, its GDP per capita could be around 1.3% higher by 2035. Although this estimate is a simplified projection that assumes that current economic relationships hold steady, it highlights the significant scale of the opportunity for the European economy.

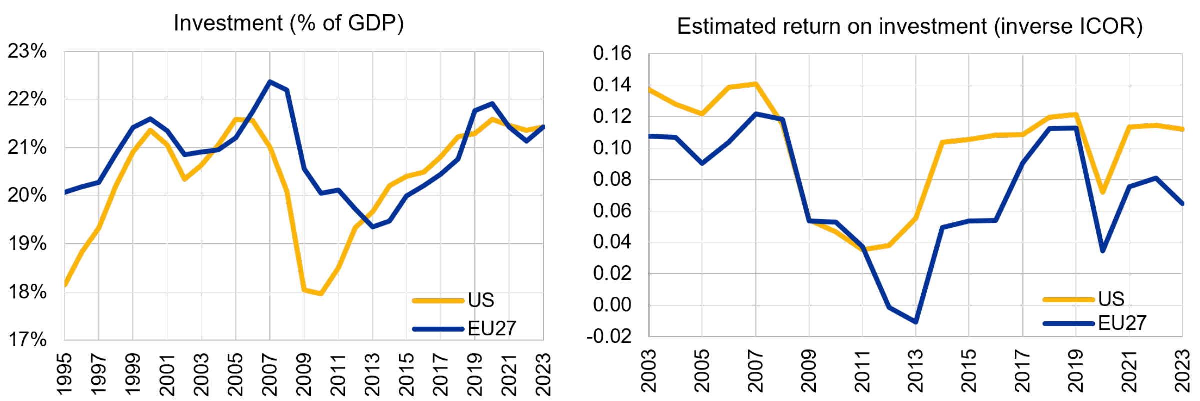
To unlock the potential of intangible and tangible ICT investments, EU policymakers should pursue a holistic strategy that incentivises capital provision towards high-technology sectors, strengthens human capital through education and digital skills development and reduces financing frictions by deepening European capital-market integration and expanding support for venture capital, startup funding, and public-private partnerships.

1 Introduction

Europe's long-term growth performance has lagged behind other advanced economies. Many analysts have attributed the EU-wide slowdown in economic growth to insufficient investment. For example, Mario Draghi, in his report on European competitiveness, concludes that the EU would need additional annual investment of EUR 750–800 billion— equivalent to 4.4–4.7 percent of EU GDP in 2023 (Draghi, 2024). The idea of a systematic plan to boost investment and thereby spur economic recovery across the EU has also underpinned previous initiatives such as the Juncker Plan in 2015 and the EU Recovery and Resilience Facility in 2020.

Yet, despite these concerns about underinvestment, the investment-to-GDP ratios in the EU and the US are broadly comparable. However, the returns on investment are persistently lower in the EU than in the United States (Figure 1). These observations challenge the idea of a general "underinvestment" problem and shift the focus towards increasing the efficiency of investment —highlighting the need to reallocate resources toward more productive and growth-enhancing uses.

Figure 1: Investment ratio over time and inverse ICOR



Sources: Authors' own calculations based on AMECO.
Notes: The inverse Incremental Capital Output Ratio (ICOR) is calculated as the ratio between the 5-year rolling average of real GDP growth (in PPS) and the 5-year rolling average of investment-to-GDP ratio (following Gros et al. (2024)).

One notable difference in terms of the composition of investment between the EU and the US is the relatively lower share of EU investment directed towards intangible and tangible information and communication technology (ICT) (Figure 2 and Figure 3). While the US has prioritized investments in high-technology sectors such as ICT, artificial intelligence (AI), cloud computing, and biotechnology, EU member states have largely focused on other tangible investments in traditional mid-tech industries like automotive. These mid-tech sectors tend to have lower innovation intensity and R&D spending, often directed toward incremental improvements rather than disruptive advancements. This divergence in sectoral investment priorities has coincided with slower productivity growth in the EU, as mid-tech investments generally produce fewer spillover effects compared to high-tech investments (Fuest et al., 2024). This fact could explain part of the well documented productivity growth gap between the two regions (Draghi, 2024; Gordon and Sayed, 2020).

Figure 2: Investment by asset type in real terms, 2021 (bn of EUR)

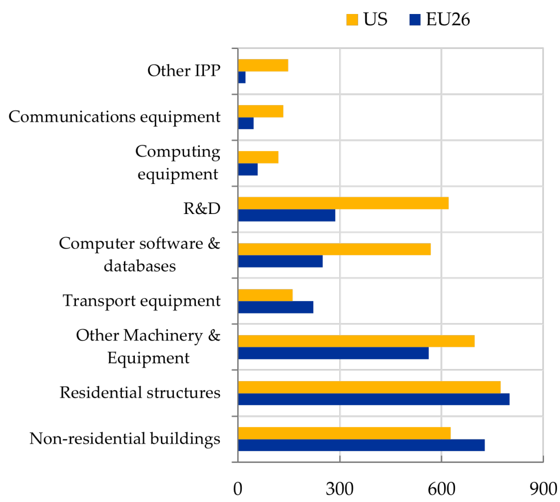
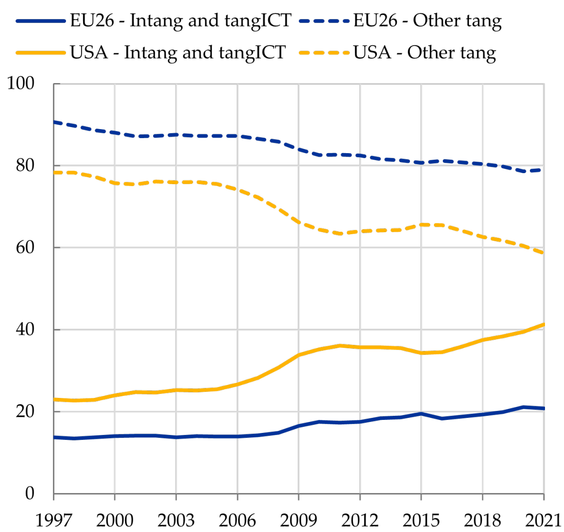


Figure 3: Investment by type over time (percent of total investment)



Sources: EUKLEMS.
Notes: The EU26 is the unweighted average of EU Member States excluding Ireland. *Intangible and tangible ICT* contains communications equipment, computing equipment, other Intellectual Property Products (IPP), R&D, and computer software & databases. *Other investment* includes other machinery, residential buildings, non-residential buildings, and transport equipment.

Against this backdrop, this study empirically investigates which types of investment have historically been associated with economic growth over the period 1996-2021. The analysis covers two country groups: EU Member States, and an extended sample that additionally includes the United States (US), the United Kingdom (UK), and Japan. While our results should be interpreted as associations rather than causal effects, our empirical approach based on panel fixed effects and panel local projection methods provides robust empirical evidence that challenges the notion of general underinvestment and highlights significant heterogeneity in the association between different types of investment and economic performance.

The paper makes two main contributions to the literature on capital accumulation. First, we construct a standardised investment efficiency ratio that accounts for the relative weight of each asset in total investment. Using this metric, we demonstrate empirically that intangible and tangible ICT investments have a significantly stronger association with GDP per capita growth in the short- and medium-term compared to other tangible investments. This distinction provides quantitative evidence for the view that differences in investment composition contribute to the productivity gap between the EU and the United States.

Second, we uncover significant heterogeneity in the investment-growth nexus across countries and over time. By segmenting countries based on income level, human capital endowments, and sub-periods, we show that complementarities between investment types and country characteristics play a crucial role. In particular, economies with higher human capital and income levels are better positioned to benefit from ICT and other knowledge-intensive investments, thereby amplifying their growth effects. In contrast, countries with lower human capital and income levels appear less able to translate similar investment volumes into productivity gains, suggesting that improvements in skills and basic infrastructure may be necessary to fully realise the benefits of ICT investment. Finally, the results point to a weakening of the investment–growth relationship after 2008, particularly for ICT-related investment. This pattern may reflect factors such as the "productivity paradox" associated with the diffusion of general-purpose technologies, potential measurement issues, or rising structural impediments to growth (Brynjolfsson et al., 2021; Ahmad et al., 2017; Masuch et al., 2018).

The remainder of the paper is organised as follows: Section 2 presents the literature review, while Section 3 describes the dataset. Section 4 presents the methodologies and the main results of the study, and Section 5 contains some robustness checks. Finally, Section 6 concludes.

2 Literature review

The relationship between investment and economic growth has long been central to the growth literature, both in theoretical and empirical research. Traditional models emphasize the role of capital accumulation in driving output (Solow, 1956; Mankiw et al., 1992). With greater data granularity, more recent literature has shown that the composition of investment matters for how effectively capital formation translates into sustained GDP growth.

A first strand of literature highlights the role of intangible assets in driving economic performance. It shows that investment in intangible assets -such as R&D or software and databases- not only accounts for a growing share of total investment, but also makes a disproportionately strong contribution to output growth (Corrado et al. (2005); Corrado et al. (2009)). Thum-Thysen et al. (2017) and Thum-Thysen et al. (2021) find that investment in different asset types tends to be complementary, improving firm performance through spillover effects. Empirical evidence for EU Member States based on EU KLEMS data confirms a positive association between intangible investment and labour productivity (Roth and Thum, 2013; Roth and Mitra, 2025), while also documenting a persistent gap in intangible investment between the EU and the United States since the global financial crisis (Corrado et al., 2018; Hanzl-Weiss and Stehrer, 2024). This difference is often cited as one explanation for the EU–US productivity gap (Fuest et al. (2024)). A comprehensive synthesis of the literature on intangible capital and productivity growth is provided by Roth (2019).

A second strand of work investigates, more specifically, the role of ICT-related investment in explaining cross-country differences in economic growth. Jorgenson et al. (2008) find that ICT investment accounted for a substantial share of the US productivity growth resurgence in the late 1990s and early 2000s. Cette et al. (2015) cover a set of advanced economies, including the euro area, and show that the contribution of ICT to labour productivity growth rose significantly in 1994-2004 compared to 1974-1994. Bloom et al. (2012) compare the productivity of American and European firms investing in ICT and find that European firms benefited less from the potential offered by computers (during the past technological revolution), as they were more reluctant to introduce changes in their organisational practices.

A third body of research related to our study documents the *productivity paradox* or *productivity puzzle*, which points to the subdued productivity growth in advanced economies despite the widespread diffusion of digital technologies. As observed by Solow (1987), '*one can see the computer age everywhere but in the productivity statistics*'. Building on this paradox, Brynjolfsson et al. (2021) proposed the notion of a "*productivity J-curve*", according to which measured productivity may initially decline or stagnate following the adoption of new general-purpose technologies. This occurs because firms invest in unmeasured intangible capital and restructuring before complementary assets and organisational practices fully materialise and productivity accelerates. At the same time, Asirvatham et al. (2026) have calculated that the speed of adoption of general purpose technologies has increased in recent decades.

