

Editors' Overview

The 46th issue of the *International Productivity Monitor* contains five articles. The issue features a symposium of three articles on international productivity performance with a particular focus on the role of intangible capital. Two additional articles discuss the reasons for the recent fall in GDP per capita in Canada and the relationship between productivity and managerial quality.

The sources of growth in modern economies have drastically changed in recent decades. This is especially true for the composition of productive capital. Since the 1990s the investment share of intangibles capital, when broadly measured by including, for example, organizational capital, marketing and branding and business training, has outpaced that of tangible capital, especially in advanced economies. A new stream of research on intangibles and productivity has emerged pointing out the increased contribution of intangible capital to output and productivity growth relative to tangible capital.

This issue of the *International Productivity Monitor* features a symposium entitled International Productivity Growth: The Role of Intangibles. It contains three articles making use of a new and unique international dataset, EUKLEMS & INTANProd database which has merged the original EUKLEMS Growth and Productivity Accounts with a comprehensive range of data on intangible capital by industry. The 2023 release of the EUKLEMS & INTANProd database includes 30 countries with investment and capital metrics for seven tangible assets and eight intangible assets and growth contributions for 38 industries. It provides a version of accounts which is consistent with the official national accounts, and one that uses additional types

of intangible assets, which of course affects the measures of capital, value added and productivity.

The three articles in the symposium analyze the new dataset through different lenses. The first article is by **Filippe Bontadini**, **Carol Corrado**, **Jonathan Haskel**, **Massimiliano Iommi**, **Cecilia Jona-Lasinio** and **Tsutomu Miyagawa**. They provide a comprehensive description and analysis of the data, sketching out a stylized “upstream/downstream” model of production with intangible capital, which is used to assess the performance of innovation, intangibles and productivity for Japan, the United Kingdom, the United States and a range of EU economies.

The second article by **Bart van Ark**, **Klaas de Vries**, and **Abdul Erumban** focuses on one specific question, namely whether intangibles may have contributed to the productivity slowdown in advanced countries since the Global Financial Crisis. The authors analyze a range of different metrics from the EUKLEMS-INTANProd database for the UK, and find a moderate slowdown in the growth of the intangible capital stock and a slightly weaker contribution to productivity growth since 2011. In contrast, the authors of the first article argue that, when using a somewhat shorter timeframe (2014-2019, avoiding the aftermath of the European sovereign debt cri-

sis) and adjusting for mismeasurement of prices for consumer digital services, green shoots of improvements in the performance of intangible capital can be observed.

The third article in the symposium, **John van Reenen** and **Xuyi Yang** uses the EUKLEMS-INTANProd database to analyse the slowdown in UK productivity growth, using France, Germany and the United States as the main comparator countries. The authors show that the extraordinary weakening in UK productivity growth since the Global Financial Crisis is mostly due to the comparatively large slowdown in the growth of capital intensity whereas the fall in TFP growth was broadly similar to other countries. They also find that roughly half of the Britain's gap in productivity level to other countries can be accounted for by lower tangible and intangible capital intensity. Their findings suggest that UK policy should focus on the problem of chronic underinvestment, which might be reversed by greater regulatory convergence to Europe following Brexit, a credible Growth Plan by the government, a better supply of finance for investment from pension funds, a strengthening of the creation of intermediate skills, and improvements in the land use planning system.

In sum, the three papers set out a large academic and policy-focused research agenda for the role of investment and capital for economic growth and productivity.

Real GDP per capita has fallen since mid-2022 in Canada, a situation normally experienced only during recessions. But real output growth was positive in both 2022 and 2023. In the fourth article in the

issue, Philip Smith, formerly a senior official at Statistics Canada, addresses this paradoxical situation through a detailed decomposition of GDP per capita into six components.

The author identifies the very large increase in 2022 and 2023 in the non-permanent resident (NPR) population, driven by increases in the number of temporary foreign workers and international students as the key factor behind the fall in real GDP per capita. This development disincentivized business investment, reducing labour productivity growth. The low wages and productivity levels of NPRs also impeded aggregate productivity and income growth.

It is widely recognized that managerial quality is a key determinant of firm performance including productivity growth in the medium and long term. But the importance of managerial quality in the short term is less well documented. In the fifth and final article in the issue, **Gilbert Cette**, **Jimmy Lopez**, **Jacques Mairesse** and **Giuseppe Nicoletti** contribute to this gap in the literature by showing that during the Great Recession countries with better managed firms experienced smaller employment and output losses which preserved productivity levels.

The authors use a projection method to estimate the impact of shocks on post-2009 macro development at different levels of managerial quality in a country-industry panel for 2007-2015 for 18 industries in 10 OECD countries. Both output and employment are resilient when managerial quality is higher.