Finally, a recent strand of the literature, building on the analysis by Draghi (2024) and Fuest et al. (2024), has contributed to the ongoing policy debate about the structural factors underlying the productivity growth gap between Europe and the US. Several authors discuss the role of institutional governance, regulatory frameworks and human capital in the context of the EU-US innovation gap. Alvarez et al. (2026) demonstrate that in EU regions, high-quality government institutions act as key mediators that significantly boost economic returns to education, physical capital, and innovation investment. Similarly, Bothner et al. (2026) and Coatanlem and Coste (2025) find that better institutional quality and more efficient labour markets are associated with higher investment in innovative, high-tech, and artificial intelligence industries. Roth and Mitra (2025) find an important role for human capital and organisational capital in explaining labour productivity growth.

Overall, the literature suggests that the type of investment matters for productivity and therefore for economic growth. However, the literature offers relatively limited evidence on which specific types of investment are most efficient and have higher link with growth —a gap this study seeks to address. Specifically, our analysis contributes to the literature by introducing a standardised investment efficiency ratio showing that intangible and tangible ICT investments are more strongly associated with short- and medium-term GDP growth than other assets, while also uncovering significant heterogeneity in this relationship across income levels, human capital, and time periods.

3 Dataset

The analysis is conducted for two country groups. The first group consists of EU member states excluding Ireland. We exclude Ireland from the main analysis, as its GDP growth is heavily distorted by multinational corporations relocating intellectual property assets for tax purposes.[1] The second group incorporates three additional advanced countries: the United States, the United Kingdom, and Japan. The sample comprises annual data from 1996 to 2021. The list of variables used in the study was compiled from publicly available databases such as the World Bank, AMECO, the ECB, Penn World tables (PWT) 11.0 (Feenstra et al., 2015) and EUKLEMS (Bontadini et al., 2023). A complete list of the variables used and their descriptive statistics are

[1] This phenomenon was particularly evident in 2015, when the Irish statistical office reported a 26% surge in GDP (Central Statistics Office (2016) and Andersson et al. (2024)). Investment figures are likewise affected by this distortion. As a robustness check, however, we also report results from our panel fixed-effects model including Ireland, and the main conclusions remain unchanged, see Appendix A.3.

shown in Table 1.

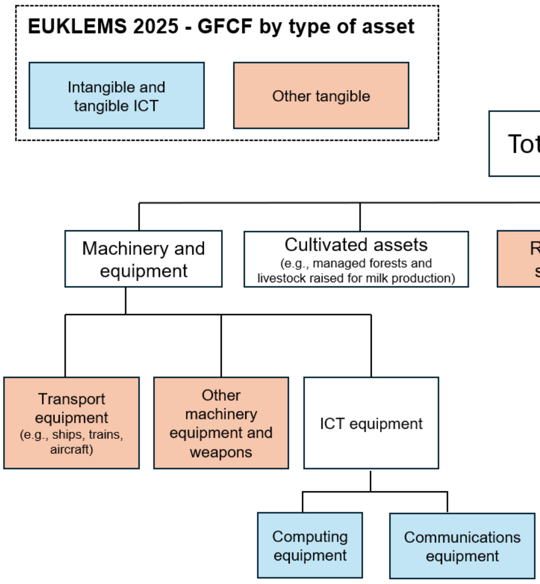
Table 1: Descriptive statistics of the variables

Source / Variable (units)	Obs	Mean	Std Dev	Min	Max
EU KLEMS (Bontadini et al., 2023)					
Investment by asset type as % of value added					
Total GFCF	749	23.7	4.1	2.8	40.39
Other Machinery and Equipment	730	4.64	1.48	0.65	11.14
Total non-residential investment	749	7.99	2.71	1.42	17.37
Residential structures	749	5.18	2.17	0.34	13.51
Transport equipment	749	2.05	1.02	-2.71	7.2
Computing equipment	737	0.46	0.26	0.02	2.02
Communications equipment	722	0.37	0.23	0.04	1.48
Computer software and databases	749	1.32	0.85	-0.15	8.56
Cultivated assets	697	0.12	0.16	-0.04	1.44
Research and development	746	1.68	1.06	0.14	5.85
Other IPP assets	722	0.27	0.26	0.01	1.51
AMECO					
Real GDP per capita (thousands of eur)	754	26.21	17.77	3.2	101.17
Employment rate (% of labour force)	749	91.83	4.03	74.8	97.98
Govt. budget balance (% of GDP)	754	-2.9	3.39	-15.42	6.89
Total Factor Productivity (2020=100)	754	91.94	11.58	49.97	121.8
ECB					
Exchange rate (domestic currency/EUR)	754	16.7	55.51	0.61	358.52
World Bank					
Quality of institutions (rescaled from 0 to 1) (*)	754	0.72	0.12	0.44	0.94
PWT 11.0 (Feenstra et al., 2015)					
Human Capital Index (based on years of schooling and returns to education)	754	3.2	0.33	2.11	3.84

Notes: The table presents the summary statistics for the period 1996-2021 for 29 countries, 26 EU member states and the US, the UK and Japan. (*) The full database of the quality of institutions contains six governance indicators: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption. Following Masuch et al. (2016) we have created a summary indicator from the unweighted average of government effectiveness, regulatory quality, rule of law and control of corruption. These four indicators capture the quality of economic and administrative institutions, referred to as institutional quality, while the remaining two (voice and accountability, and political stability) are related to the political setting. The raw indicators range from -2.5 to +2.5, with higher values representing better quality of institutions. For the purpose of this study, we rescaled the indicators from 0 to 1 to facilitate the readability of the coefficients in the econometric estimates. These indicators contain missing values for the years 1997, 1999 and 2001, which we have interpolated (i.e., to fill in the data for the 1997 year, the linear interpolation between the data for 1996 and 1998 was used).

Data on total investment and its composition are obtained from the EUKLEMS 2025 release (Bontadini et al., 2023). The disaggregation available in the dataset is represented by the coloured boxes in Figure 4 where the various categories of investment are classified into intangible and tangible ICT (represented by blue) and other forms of tangible investment (represented by orange).[2]

Figure 4: Gross fixed capital formation decomposition by type of investment



Sources: Authors' calculations based on The Vienna Institute for International Economic Studies (2019) and EUKLEMS 2025.
Notes: The types of assets are based on ESA 2010 definition. We exclude the cultivated investment asset type since data is not available for all countries and its share in total investment is low.

4 Methodologies and results

To assess the relationship between investment and economic performance across countries, we employ a two-step empirical strategy. First, we estimate a panel fixed-effects model to capture the instantaneous relationship between different types of investment growth and real GDP per capita growth. Second, we expand the approach and use panel local projections to trace the dynamic effects. This methodology aims to capture both the short-term aggregate demand relationship of investment as well as the medium-term supply link of investment, which enhances

[2]As a robustness check, we compare total investment as a share of value added from the EUKLEMS dataset with total investment as a share of GDP from the OECD. Overall, both sources display similar trends in investment, as illustrated in Figure 13 in the Appendix. For the purposes of this study, we rely on the EUKLEMS database, primarily due to its more granular breakdown by type of investment.

the economy's long-term production capacity. To investigate potential non-linearities across time, the sample is divided into two subperiods: 1996–2007, corresponding to the pre-Global Financial Crisis (GFC) era, and 2008–2021, representing the post-GFC period.

A potential concern in our empirical specifications is endogeneity. First, investment is a component of GDP by construction, implying a contemporaneous accounting link that may mechanically induce a positive correlation between investment growth and GDP growth. Second, reverse causality may be present, as higher economic growth can itself stimulate investment through increased demand, profits, and improved expectations. Together, these channels may bias the estimated coefficients.

A standard approach to addressing such concerns would be the use of instrumental variables that are correlated with investment but orthogonal to the error term. However, identifying credible instruments in a cross-country setting with disaggregated investment data is particularly challenging. To partially mitigate endogeneity, our baseline specifications include lagged values of investment and other control variables, which helps reduce simultaneity bias and captures pre-determined dynamics. While our results remain robust to this specification, we acknowledge that this strategy does not fully eliminate endogeneity concerns. Consequently, our findings should be interpreted as documenting robust empirical associations rather than causal effects.

4.1 Panel fixed effects

Methodology

To explore the short-run and static relationship between the different types of investment and GDP per capita growth, we employ the following panel fixed effects methodology:

$$\begin{aligned} \ln RGDPpc_{i,t} - \ln RGDPpc_{i,t-1} = \sum_{j=1}^{J} \beta_j \Delta \ln Inv_{i,t,j} + \gamma_1 \ln Inv_{i,t-1} + \gamma_2 \ln RGDPpc_{i,t-1} \\ + \sum_{k=1}^{K} \psi_k X_{i,t,k} + \theta_i + \alpha_t + \epsilon_{i,t} \quad where \quad j = 1, ..., J \end{aligned} \tag{1}$$

The dependent variable is the annual growth rate of real GDP per capita. As explanatory variables we use: $\Delta \ln Inv_{i,t,j}$ which is the investment growth by type of asset j; $RGDPpc_{i,t-1}$ and $Inv_{i,t-1}$ are the natural logarithm of real GDP per capita and natural logarithm of total investment in t-1, respectively; $X_{i,t,k}$ are additional control variables (k) including the employment rate, the government budget balance as share of GDP, and institutional quality. Finally, we control for country (θ_i) and time (α_t) fixed effects[3], and $\epsilon_{i,t}$ is the error term.

Results

The results indicate that most categories of investment exhibit a statistically significant and positive relationship with economic growth in the same period.[4] For the sample of EU26 countries for the period 1996 to 2021, the following investment assets are found to be significant at the 1% level: (i) communications equipment, (ii) research and development (R&D), (iii) other intellectual property products (IPP), (iv) other machinery and equipment, (v) residential structures, (vi) non-residential buildings, and (vii) transport equipment. In contrast, computing equipment and computer software and databases do not display statistically significant effects. Expanding the sample to include the US, Japan, and the UK yields broadly consistent significance levels, with the notable observation that estimated coefficients are generally higher. This suggests a comparatively stronger relationship between investment growth and GDP per capita growth in these additional economies. Splitting the sample into the period before and after GFC indicates that the contemporaneous investment-growth link was stronger before the GFC. The additional control variables show overall the expected sign. For instance, the negative and statistically significant coefficient of the lagged level of GDP per capita confirms the standard convergence or "catching-up" effect (Table 2).

[3] The fixed effects estimator addresses the influence of time-invariant omitted variables.

[4] We conducted a Variance Inflation Factor (VIF) analysis to assess potential multicollinearity among the different types of investment assets. The results indicate that all VIF values are well below the threshold of 5, suggesting no serious multicollinearity concerns in our specifications.

Table 2: Relationship of investment types and GDP per capita growth

Dependent variable	GDP per capita growth					
Countries coverage	EU			EU+US,JP,UK		
Time span	1996-2021	1996-07	2008-21	1996-2021	1996-07	2008-21
Residential structures	0.042***	0.044***	0.044***	0.065***	0.062***	0.067***
	(0.014)	(0.014)	(0.013)	(0.019)	(0.019)	(0.020)
Non residential buildings	0.075***	0.114***	0.063***	0.101***	0.143***	0.085***
	(0.011)	(0.025)	(0.010)	(0.019)	(0.028)	(0.018)
Other machinery & equipment	0.067***	0.053**	0.054***	0.084***	0.065**	0.075***
	(0.010)	(0.022)	(0.015)	(0.014)	(0.027)	(0.019)
R&D	0.045***	0.065***	0.034**	0.060***	0.081***	0.050**
	(0.012)	(0.021)	(0.015)	(0.014)	(0.023)	(0.021)
Transport equipment	0.016***	0.033***	0.017**	0.017***	0.039***	0.019**
	(0.005)	(0.008)	(0.007)	(0.006)	(0.009)	(0.009)
Computing equipment	0.006	0.013**	0.008	0.009	0.017***	0.011
	(0.006)	(0.005)	(0.005)	(0.007)	(0.006)	(0.007)
Communications equipment	0.012***	0.017**	0.009*	0.015***	0.019**	0.013**
	(0.004)	(0.007)	(0.004)	(0.005)	(0.008)	(0.005)
Computer software & databases	0.016	0.043***	0.003	0.022*	0.046***	0.011
	(0.011)	(0.011)	(0.007)	(0.013)	(0.013)	(0.010)
Other IPP assets	0.006***	-0.003	0.011***	0.008**	-0.001	0.015***
	(0.002)	(0.004)	(0.004)	(0.003)	(0.005)	(0.005)
ln Real GDP pc (-1)	-0.098***	-0.289**	-0.149***	-0.098***	-0.266***	-0.215***
	(0.034)	(0.111)	(0.033)	(0.027)	(0.085)	(0.046)
ln GFCF (-1)	0.037**	0.152***	0.038**	0.046***	0.176***	0.062**
	(0.015)	(0.049)	(0.018)	(0.016)	(0.050)	(0.027)
Employment rate	0.034	-0.291	0.207*	-0.025	-0.418**	0.219*
	(0.071)	(0.172)	(0.108)	(0.080)	(0.153)	(0.121)
Govt. Budget balance %GDP	0.001	0.001	0.001**	0.001	0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Quality of institutions	0.154	0.376**	0.144	0.141*	0.248**	0.034
	(0.112)	(0.178)	(0.093)	(0.082)	(0.116)	(0.125)
Constant	-0.220*	-0.754***	-0.269**	-0.267**	-0.913***	-0.244
	(0.120)	(0.248)	(0.119)	(0.128)	(0.265)	(0.153)
Observations	593	246	322	667	279	360
R-squared	0.740	0.690	0.828	0.715	0.713	0.777
No of countries	26	25	26	29	28	29

Notes: Time and country fixed effects estimates. *** significant at 1% level, ** significant at 5%, * significant at 10%. Cluster standard errors by country in parentheses. EU includes all EU member states except Ireland.

The estimated coefficients can be interpreted as follows: A one percentage point increase in the growth rate of investment of type j is associated with a $\hat{\beta}$ percentage point change in GDP pc growth. However, this interpretation abstracts from differences in the economic magnitude of each investment category. For instance, a 1% increase in R&D does not correspond to the same euro value as a 1% increase in residential structures. To account for these differences and enable meaningful comparisons across investment types, we scale the estimated effects by their relative importance in total investment. Specifically, we construct an investment efficiency ratio, defined as a normalised measure that relates the estimated growth impact of each investment category to its average share in total investment. This metric provides an approximation of the growth return per unit of investment, allowing us to assess which types of investment are associated with higher GDP per capita gains in euro terms.

For the construction of the investment efficiency ratio, we first compute the weighted investment share ($s_{i,j}$) on average across countries ($\bar{s}_j$) as follows:

$$s_{i,j} = \underbrace{\frac{a_{i,j}}{\sum_{i=1}^{N} a_{i,j}}}_{\text{country weight}} \cdot \underbrace{\frac{a_{i,j}}{\sum_{j=1}^{J} a_{i,j}}}_{\text{asset share}} \rightarrow \bar{s}_j = \sum_{i=1}^{N} s_{i,j} \tag{2}$$

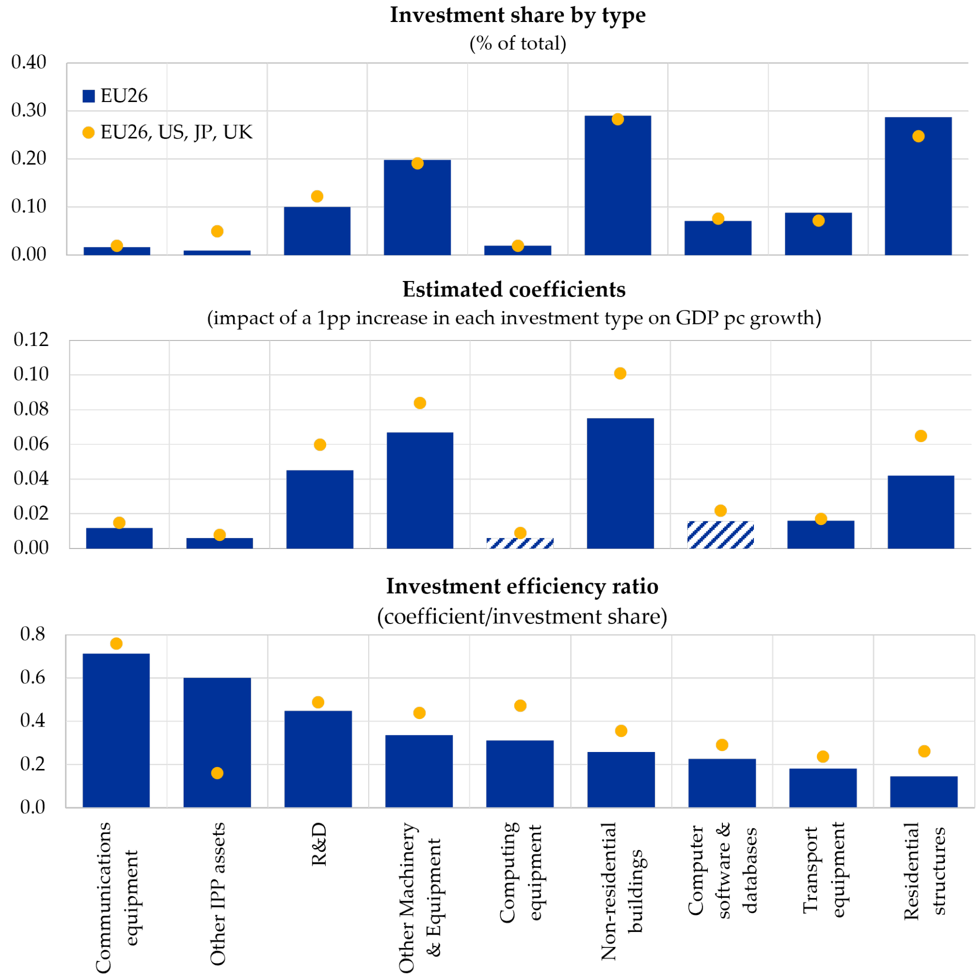
where, $a_{i,j}$ is the investment value of asset j in country i; N represents all countries and J all types of investment on average across the period analysed. Intuitively, this weighted share reflects how large each investment type is in the total capital formation of each country. Second, we compute the investment efficiency ratio as follows:

$$\text{Investment Efficiency ratio}_j = \frac{\hat{\beta}_j}{\bar{s}_j}$$

where, $\hat{\beta}$ is the estimated coefficient of each asset j from the panel fixed effect results in Table 2.

The efficiency ratio expresses the relative return per unit share of investment. While this metric relies on simplifying assumptions, most notably linearity and constant returns, and should not be interpreted as a causal or structural measure of investment efficiency, it provides a useful proxy for comparing the relative efficiency across different types of investment. Figure 5 illustrates the key components underlying this measure: (i) the weighted share of each type of investment in total investment (top panel), (ii) the estimated coefficients of each investment from Table 2 (middle panel), and (iii) the resulting investment efficiency ratios (bottom panel). The results are presented for the EU26 countries and the broader group of 29 countries. The analysis reveals that investment in communications equipment, other IPP, and R&D have the highest investment efficiency among all investment categories. Furthermore, the inclusion of the US, Japan, and the UK in the country sample leads to a generally higher investment efficiency ratio (except for other IPP), suggesting that these economies show greater output per capita gains in the presence of comparable investments in technology-intensive assets. This is in line with Bloom et al. (2012), who find that US firms achieve higher productivity returns from IT investment than European firms due to superior management practices and labour flexibility. Our findings may thus reflect the macroeconomic manifestations of these micro-level differences in the ability to translate technological investment into productivity growth.

Figure 5: Investment: Weighted shares, estimated coefficients and efficiency ratio



Source: Authors' own calculations.
Notes: The top panel shows the weighted share of each type of investment in total investment. The middle panel shows the estimated coefficients of each investment equation based on Equation 1. The bottom panel shows the resulting investment efficiency ratios, defined as the relative return per unit share of investment (Equation 2). The dashed bars represent not significant coefficients. We exclude the cultivated investment asset type since data is not available for all countries and its share in total investment is low.

To explore possible non-linearities across time, and as a robustness check, we re-estimate the baseline specification by grouping the investment types into two broad categories: a) intangible and tangible ICT investments, and b) other tangible investments. The results, reported in

Table 3, indicate that both categories remain positively and significantly associated with GDP per capita growth, with higher coefficients in the period prior to the GFC. Constructing the investment efficiency ratio reinforces the message of higher efficiency in intangible and tangible ICT investments compared to other tangible across all periods analysed.