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Intangible Capital, TFP Growth and Green Shoots in New Productivity Data

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Abstract

This article undertakes a comparative analysis of recent productivity growth in European economies, Japan, the United Kingdom, and the United States using the EU KLEMS & INTANProd database. The influence of intangible capital on productivity growth and insights from combining long historical time series for TFP with the current estimates in EU KLEMS & INTANProd are central features of our analysis. Our comparative analysis of growth decompositions before and after the productivity slowdown suggests that productivity growth in the 2014-2019 period in advanced economies has been relatively

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strong, consistent with a slew of the newer digital technologies (cloud, big data, AI) gaining wider use. Recent research finds that mechanisms governing knowledge diffusion are weaker recently than in the past—implying that advanced economies are not experiencing their full potential for productivity growth. Unless policies or voluntary industry actions create new platforms for technology extension and data sharing (e.g., open banking policies), the potential for spillovers to amplify intangible-investment induced innovations will be less strong than they have been in the past.

The slow productivity growth since the Global Financial Crisis (GFC) has been widely discussed, with some attributing its causes to the recession’s aftermath (e.g. financial frictions, slowdown of international trade), others to structural factors (e.g. population aging, capital misallocations, decline in business dynamism). This article contributes to this debate using a new database for productivity analysis, the EU KLEMS & INTANProd dataset, to provide new estimates and undertake a comparative analysis of the productivity performance of European economies, Japan, the United Kingdom and the United States.

This database updates and extends previous editions of the widely used EU KLEMS database to incorporate measures of intangible investment from INTAN Invest.² This represents a significant advancement for productivity analysis and policymaking in that it is the first cross-country productivity database including all intangible assets as defined by Corrado, Hulten, and Sichel (2005, 2009) in a framework coherent with national accounts. As in previous editions of EU KLEMS, the Japanese module is kindly supplied by The

Research Institute of Economy, Trade, and Industry (RIETI) and Hitotsubashi University.

The inclusion of all Corrado-Hulten-Sichel intangibles in EU KLEMS & INTANProd both modifies the asset boundary of existing national accounts and the interpretation of total factor productivity (TFP). As a result, this article examines how these first-order modifications affect the analysis of post-GFC productivity developments. In a nutshell, the article finds the oft-quoted magnitudes for the productivity slowdown in the United Kingdom and United States to be exaggerated, especially for the United Kingdom but that sustainable trends in TFP are a notch lower than in the past (as suggested by much recent literature). After reviewing and evaluating the slowdown, the article shifts focus to assessing the growth performance of advanced economies in the six-year period from 2013 to 2019 and finds evidence that productivity growth has been relatively strong—not strong enough in most countries to make up the shortfalls cumulative in the GFC and European sovereign debt crisis periods—but elevated by sus-

2 EU KLEMS & INTANProd is funded by the Directorate General for Economic and Financial Affairs (DG-ECFIN) of the European Commission. For information about past releases of EU KLEMS, see www.euklems.net, van Ark, O’Mahony and Timmer (2008), and Timmer, Inklaar, O’Mahony and van Ark (2010). The 2019 edition of EU KLEMS included intangibles, but the coverage was not comprehensive. For more information about INTAN Invest, see www.intaninvest.net and Corrado *et al.* (2012, 2013, 2016).

tained investments in innovation that seem to have paid off, especially when placed in the context of convergence and trend growth in intangibles-adjusted TFP at the frontier.

This article has five sections. The next section introduces our stylized “upstream/downstream” model of production with intangible capital, a framework we have used in previous works to address how innovation, intangibles and TFP are related in an economy. In the second section, we present the EU KLEMS & INTANProd dataset which offers many new features besides the inclusion of intangible capital. We examine how extending national accounts asset and production boundaries to include intangibles affects the EU KLEMS & INTANProd measures of investment and labour productivity. In the third section we use standard growth accounting techniques to analyze the contribution of intangible capital and TFP to labour productivity growth in the market-sector industries of nine EU economies (aggregated), Japan, United Kingdom, and United States.

In the fourth section we provide a long-term perspective on TFP growth in the non-farm business sector of the US economy and analyze the impact of adjustments for mismeasurement of prices due to product quality change. This allows us to develop an estimate of intangibles-adjusted growth of TFP at the market sector frontier for the United Kingdom and United States. We find that the productivity slowdowns in the United Kingdom and the United States are exaggerated when measured using data starting in 1995 and that TFP growth in the United Kingdom, United States and Japan since 2013 is at or near the rate of