Table 3: Link between groups of investment types and GDP per capita growth

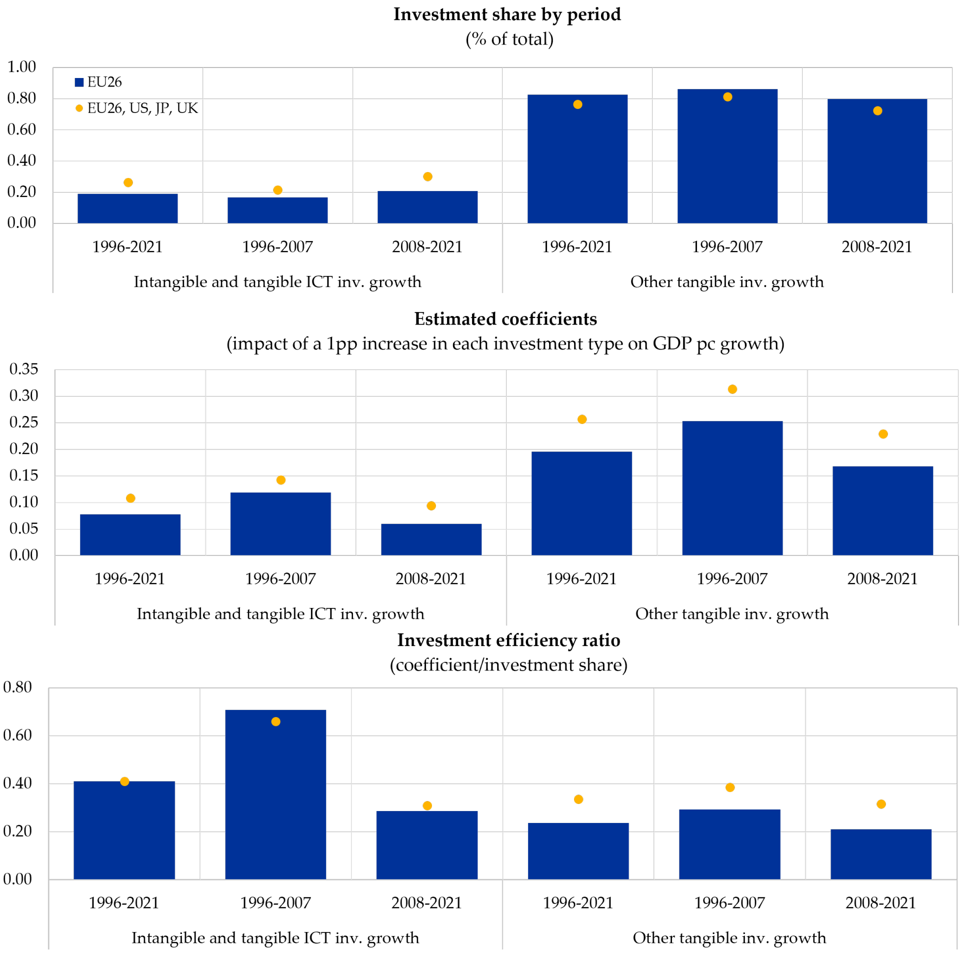
Dependent variable	GDP pc growth					
Countries coverage	EU26			EU26+US,JP,UK		
Time span	1996-2021	1996-07	2008-21	1996-2021	1996-07	2008-21
Other tangible inv.	0.196***	0.253***	0.168***	0.257***	0.314***	0.229***
	(0.027)	(0.046)	(0.024)	(0.043)	(0.055)	(0.044)
Intangible & tangible ICT inv.	0.078***	0.119***	0.060***	0.108***	0.143***	0.094***
	(0.017)	(0.033)	(0.014)	(0.024)	(0.036)	(0.027)
ln Real GDP pc (-1)	-0.100***	-0.290***	-0.162***	-0.103***	-0.277***	-0.234***
	(0.032)	(0.099)	(0.032)	(0.024)	(0.071)	(0.047)
ln GFCF (-1)	0.038**	0.158***	0.033**	0.048***	0.184***	0.059**
	(0.015)	(0.046)	(0.014)	(0.015)	(0.043)	(0.024)
Employment rate	0.060	-0.244	0.262**	0.022	-0.349**	0.307**
	(0.071)	(0.163)	(0.109)	(0.079)	(0.141)	(0.122)
Govt. Budget balance %GDP	0.001	0.001	0.001**	0.001	0.003	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Quality of institutions	0.145	0.340*	0.167**	0.134*	0.229*	0.064
	(0.103)	(0.173)	(0.074)	(0.078)	(0.117)	(0.113)
Constant	-0.240**	-0.823***	-0.252**	-0.312**	-1.007***	-0.264*
	(0.115)	(0.228)	(0.094)	(0.124)	(0.218)	(0.130)
Observations	595	248	322	669	281	360
R-squared	0.739	0.672	0.822	0.709	0.699	0.772
No of countries	26	25	26	29	28	29

Notes: Time and country fixed effects estimates. *** significant at 1% level, ** significant at 5%, * significant at 10%. Cluster standard errors by country in parentheses. EU26 includes all EU member states except Ireland. Other tangible includes other machinery, residential buildings, non-residential buildings, and transport equipment. Intangible and tangible ICT contains communications equipment, computing equipment, other IPP, R&D, and software databases.

At the same time, the results show some evidence of time variation in these relationships. The efficiency ratios are higher in the 1996-2007 period than in 2008-2021, with a particularly pronounced reduction for intangible and tangible ICT investments (Figure 6). The observed decline in investment efficiency ratios after 2008 could reflect a productivity paradox associated with the diffusion of new general-purpose technologies. As argued by Brynjolfsson (2021), the adoption of such technologies often requires substantial complementary intangible and organisational investments that are not immediately captured in output statistics. This delay gives rise to a productivity J-curve phenomenon, whereby productivity temporarily lags behind technological adoption before rebounding as complementarities materialise.

An alternative explanation relates to measurement issues. In the post-GFC period, innovation has increasingly shifted toward data-driven and digital services, many of which generated unpriced benefits (for instance, free digital platforms or applications). As a result, conventional GDP measures may underestimate the true contribution of these investments to consumer welfare (Ahmad et al., 2017). Moreover, increasing structural weaknesses related to inefficient labour and product market regulations that hinders the entry of new firms and job creation, and provides insufficient incentives to innovate may have played a role (Masuch et al., 2018, 2023; Bothner et al., 2026; Coatanlem and Coste, 2025).

Figure 6: Results by grouping investments and different periods



Sources: Authors' own calculations
Notes: The top panel shows the weighted share of each type of investment in total investment. The middle panel shows the estimated coefficients of each investment equation based on Equation 1. The bottom panel shows the resulting investment efficiency ratios, defined as the relative return per unit share of investment (Equation 2). The dashed bars represent not significant coefficients. We exclude the cultivated investment asset type since data is not available for all countries and its share in total investment is low.

High- versus low-income EU26 member states

In addition to time variation, we also explore heterogeneity across countries by splitting the EU26 sample according to income levels. Countries are classified as high income if their GDP per capita in 2021 exceeds the EU-26 median, and as low income otherwise. Under this classification, the high-income group comprises Austria, Belgium, Cyprus, Germany, Denmark, Spain, Finland, France, Italy, Luxembourg, Malta, the Netherlands, and Sweden, while the remaining EU-26 countries fall into the low-income group.

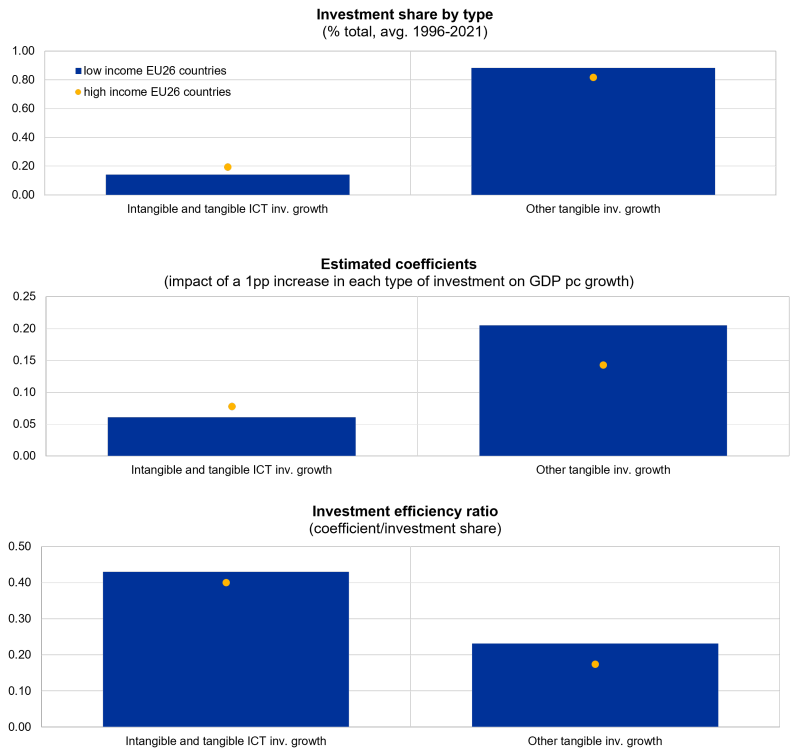
The results reveal clear heterogeneity in the investment–growth relationship (see Table 4). In low-income EU countries, other tangible investments exhibit a stronger association with economic growth, whereas the estimated coefficients for both intangible and tangible ICT investments are relatively lower than in high-income countries. This highlights the importance of complementarities between different types of investment in fostering economic growth (Thum-Thysen et al. (2017); Thum-Thysen et al. (2021)). In particular, lower-income economies may benefit from strengthening their basic infrastructure and physical capital -such as transport equipment and other machinery- to enhance the effectiveness of intangible and tangible ICT investments -such as, R&D and other IPP- which are more efficient (see Figure 7).

Table 4: High vs low income EU member states

Dependent variable	GDP per capita growth	
Countries coverage	High income countries	Low income countries
Other tangible investment	0.143**	0.205***
	(0.061)	(0.032)
Intangible & tangible ICT investment	0.078*	0.061***
	(0.041)	(0.015)
ln Real GDP pc (-1)	-0.090	-0.194***
	(0.061)	(0.050)
ln GFCF (-1)	0.027	0.061*
	(0.024)	(0.029)
Employment rate	-0.055	0.152
	(0.069)	(0.115)
Govt. Budget balance %GDP	0.002**	-0.000
	(0.001)	(0.001)
Quality of institutions	-0.028	0.233
	(0.064)	(0.171)
Constant	0.100	-0.421***
	(0.156)	(0.137)
Observations	293	302
R-squared	0.755	0.794
No of countries	13	13

Notes: Time and country fixed effects estimates. *** significant at 1% level, ** significant at 5%, * significant at 10%. Cluster standard errors by country in parentheses. Other tangible includes other machinery, residential buildings, non-residential buildings, and transport equipment. Intangible and tangible ICT contains communications equipment, computing equipment, other IPP, R&D, and software databases.

Figure 7: Investment in high- vs low-income EU26 countries



Source: Authors' own calculations.
Notes: High-income group contains Austria, Belgium, Cyprus, Germany, Denmark, Spain, Finland, France, Italy, Luxembourg, Malta, the Netherlands, and Sweden. Low-income group covers Bulgaria, Czechia, Estonia, Greece, Croatia, Hungary, Lithuania, Latvia, Poland, Portugal, Romania, Slovakia, and Slovenia. The top chart shows the weighted share (following equation 2) of each type of investment in total investment.

Scenario analysis

This section examines the potential gains in terms of real GDP per capita if the EU26 countries were to adopt an investment strategy aligned with that of the US. This exercise is intended as an illustrative scenario analysis rather than a formal forecast. It provides a partial-equilibrium scaling of potential impacts based on stable estimated coefficients of each investment type from Table 2, combined with assumptions about the growth rates of the different investments.

We consider three alternative scenarios: (i) *EU26 trend growth* where the EU26 investments continue to grow at its 2010-2019 average annual rate; (ii) *US trend growth* where EU26 countries match US growth rates in intangible and tangible ICT investment while other components evolve according to EU trends; and (iii) *US catch-up* where the EU26 countries fully converge with the US investment levels by 2035, assuming continued US growth at its average rate of 2010-2019.

The growth assumptions (Table 5) for the *EU26 trend growth* and *US trend growth* scenarios are benchmarks based on historical performance. The *US catch-up* scenario is a stylised "upper bound" exercise. While the implied growth rates required for full convergence may be ambitious from a structural perspective, the scenario serves to illustrate the magnitude of the existing investment gap and the potential gains from closing it.

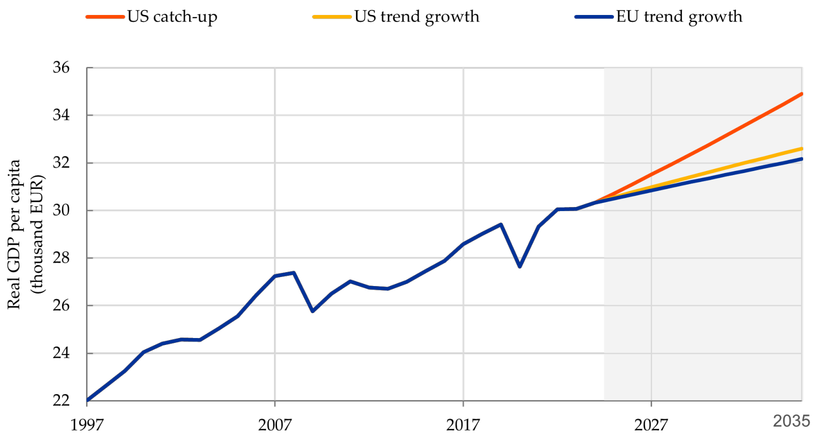
Table 5: Assumptions on investment growth

Investment type	**EU26 trend (2010–19)**	**US trend (2010–19)**	**US catch-up (by 2035)**
Computer software & databases	2.8%	4.4%	16.3%
R&D	1.9%	3.2%	10.8%
Communications equipment	2.3%	4.7%	21.0%
Other IPP assets	0.8%	0.7%	17.6%
Computing equipment	2.0%	3.0%	11.4%

Notes: The table displays the average annual growth rates for the period 2025-2035.

Table 5 summarises the assumed growth rates for the five ICT-intensive investment categories under each scenario. Under the US trend growth scenario, ceteris paribus, GDP per capita in the EU26 could be more than 1.3% (or €430) higher by 2035 relative to the EU trend scenario. Under the more ambitious US catch-up scenario, GDP per capita could be more than 8.5% (corresponding to more than €2700) higher relative to the EU26 trend scenario (Figure 8). These results should be interpreted as indicative of the "cost of inaction" regarding the investment gap, bearing in mind the limitations of the analysis, including the assumptions of stable coefficients and the absence of general equilibrium effects.

Figure 8: Scenario analysis



Sources: Authors' own calculations
Notes: The solid blue line which is not in the shaded area represents the actual Real GDP per capita of the EU26. The solid blue line under the shaded area represents the *EU trend growth scenario.* The solid yellow line represents the *US trend scenario.* The solid orange line represents the *Us catch-up scenario.* The variables for which an assumption is not made in Table 5 remain at their 2010-2019 averages.

4.2 Panel local projections

Methodology

To explore the dynamic relationship of asset-specific investment and GDP per capita, we implement panel local projections (Jordà, 2005; Jordà and Taylor, 2024).

$$\begin{aligned} \ln RGDPpc_{i,t+h} - \ln RGDPpc_{i,t-1} = \beta_1^h \Delta \ln Inv_{i,t}^{(j)} + \beta_2^h \Delta \ln Inv_{i,t-1}^{(j)} + \beta_3^h \ln RGDPpc_{i,t-1} + \\ + \beta_4^h \ln Inv_{i,t-1} + \sum_{k=1}^{K} \psi_k^h X_{i,t,k} + \sum_{k=1}^{K} \omega_k^h X_{i,t-1,k} + \\ + \theta_i^h + \alpha_t^h + \epsilon_{i,t}^h \end{aligned} \tag{3}$$

The dependent variable is the long difference of log GDP per capita at horizon h where $h = 0, 1, 2, 3, 4.$[5] $\Delta \ln Inv_{i,t}^{(j)}$ is the contemporaneous impulse variable (each one of the investment types j individually). $\Delta \ln Inv_{i,t-1}^{(j)}$ is one lag of the impulse variable j. $\ln RGDPpc_{i,t-1}$ and $\ln Inv_{i,t-1}$ are natural logarithm of real GDP pc, and natural logarithm of total investment

[5] As the effective sample size in local projections declines as the horizon increases, statistical power deteriorates at longer horizons. To mitigate this concern, we report impulse responses only up to horizon $h = 4$, where confidence intervals remain sufficiently informative. This choice reflects a conservative approach to inference rather than an absence of medium-run dynamics.

in t-1, respectively. $X_{i,t,k}$ covers additional contemporaneous control variables (k) including employment rate, government budget balance as a share of GDP, institutional quality, and investment growth for the type of investments that are not included as impulse variable. $X_{i,t-1,k}$ represents one lag of all control variables k. Finally, θ_i and α_t are the country and time fixed effects, respectively, and $\epsilon_{i,t}^h$ is the error term.

In this case, we are interested in the evolution of β_1^h across the horizon h to analyse the medium-run dynamics of the relationship between investment by type of asset and real GDP per capita. Following (Jordà et al., 2015), we estimate the panel local projections plotting the cumulative impulse responses of GDP per capita growth ($\ln RGDPpc_{i,t+h} - \ln RGDPpc_{i,t-1}$) to different types of investments.

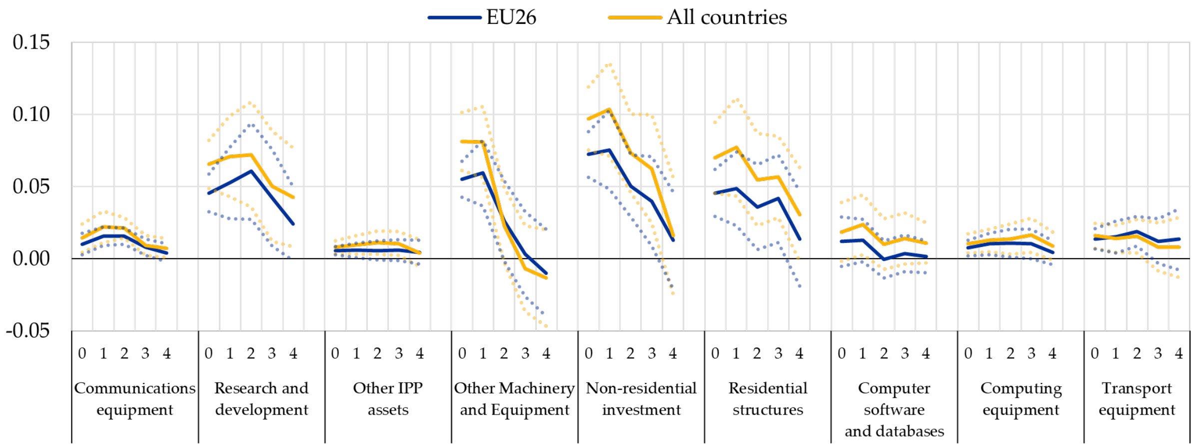
To ensure the validity of our estimates, we address the potential Nickell bias (Nickell, 1981), which can lead to substantial biases in local projection impulse responses when the time-series dimension (T) is small relative to the cross-sectional dimension (N) (Herbst and Johannsen, 2024). We mitigate this by implementing the split-panel jackknife estimator developed by Dhaene and Jochmans (2015).[6] This procedure corrects for the downward bias inherent in fixed effects estimators of dynamic panels.

Results

The impulse response functions (IRFs) show that investments in intangible and tangible ICT exhibit the most persistent and long-lasting association with GDP per capita growth compared to other tangibles investments (Figure 9). Within this category, R&D stands out as the investment type with the largest cumulative response. Communications equipment, other IPP, computer and software, and computing equipment exert a more modest but still positive and persistent relationship. By contrast, other tangibles, like other machinery, non-residential, and residential assets exhibit a short-lived association with GDP per capita that largely dissipate after one period. The results for the EU26 countries are broadly consistent with those for the extended sample that includes the US, the UK and Japan.

[6] We use the split-panel jackknife (SPJ) correction instead of generalized method of moments introduced by Arellano and Bond (1991) to address the dynamic panel (Nickell) bias. The GMM estimators can easily generate numerous instruments that can overfit endogenous variables, which can lead to severely biased estimates and low-power specification tests (Roodman, 2009). In contrast, the SPJ provides a transparent, resampling-based correction that is more robust to the arbitrary lag-selection and instrument-collapse decisions inherent in GMM frameworks. As demonstrated by Dhaene and Jochmans (2015), the SPJ effectively reduces the first-order bias of the fixed effects estimator while maintaining higher efficiency and avoiding the restrictive identification assumptions required by the GMM approach.

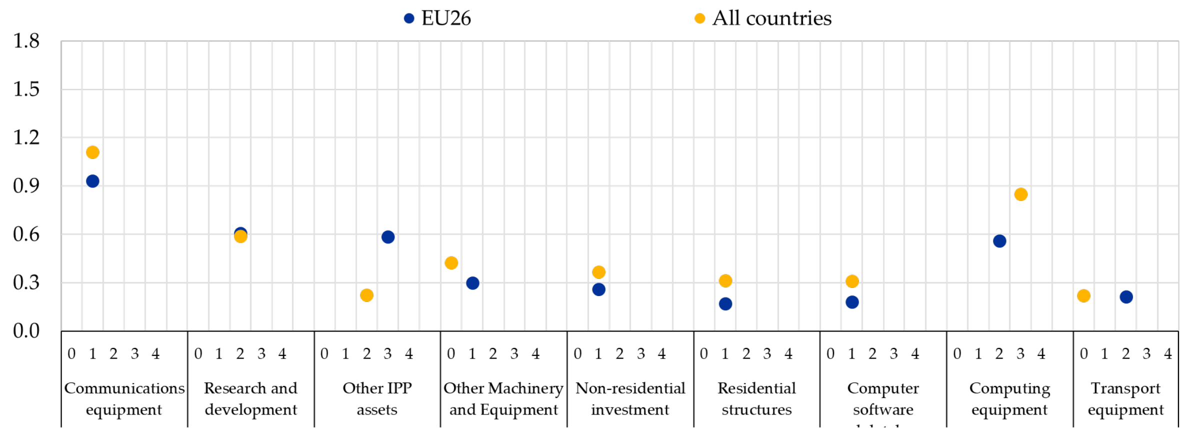
Figure 9: IRFs of GDP per capita growth to different types of investment



Source: Author's own calculations.
Note: The figure displays the cumulative effect of investment on real GDP per capita (solid lines) over four periods ahead and 68% confidence bands (dashed lines).