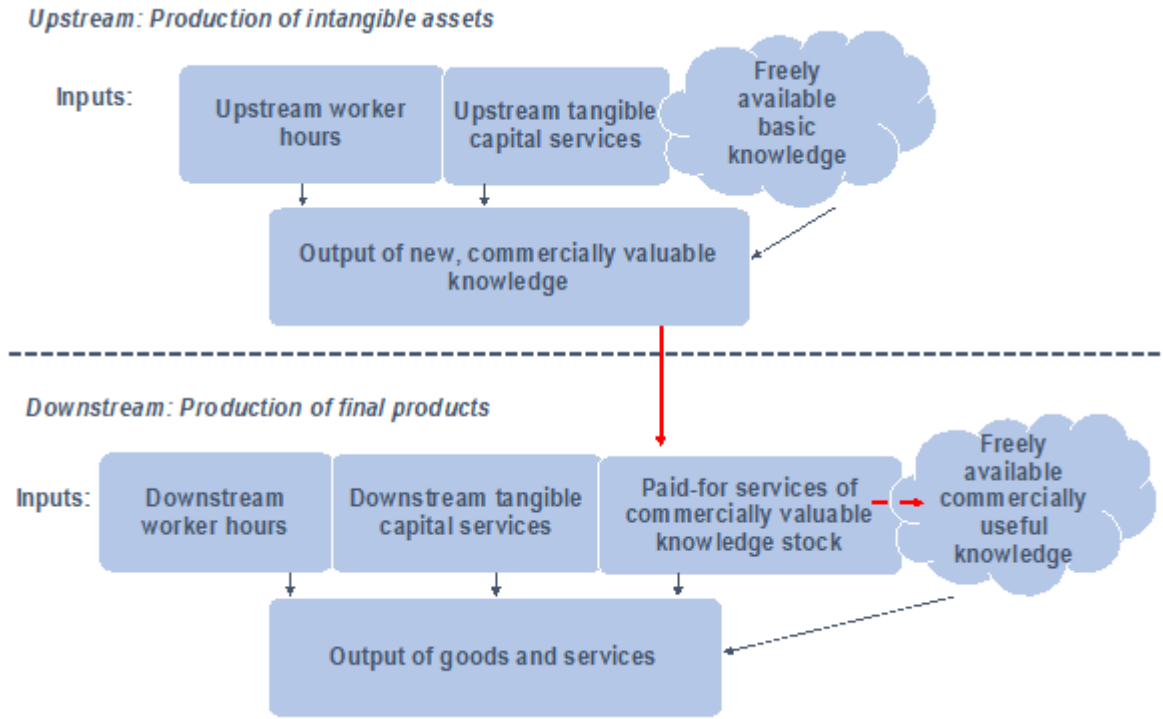
intangibles-adjusted growth at the frontier of 0.5 to 0.8 per cent. TFP growth in the EU9 aggregate is less strong. A solid performance in the EU North region (Sweden, Denmark and Finland) only partially offset very weak TFP growth in France and Germany. We also find that investment in innovation after the GFC continued and that the contribution of intangible assets to labour productivity growth did not materially diminish. Nevertheless, TFP growth weakened in the aftermath of the GFC and period of the European sovereign debt crisis.

This seeming paradox—that investment in innovation-promoting intangibles was well maintained in the face of a slowdown in TFP growth—is examined in a fifth section. We find that the results from EU KLEMS & INTANProd support arguments that TFP growth has slowed due to weakened knowledge spillover mechanisms (Akcigit and Ates, 2021, Corrado *et al.*, 2024). This finding is consistent with firm-level/microdata studies showing that the acquisition of intangibles is associated with increased within-industry productivity dispersion (e.g. Corrado, Criscuolo *et al.* 2021; see also the discussion in Haskel and Westlake, 2018) and diminished competition (Bessen 2022, Aghion *et al.*, 2023, De Ridder, 2024).

Conceptual Framework

In the standard neoclassical production framework, changes in real output are proximately determined by changes in factor inputs and changes in TFP, with the latter attributed to structural (exogenous) factors or mismeasurement. In the concep-

Figure 1: Conceptual Framework for a Model with Intangible Capital



Source: Authors' illustration; from Chart 2 in Corrado *et al.* (2022)

tual framework of production with intangibles, intangible capital becomes an additional factor input and proximate determinant of TFP while also playing a growth-promoting role akin to R&D in endogenous growth theory. To explain, let us set out the intangible capital conceptual framework using a simplified model of the economy.

Model of an Economy with Intangible Capital³

In our simplified model of the economy, production activity is divided into two parts. The first is an “upstream” set of ac-

tivities that produces innovations that can be commercialized, like a new system for organizing production or a software program adapted to the needs of the organization. The second is a “downstream” set of activities that uses the knowledge generated by upstream activities to produce final goods and services. By “final” we mean output for sale to consumers or for export or domestic investment; for simplicity, we ignore intermediate inputs. These two interlinked, yet distinct, production activities are depicted in Figure 1.

The outstanding stock of intangible capital in this framework, which might also be called “commercial knowledge,” reflects the

³ This section is drawn from Corrado *et al.* (2022). For an algebraic formulation, see Corrado *et al.* (2023) and Corrado (2024), which are drawn from Corrado, Goodridge, and Haskel (2012) and based on the original Corrado-Hulten-Sichel intangible framework.

accumulation of upstream output, after adjusting for losses due to aging (or economic depreciation). Downstream producers acquire commercial knowledge much as they acquire plant and equipment, via capital expenditure. But the stock of this knowledge is non-rival and only partially appropriable. The possible leakage from paid-for commercial knowledge to freely available useful knowledge is shown by the dashed arrow in the downstream sector.