Building on the approach applied in the panel fixed effects analysis, we construct an investment efficiency ratio based on the peak cumulative response for each investment category. The results are broadly consistent with those obtained under the fixed effects framework: communications equipment, R&D, and other IPP continue to emerge as the most efficient forms of investment, reinforcing the robustness of our findings. Moreover, extending the sample to incorporate the US, the UK, and Japan leads to larger estimated effects and, correspondingly, higher efficiency ratios (Figure 10). An additional insight from the dynamic analysis is the timing of peak effects. For intangible and tangible ICT investments, the maximum impact on GDP per capita growth typically materialises after one year, whereas other tangible investments tend to peak either contemporaneously or within one year. This pattern further supports the view that ICT-related investments are more strongly linked to medium-term growth dynamics.

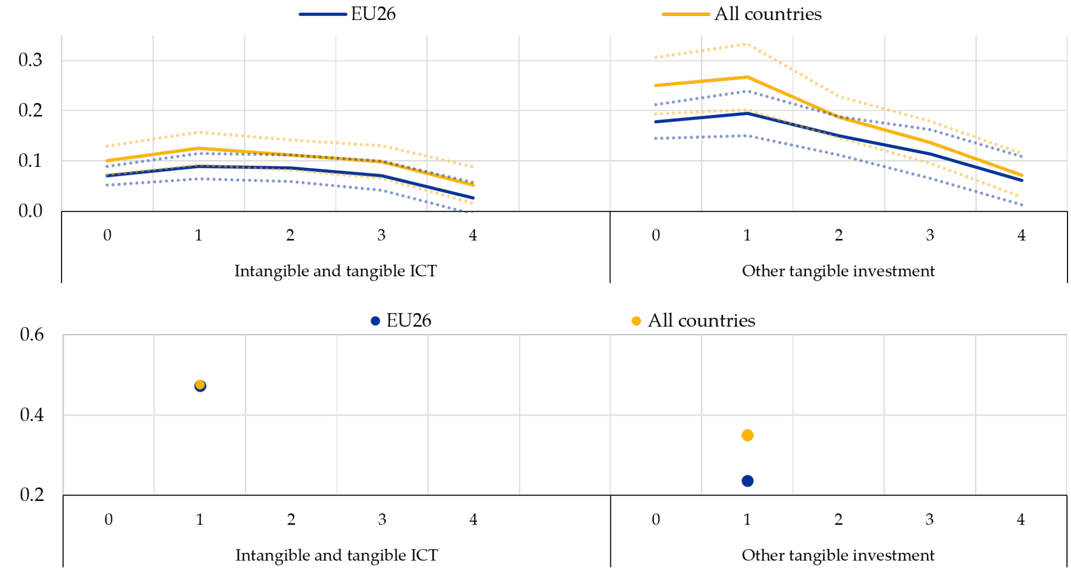
Figure 10: Investment efficiency ratios by asset



Source: Author's own calculations.
Note: The efficiency ratio is calculated as the ratio between the estimated coefficients of each asset by their weighted share in total investment. The results are represented at the peak impact period.

When aggregating investment types into two broad groups -intangible and tangible ICT investments, and other tangible investments- a similar pattern emerges. The IRFs for intangible and tangible ICT investments exhibit more persistent effects over the medium term, and their associated efficiency ratios remain higher than those of other tangible assets (Figure 11).

Figure 11: IRFs of GDP per capita growth to different types of investment (top chart) and investment efficiency ratios (bottom chart)



Source: Author's own calculations.
Note: The upper panel displays the cumulative effect of investment on real GDP per capita (solid lines) over four periods ahead and 68% confidence bands (dashed lines), for the EU26 sample (blue) and full sample (yellow). The lower panel illustrates the investment efficiency for each investment category and estimation sample at the period of peak impact.

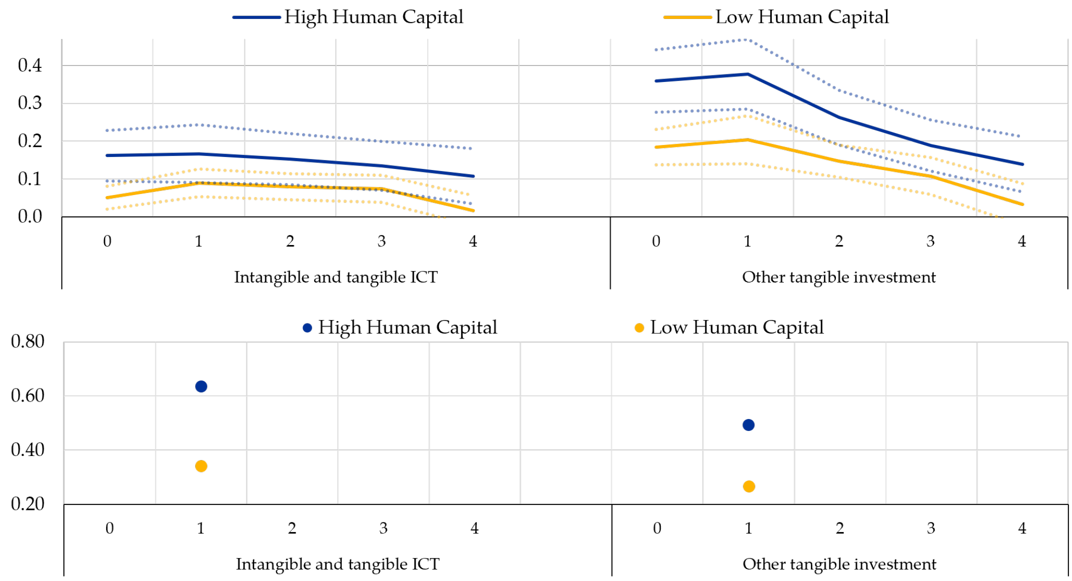
To assess whether the relationship of investment and economic growth varies with countries' human capital levels, we estimate state-dependent local projections as follows:

$$\begin{aligned}\ln RGDPpc_{i,t+h} - \ln RGDPpc_{i,t-1} = {} & \mathbf{1}[hc_{i,t} \leq \text{median}(hc_{i,t})]\,(\beta^h_{1\,low}\Delta \ln Inv^{(j)}_{i,t})+ \\ & \mathbf{1}[hc_{i,t} > \text{median}(hc_{i,t})]\,(\beta^h_{1\,high}\Delta \ln Inv^{(j)}_{i,t})+ \\ & \beta^h_2 \Delta \ln Inv^{(j)}_{i,t-1} + \beta^h_3 \ln RGDPpc_{i,t-1} + \beta^h_4 \ln Inv_{i,t-1}+ \\ & \sum_{k=1}^{K} \psi^h_k X_{i,t,k} + \sum_{k=1}^{K} \omega^h_k X_{i,t-1,k}+ \\ & + \theta^h_i + \alpha^h_t + \epsilon^h_{i,t}\end{aligned} \tag{4}$$

An advantage of adopting a state-dependent approach is that it allows for heterogeneity without splitting the sample, thereby preserving the full set of observations. This is an important consideration in our context, given the relatively short time dimension of our dataset. Countries are classified in each year according to the median value of the human capital index: those with values below or equal to the annual median are assigned to the low human capital group, while those above the median are classified as high human capital economies.[7] Therefore, the evolution of the estimated coefficients $\beta^h_{1\,low}$ and $\beta^h_{1\,high}$ represents the medium-run dynamics between investment and real GDP per capita under low and high levels of human capital, respectively.

The results, presented in Figure 12, reveal clear heterogeneity across these regimes. In countries with high human capital, the positive relationship between investment growth -both in intangible and tangible ICT, as well as other tangible assets- and GDP per capita growth is stronger and more persistent than in countries with low level of human capital. Moreover, the efficiency ratio of intangible and tangible ICT investments is higher than that of other tangible investments, reinforcing the importance of complementarities between human capital and technology-intensive investment.

Figure 12: Low vs high levels of human capital - IRFs of GDP per capita growth to different types of investment (top chart) and investment efficiency ratios (bottom chart)



Source: Author's own calculations.
Note: The upper panel displays the cumulative effect of investment on real GDP per capita (solid lines) over four periods ahead and 68% confidence bands (dashed lines), disaggregated by type of investment and distinguishing between countries with human capital above (blue) and below (yellow) the median. The lower panel illustrates the investment efficiency for each investment category and human capital group at the period of peak impact. Countries are classified as having low (high) human capital if their human capital index is below or equal to (above) the yearly median value across all countries.

[7]See Figure 16 in the Appendix A.1 for the specific distinction of groups.

5 Robustness checks

To further reinforce our empirical findings, we conduct two robustness checks.

First, we replace GDP per capita growth with Total Factor Productivity (TFP) growth as the dependent variable in order to better isolate the productivity effects of different types of investment (see also Nikolov et al. (2024) or Jona-Lasinio et al. (2019)). While GDP growth is mechanically linked to investment through the national accounts identity and also reflects cyclical demand and demographic effects, TFP growth captures changes in the efficiency with which inputs are used. The results (Table 6 in Appendix A.2) show positive and significant coefficients for both intangible and tangible ICT investment, as well as for other tangible assets, consistent with our baseline findings. Nevertheless, we focus on GDP per capita growth as our preferred outcome variable. Our primary interest lies in understanding how different forms of investment contribute to improvements in living standards, rather than to productivity alone. In this respect, GDP per capita growth provides a more comprehensive measure, as it reflects the combined effects of capital deepening, labour utilisation, and efficiency gains, whereas TFP is a residual measure..

Second, we verify the robustness of the results by extending the sample with Ireland to include all 27 EU member states (see Appendix A.3). The main findings remain largely unchanged, with intangible and tangible ICT investments consistently exhibiting higher relative efficiency compared to other forms of investment.

6 Conclusions

In this paper we examine the associations between different types of investment and economic growth across the EU and other advanced economies (including the US, the UK, and Japan). While the aggregate investment-to-GDP ratios in the EU and the US are broadly comparable, our results highlight that the composition of investment plays a crucial role for growth performance. In particular, the EU's relatively lower share of investment directed towards intangible and tangible ICT capital helps explain part of the productivity gap with the US.

Using both a panel fixed effects model and panel local projections to capture short- and medium-term effects, we have shown that intangible and tangible ICT investments, especially investments on communications equipment, R&D, and other intellectual property products, are consistently associated with stronger and more durable effects on output growth. The construction of an investment efficiency ratio, which scales estimated returns by the relative weight of each asset in total investment, highlights these categories as generating the highest efficiency across countries. The inclusion of the US, the UK, and Japan alongside the EU26 reinforces the robustness of our findings, with these economies exhibiting even higher efficiency ratios.

Our results also reveal important dynamics over time. Splitting the sample into pre- and post-GFC periods indicates evidence of non-linearities, with higher investment efficiency before the crisis, particularly for intangible and tangible ICT investments. Moreover, an illustrative scenario analysis suggests that EU GDP per capita could be 1.3% higher by 2035 if EU countries were to match US growth rates in intangible and tangible ICT investment. While these estimates should be interpreted with caution (given the partial-equilibrium nature of the exercise and the assumption of stable coefficients), they provide a useful benchmark for the potential magnitude of the investment gap.

We further document substantial heterogeneity across countries. Economies with higher levels of human capital exhibit a stronger and more persistent association between investment —especially in ICT-related assets— and economic growth. A similar pattern emerges when comparing income groups within the EU: in lower-income countries, other tangible investments are more strongly associated with growth, whereas ICT-related investments display relatively weaker effects. These findings highlight the importance of complementarities between human capital, economic development, and the effectiveness of different types of investment.

Taken together, our results suggest that policies aimed at improving the composition, rather than merely the level, of investment are key to enhancing long-term growth performance in Europe. To unlock the potential of intangible and tangible ICT investments, EU policymakers should pursue a holistic strategy that incentivises capital provision towards high-technology sectors, strengthens human capital through education and digital skills development and reduces financing frictions by deepening European capital-market integration and expanding support for venture capital, startup funding, and public-private partnerships.

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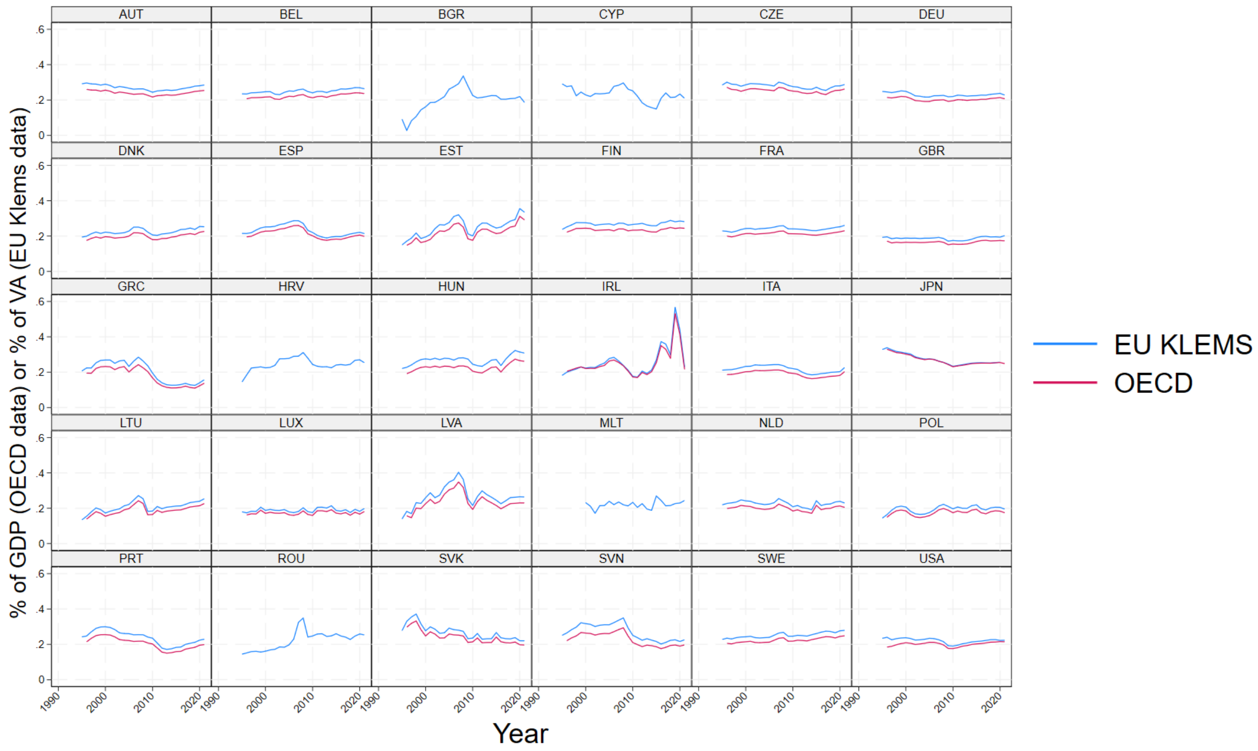
A Appendix

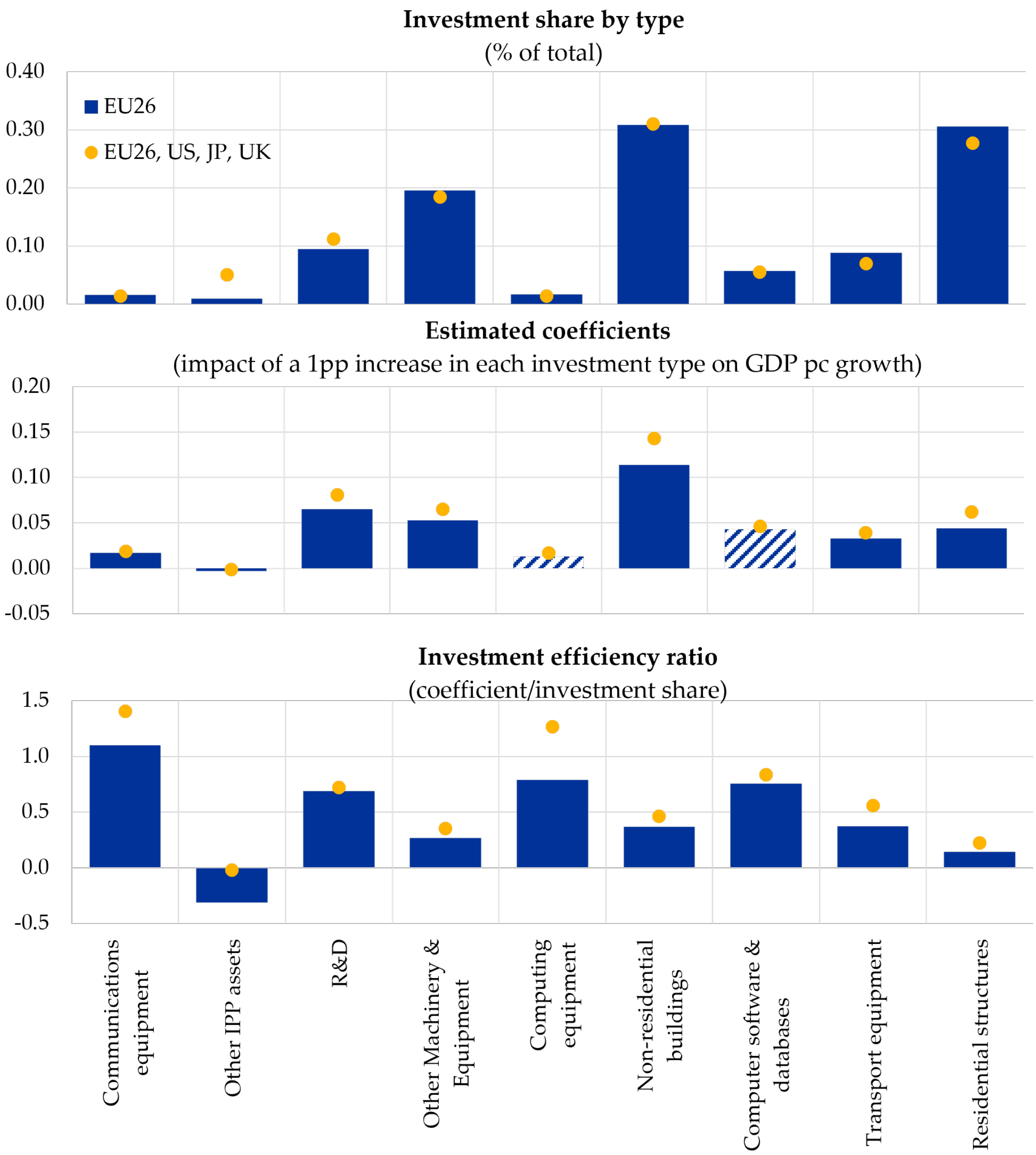
A.1 Additional charts

Figure 13: Total investment (% GDP or %VA)



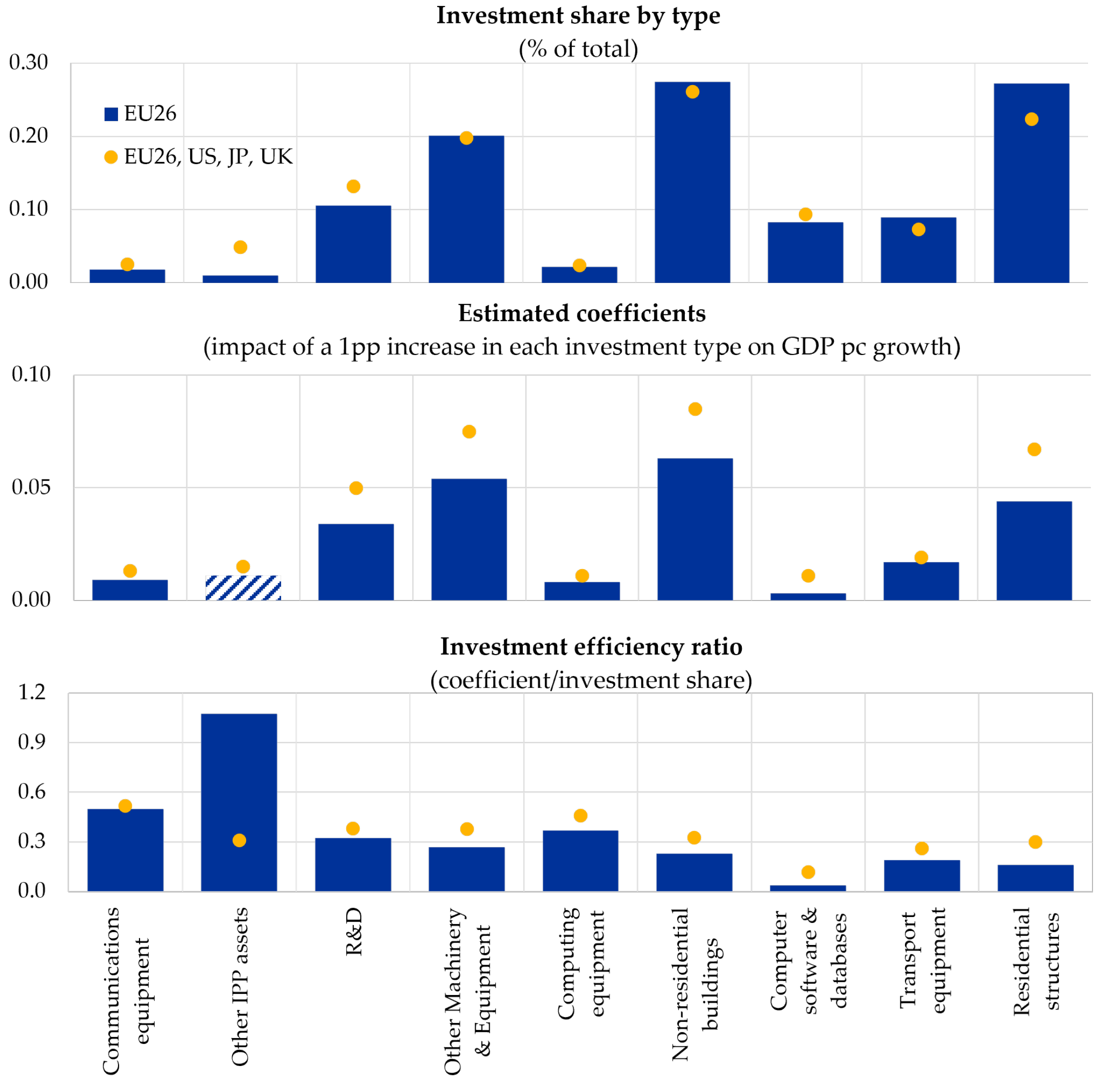
Source: EUKLEMS, OECD and Author's calculations.