In contrast to this commercialized knowledge, “basic” knowledge, generated (say) via public funds for basic scientific research to universities, is assumed to be a free input in the upstream production function. So, while basic knowledge is an input to the production of commercial knowledge, it receives no factor payments because its services are assumed to be freely available. “Basic” knowledge in this model is not viewed as stemming solely from scientific breakthroughs. The idea of creating efficient supply chains relies on customer-determined product specifications and operational knowledge as well as practices with roots in engineering and information technologies. In fact, investments in branding and marketing, organization structure, and employer-provided training long have been modeled as complements with information technology.⁴

This model’s depiction of the two sectors captures some important aspects of business innovation in modern economies. The upstream sector would include firms that are almost fully reliant on the production

of innovations in the form of new intangible assets—say, biotech startups producing new formulas for drugs. The downstream sector comprising producers that acquire the use of the innovations via outright purchase or license agreements with annual payments. More generally, many innovating firms have their own internal “innovation labs” and “business strategy teams” that produce and commercialize new ideas for downstream production (for example, Alphabet’s “X” research arm). In our model, these innovation labs and strategy teams are upstream knowledge producers residing within larger organizations, and the internal payments to these innovation labs and strategy teams represent their contribution to total revenue.

Further, the intuition of an upstream entity commercializing knowledge helps, we believe, relate economic theory and measurement to the interests of management and innovation scholars. Such scholars typically find the economist’s use of productivity to represent innovation hard to reconcile with their detailed and diverse case studies of the internal process by which firms develop new products and processes whereas the innovation divisions within firms (“Skunk Works” described by Greenstein, 2016) are, collectively, upstream sector knowledge producers in our model. Edison’s Menlo Park innovation facility is another, more venerable, example.

Finally, the idea that innovators hold temporary product market power for their inventions is a common feature of economic

⁴ Brynjolfsson and Hitt (2000) and Corrado, Haskel, Jona-Lasinio (2017a) find justification for this in firm-level and cross-country macroeconomic data on intangibles, respectively.

models of innovation. Such market power lasts for the time during which the innovator can sell or rent the knowledge for a monopoly price to the downstream sector, which in the intangible capital framework of Figure 1 is treated as a price-taker for knowledge. Prices for other inputs are assumed to be competitive, as are final product prices (given the cost of producing new commercial knowledge). This implies that the first-order impact of market power is higher intangible asset prices, and if intangibles are not accounted for in firm-level or macroeconomic data, measures of market power such as price markups are biased.⁵

GDP and Labour Productivity with Intangible Capital

Without the capitalization of intangibles, spending on intangibles (and production in the upstream sector of the model sketched out above) is denoted $P^N N$ but is treated as a purchase of intermediate inputs. This GDP consists solely of downstream output, denoted $P^Y Y$.

When the definition of investment is expanded to include spending on intangibles, intangible investment becomes a final expenditure along with consumption and tangible investment. GDP is then $P^Y Y + P^N N$ and denoted $P^Q Q$. In our simplified model, which is closed, output is the sum of the production of intangibles and the production of all other final goods and services, or alternatively the sum of final expenditures:

$$P^Q Q = P^Y Y + P^N N \equiv P^C C + P^I I + P^N N \quad (1)$$

Here, the P terms are prices, C is consumption, and I is investment in tangible capital K. Equation (1) shows that when investments in intangibles, N, are capitalized, GDP (the level of real output, previously Y, now Q) becomes larger—and so does real output per hour, the level of labour productivity.

In contrast, the impact on real GDP growth could be positive or negative. With intangibles capitalized, the growth rate of GDP equals a weighted average of the growth rates of previous GDP and the new investment. Denoting as the growth rates (defined as log-changes) of existing GDP, new GDP, and new investment by dy , dq , and dn respectively, and letting s_Q^N be the share of new nominal GDP accounted for by investment in intangibles in equation (1), this weighted average is:

$$dq = s_Q^N dn + (1 - s_Q^N) dy \quad (2)$$

The gap between true less measured GDP growth ($dq - dy$) is then given by

$$dq - dy = s_Q^N (dn - dy) \quad (3)$$

which implies that the impact on labour productivity growth of capitalizing intangibles depends on the relative *growth* rate of *real* intangible investment.

⁵ See Corrado *et al.* (2022, 2024) for further discussion.

Growth Accounting with Intangible Capital

As set out above, the upstream sector of this simplified economy produces N , real intangible investment, and the downstream sector produces all other final output Y , consumption and tangible investment. Each production sector uses labour L and tangible capital K inputs, whose prices P^L and P^K are competitive, but their production functions differ. The basic knowledge that the upstream sector uses is “free” whereas downstream producers pay P^R (per year) for their use of commercially valuable knowledge R .

The aggregate factor payments equation for this economy is written:

$$P^Q Q \equiv P^L L + P^K K + P^R R \quad (4)$$

where P^R is the rental price of intangible capital. This refers to Jorgenson’s user cost relationship (Jorgenson, 1963), which for intangibles is given by:

$$P^R = (r + \delta_R + dp_R^e) P^N \quad (5)$$

where δ_R is the rate of depreciation of intangible assets and dp_R^e is their expected holding gain. The asset price P^N includes the Schumpeterian (monopolistic) returns to innovation as discussed above whereas the ex post calculated rate of return to cap-

ital r is a competitive return arbitrated over across all assets, tangible and intangible, in the economy.⁶

As in the Solow model, GDP growth in this model is decomposed into contributions from changes in inputs and from TFP, where TFP is residual growth not explained by input changes weighted by their income shares in (4). Let σ_Q^X be the combined factor income share for the conventional inputs L and K , dx the combined growth of these two inputs, σ_Q^R the factor income share attributed to intangible capital, and dr the growth of inputs of intangible capital. The sources-of-growth decomposition with intangibles is then:

$$dq = \sigma_Q^X dx + \sigma_Q^R dr + da \quad (6)$$

which says that output growth consists of a contribution from conventional inputs $\sigma_Q^X dx$, a contribution from paid-for, commercially held knowledge $\sigma_Q^R dr$, and TFP growth da . The contribution of freely available knowledge, whether basic knowledge or commercial innovations able to be replicated at low cost, is included in da . What is different in the model with intangible capital is that paid-for, commercially valuable knowledge has become a proximate, measurable source of growth (rather than being relegated into TFP growth). That is, the services from the stock of intangibles becomes an input used in production while investment in new intangibles becomes one of the outputs.

⁶ In growth accounting with intangibles, the overall ex post calculated rate of return to capital is lowered and found to be generally aligned with calculations of the financial cost of capital; see Corrado *et al.* (2022) for further discussion and an illustration. For a discussion of how growth accounting with intangibles is consistent with Schumpeterian competition at the firm level, see Hulten (2010).

Now let da' be measured TFP when using $P^Y Y$, and let dx' be the contribution of conventional inputs (K and L) to the growth in dy , i.e. $da' = dy - dx'$. Combining that with equations (5) and (3), we have that:

$$da - da' = -[(\sigma_Q^R dr + \sigma_Q^X dx) - dx'] + s_Q^N (dn - dy) \quad (7)$$

as an expression of the difference between da as knowledge spillovers in the intangible capital model and measured TFP ignoring intangibles, da' .

Before we discuss the terms in equation (7) per se, it is important to underscore that theory provides some insight on the behavior of TFP when a new investment stream enters the picture. One is the J-curve effect of Brynjolfsson, Rock and Syverson (2021), which pertains to the impact on measured TFP (da') of the investment and income dynamics that take place in the early stages of a new technology. At first the output effect dominates, holding down da' relative to da because the new investments are not counted in real output. But eventually the income earned from the investments grows and boosts measured TFP, which by ignoring the capital created by the new investment stream exaggerates measured TFP growth, as in the upward “swoosh” of the letter J.

Theory also suggests that the contribution of investment to the output and input sides of (5) cancel out when the investment share of output (the savings rate) is equal

to capital’s share of income. This situation occurs on a “maximal” consumption steady-state growth path (Phelps, 1961), which in turn suggests that the addition of a new investment stream will eventually have little to no effect on measured TFP growth in advanced economies (Jorgenson 1966), i.e. the J-curve effect is a temporary dynamic.

Turning now to equation (7), it is a very simple statement of how TFP is affected when an investment stream is capitalized versus when it is not. The equation implies that there is an impact stemming from the difference in inputs growth rate (the first term in brackets) and an impact stemming from the difference in output growth rate (the second term). These impacts work in opposite directions, i.e. intangibles-adjusted TFP growth may be lower than the conventional calculation when the combined inputs grow faster than conventional input, which is the case when real intangible capital is growing faster than tangible capital. On the other hand, when real intangible investment is growing relatively rapidly, TFP growth is elevated relative to the conventional calculation, which may happen when intangible capital grows faster than tangible capital. But the dynamics of consumption and investment on the one hand and income on the other also enter the picture. All told, as an empirical matter equation (7) may be positive, negative, or essentially zero.

Finally, the intangible capital framework helps explain the origins of TFP growth. The knowledge embedded in intangible capital is inherently nonrival and only partially appropriable. Nonrival assets (such as a piece of software code) can be copied

and used simultaneously in production by owners and non-owners alike, creating a situation where owner/developers do not capture the full returns to their investments. As in endogenous growth theory (e.g. models following Romer, 1990), these unappropriated returns are a source of TFP growth. The boost to TFP via the costless diffusion (or spread) of innovators' knowledge from one organization to another is a form of economic externality called "knowledge spillovers" discussed as an empirical matter below.

The EU KLEMS & INTANProd dataset

The EU KLEMS & INTANProd dataset covers 27 EU Member States, the United Kingdom, the United States and Japan across 38 NACE industries from 1995 to 2020.⁷ NACE industries in EU KLEMS & INTANProd are listed in appendix table A1.⁸ The project provides a portal for selective or bulk downloading of the EU KLEMS and INTANProd data, with LLEE (2023) the version used in this article. Bontadini *et al.* (2023) provide details on methods and estimation of variables in the database. Data and documentation for the Japanese intangible and productivity estimates are available from Japanese Industrial Database (2023).