Figure 14: Results for period 1996-2007



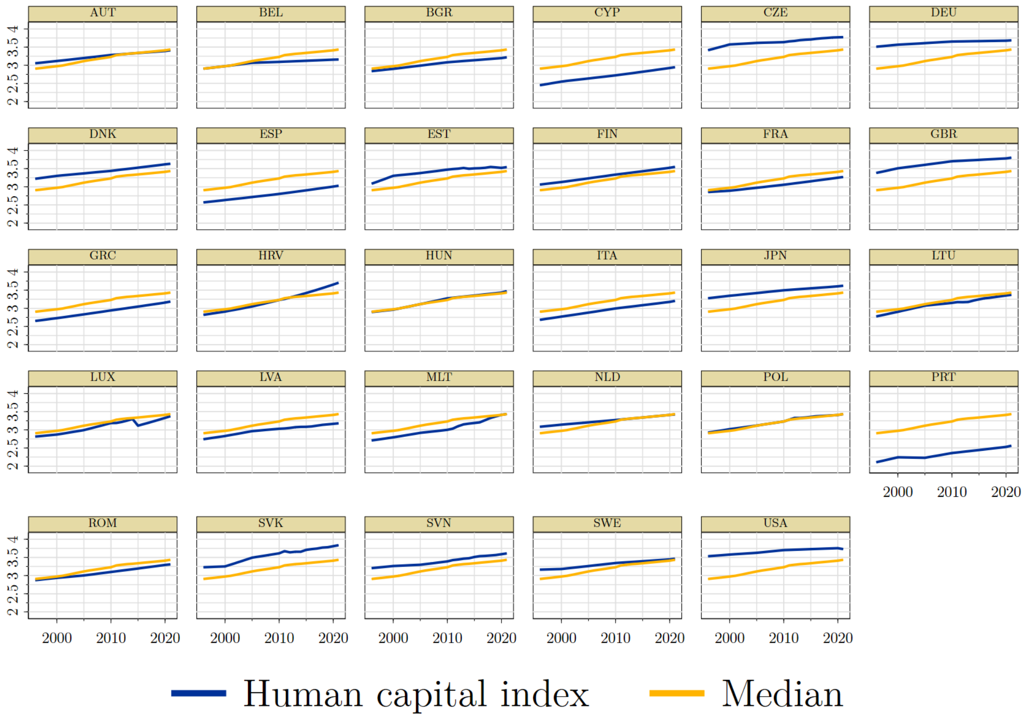
Source: Authors' own calculations.
Notes: The top panel shows the weighted share of each type of investment in total investment. The middle panel shows the estimated coefficients of each investment equation based on Equation 1. The bottom panel shows the resulting investment efficiency ratios, defined as the relative return per unit share of investment (Equation 2). The dashed bars represent not significant coefficients. We exclude the cultivated investment asset type since data is not available for all countries and its share in total investment is low.

Figure 15: Results for period 2008-2021



Source: Authors' own calculations.
Notes: The top panel shows the weighted share of each type of investment in total investment. The middle panel shows the estimated coefficients of each investment equation based on Equation 1. The bottom panel shows the resulting investment efficiency ratios, defined as the relative return per unit share of investment (Equation 2). The dashed bars represent not significant coefficients. We exclude the cultivated investment asset type since data is not available for all countries and its share in total investment is low.

Figure 16: State dependent country classification



Source: Penn World Table and authors' own calculations.
Notes: The figure shows the evolution of the human capital index (blue line) together with the cross-country median in each year (yellow line). Countries are classified annually according to the cross-sectional median of the index: economies with values at or below the yearly median (i.e., when the blue line lies at or below the yellow line) are assigned to the low human capital group, while those above the median (when the blue line lies above the yellow line) are classified as high human capital economies.

A.2 Results using TFP as dependent variable

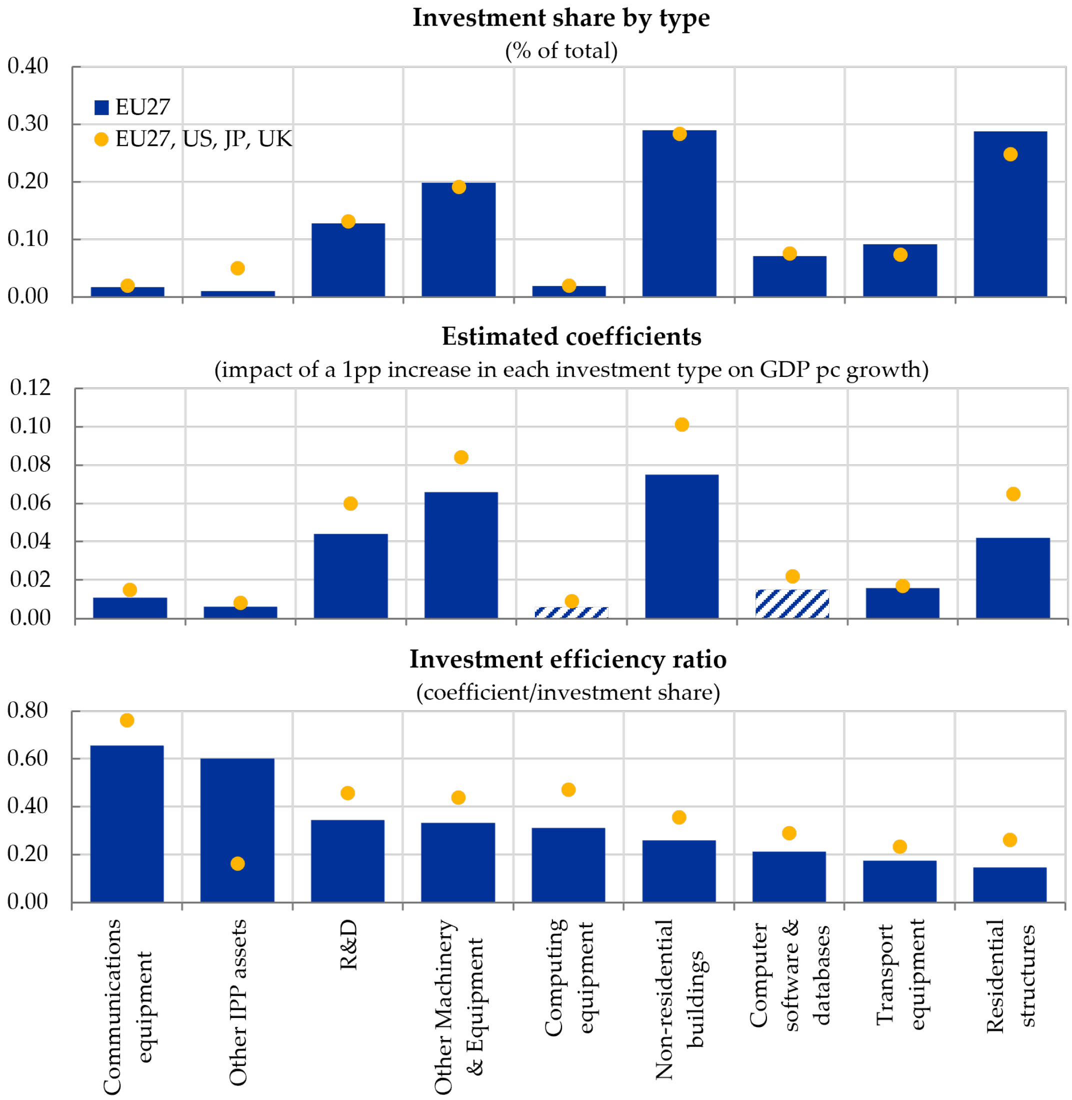
Table 6: Link between investment growth by group of assets type and TFP growth

Dependent variable	TFP growth	
Countries coverage	EU26	EU26+US,JP,UK
Other tangible inv.	0.044**	0.041***
	(0.016)	(0.014)
Intang & tangICT inv.	0.016*	0.014*
	(0.008)	(0.007)
TFP (-1)	-0.001**	-0.001**
	(0.000)	(0.000)
Employment rate	0.015	0.008
	(0.062)	(0.060)
Quality of institutions	0.029	0.033
	(0.035)	(0.029)
Constant	0.063	0.066
	(0.056)	(0.053)
Observations	620	694
R-squared	0.418	0.415
No of countries	27	30

Notes: Time and country fixed effects estimates. *** significant at 1% level, ** significant at 5%, * significant at 10%. Cluster standard errors by country in parentheses. EU26 includes all EU member states except Ireland. Other tangible includes other machinery, residential buildings, non-residential buildings, and transport equipment. Intangible and tangible ICT contains communications equipment, computing equipment, other IPP, R&D, and software databases.

A.3 Results including Ireland in the sample

Figure 17: Investment: Weighted shares, estimated coefficients and efficiency ratio



Source: Authors' own calculations.

Notes: The top panel shows the weighted share of each type of investment in total investment. The middle panel shows the estimated coefficients of each investment equation based on Equation 1. The bottom panel shows the resulting investment efficiency ratios, defined as the relative return per unit share of investment (Equation 2). The dashed bars represent not significant coefficients. We exclude the cultivated investment asset type since data is not available for all countries and its share in total investment is low.

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