For European countries, industry detail and coverage vary over time and across countries. In our analysis of intangible in-

vestment and labour productivity trends in this section, the coverage is sufficient to work with most of EU member states for the entire time span of the database. For our analysis requiring industry-level capital and labour inputs by detailed type, i.e. for examining trends in intangibles versus tangibles for the market sector and for the estimation of total factor productivity, EU country coverage over the database time span becomes more limited. The major EU KLEMS & INTANProd coverage variances are documented in Appendix Table A2.

Intangible Investment: Categories, Asset Types and Methods

Table 1 displays the intangible capital framework included in the EU KLEMS & INTANProd dataset. Compared with the prevailing national accounting framework, this approach expands the range of spending by firms that should be viewed as investment. It applies a fundamental economic criterion to define investment, namely, that business (or public) investment consists of outlays expected to yield a return in a future period. The categorization of assets in Table 1 indicates intangibles consist of a wide class of assets, from databases to business processes. These assets are instructive for understanding the performance of leading global companies, such as Apple, Microsoft and many others whose success is based on software, data, design, operations networks, and brand

⁷ NACE is the acronym (from the French 'Nomenclature statistique des activités économiques dans la Communauté européenne' - Statistical classification of economic activities in the European Community) used to designate various statistical classifications of economic activities developed by the European Union.

⁸ All appendix tables are found at: <https://csls.ca/ipm/46/AppendixCorrado.pdf>

Table 1: Corrado-Hulten-Sichel Typology of Intangible Capital: Broad Categories and Asset Types

Broad Category		Asset Type
Digitized Information	1.	Software Included in GDP
	2.	Databases
Innovative Property	3.	R&D
	4.	Mineral exploration
	5.	Artistic, entertainment, and literary originals
	6.	Attributed designs (industrial and commercial)
	7.	Financial product development
Economic Competencies	8.	Marketing, market research and branding
	9.	Operating models and platforms, supply chains and distribution networks
	10.	Employer-provided training (formal)

Note: Lines 1 to 5 (outlined in red) are included as investment in national accounts, though line 2 excludes purchases of data.

Source. Authors' elaboration of Corrado, Hulten and Sichel (2005, 2009).

and whose market capitalization greatly exceeds reported, mainly tangible assets.

The intangible capital framework in Table 1 is widely used. The OECD (2013) adopted the taxonomy, using “knowledge-based capital” to describe it. The European Union commissioned EU KLEMS & INTANProd as a vehicle for its policy work, and the World Intellectual Property Organization, an agency of the UN, is sponsor-

ing the development of estimates for emerging economies using the Table 1 framework.⁹

There have been improvements in EU KLEMS & INTANProd in the measurement of intangible assets. Estimates for these assets now cover 38 NACE industries versus 18 industries in the previous editions of INTANInvest.¹⁰ Nominal intangible investment by asset type covers all possible

⁹ The appendix to Corrado, Haskel, Jona-Lasinio, and Iommi (2022) summarizes the methods used to estimate intangible investment for assets that are not currently included as investment in GDP in national accounts; examples and data sources for a typical European country and the United States are provided. As noted in this source and on the EU KLEMS & INTANProd website, estimates of intangibles included in EU KLEMS & INTANProd for European countries and the United States incorporate significant improvements relative to previous editions of INTANInvest and EU KLEMS. The estimates for intangibles in Japan are not fully harmonized with these methods, but like the estimates for other countries, the Japanese estimates cover all Corrado-Hulten-Sichel assets, and the methods used are very close and generally aligned with those used for the other areas.

¹⁰ Manufacturing is now disaggregated to cover 12 industries. Selected service sectors (wholesale and retail trade, transport, professional services, and health) also are expanded to provide more industry detail.

purchased and own-account activity and estimates are built from industry-level total expenditure when possible.¹¹ Japanese estimates do not include an own account component for brand or a purchased component for organizational capital.

Another important improvement is that real intangible investment now incorporates price deflators based on closely aligned services output.¹² One of the major changes is the incorporation of the dramatic drop in advertising media costs since 2009. To explain the relevance of this move, consider that a price deflator for investment in marketing, market research and brand needs to incorporate two major factors affecting costs: one cost element covers content development and production of original services, and the other is the cost of disseminating content via media.¹³

To measure the latter, a price index was developed from input price indexes for internet advertising versus traditional media from the BLS producer price index system. The dynamic of these relative prices was incorporated in the price deflator for brand deflator for European economies based on information on the internet share of advertising and domestic services prices for content development and production costs.¹⁴

Another change, affecting the US results only, is that the portion of purchased investments for IT organizational change,

e.g. payments to external providers to organize a company's computing in the cloud, is deflated by the gross output deflator for the primary industry supplying these services.

The Structure of the Database

EU KLEMS & INTANProd consists of two modules. The **statistical** module is a repository of all the key variables for industry-level productivity analysis provided directly by the national accounts of individual countries. The **analytical** module complements these data with information on investment and capital stocks for intangible assets that are not included as investment in national account calculations of GDP.

The analytical module includes an intangibles submodule based on the constructs previously available via INTANInvest. This includes real industry-level value added adjusted to include the intangibles not currently included in official statistics as well as all key variables for industry-level growth accounting with intangibles. All told, the analytical module is the repository for ongoing improvements to estimates of intangibles and industry-level growth accounting with intangibles. Among the most recent developments included in its present version of the database are (a) cap-

11 Previously, there were no own account components for design or brand for European economies.

12 for details on the prices used for each intangible asset for European economies and the United States (see Bontadini *et al.*, 2023).

13 Branding and marketing are unique assets in that their value is based on information held by customers, which typically requires content dissemination.

14 For further discussion of this deflator, see Corrado *et al.* (2024); for details on its construction from US PPIs, see the appendix in Corrado (2024).

ital stocks for all assets (tangible and intangible) based on geometric depreciation with harmonized age-price profiles, and (b) growth accounting results for selected aggregates are based on “bottom up” aggregations of industry-level output and factor inputs for countries with the requisite data. This is the standard approach in the productivity literature since Jorgenson and Griliches (1967).¹⁵

The bottom-up calculations reported on the website cover nine economies of Europe, Japan, the United Kingdom and United States with consistent, industry-level growth accounts from 1995 on (1997 for the United Kingdom); estimates for 11 member states are available from 2000 on, and for 14 member states from 2009 on. The calculations for each country are performed by building up from data on 19 NACE “letter” sector industries; for industries covered see Appendix Table A1.

Descriptive Results: Intangible and Tangible Investment

A feature of EU KLEMS & INTANProd is that intangible investment covering all Table 1 assets and all NACE industry ac-

tivities are available for most EU member countries. Chart 1 uses these estimates to compare intangible and (nonresidential) tangible investment rates for the aggregate economy across eight economic areas/countries. The upper panels examine the EU (25 countries), Japan, United Kingdom and United States; the lower panels compare four regions within the EU.¹⁶ In each panel, the solid red line plots investment in all Table 1 intangible assets as a share of gross value added (GVA) whereas the black line plots the share for tangible investment (nonresidential assets only). Investment in intangible assets included in national accounts is depicted by the dashed red line.

The panels of Chart 1 reveal variability across countries and EU regions in the rate of intangible investment. In the EU, total intangible investment was 8.5 per cent of GDP in 1995 and climbed 2.5 percentage points to 11 per cent by 2019. Investment rates in the United Kingdom and United States start at about 12 per cent and climb to 14.3 and 15.7 per cent, respectively. In Japan, the rate of intangible investment was 7.5 per cent in 1995, and while the rate rose 1.5 percentage points by 2009, it flat-

¹⁵ The initial EU KLEMS editions were built from the industry-level up, but the Commission’s guidelines for the 2012 edition required the inclusion of the EU’s new member states. The lack of industry and input detail for these countries necessitated calculating the growth accounting for the available industry coverage from corresponding quantities of labour (hours worked/number of employed) and capital (capital stocks). For continuity with previous editions (per commission guidelines), growth accounting results using this “direct calculation” approach are reported in both modules of EU KLEMS & INTANProd, but these estimates are not used in this article. As stressed in the productivity literature, growth accounting with aggregates implicitly assumes that the reallocation of capital and labour across industries does not contribute to aggregate growth, i.e., it requires perfect mobility of inputs across industries, that labour and capital earn the same compensation in all industries, and that all industries have the same value-added function. These assumptions are highly restrictive, and directly calculated TFP growth tends to overstates true TFP growth, which is best approximated using industry-level real output and inputs distinguished by type.

¹⁶ The EU aggregate covers 25 EU member states excluding Austria and Ireland. These countries are excluded because the EU KLEMS & INTANProd estimates of total intangibles for these countries are understated. Owing to a lack of source data, they do not include own-account components of investment in certain asset types.

Chart 1: Intangible and Tangible Investment Rates as Share of GDP, all NACE Activities, 1995-2019



Note: Data for the United Kingdom start in 1997. European aggregates are formed using PPP-adjusted values for GVA. EU region country groupings. EU Centre: Belgium, Germany, France, Luxembourg, Netherlands. EU East: Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, Slovakia. EU North: Denmark, Finland, Sweden. EU South: Cyprus, Greece, Spain, Italy, Portugal; Malta. Note that tangible investment for Hungary, Poland, and Slovakia starts in 2000, affecting the start date for the EU East tangible investment aggregate.

Source: Authors' elaboration of data from EU KLEMS & INTANProd (LLEE, 2023).

tened and then edged down to 8.7 per cent by 2019.

The regional differences within the EU in 1995 are stark, with rates in 1995 ranging from around 6.7 per cent in EU South (the lowest) to around 11 per cent in EU North (the highest). But the expansion of intangible investment across the EU regions is somewhat uneven. Over the period shown, the EU Centre and EU North regions boost their intangible investment rates by 3 and 3.6 percentage points, respectively. By contrast, the rates for EU East and EU South show less change, 2.4 and 1.6 percentage points.

The area between the two red lines in each panel reflects the expansion of the production boundary for intangibles in the analytical module of EU KLEMS & INTAN-Prod versus that in national accounts, i.e., the effect of adding the intangibles listed on lines 6 through 10 of Table 1 to those on line 1 through line 5. For the United Kingdom, including the additional intangibles more than doubles the rate of intangible investment based on averages for the years from 2017 to 2019; for the US the rate is exactly doubled for those years, and for the EU, the boost nearly doubles the rate of intangible investment, while for Japan, the expansion of investment is rather less.

Chart 2 reports investment rates for market sector industries of the countries and regions reported in Chart 1. This group of industries excludes real estate (which is dominated by the imputation for owner-occupied housing), public adminis-

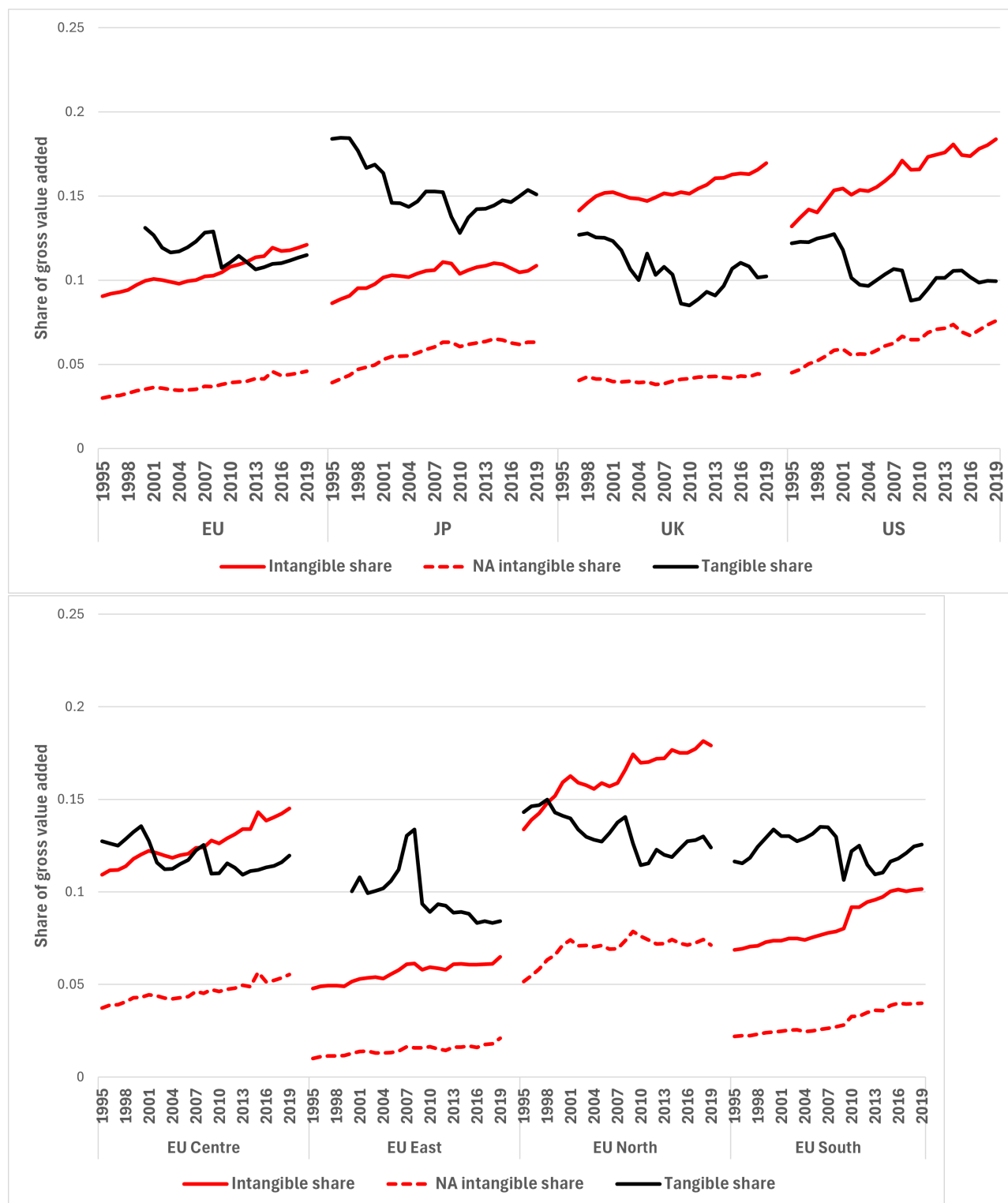
tration, education and health, and private households. In contrast to Chart 1, Chart 2 uses 17 EU member states to represent the EU, as it is necessary to exclude member states whose national accounts do not include industry-level information on investment by asset type. Thus, while a comparison of Chart 1 versus Chart 2 results mainly reflects the exclusion of nonmarket activity, some differences between the EU aggregates are due to the exclusion of countries.¹⁷

The patterns in Chart 2 are more market-driven than those in Chart 1. Accordingly, the rise in investment rates for intangibles is sharper and the rates for tangibles are more cyclical. As before, however, the trends for the rise in the investment rates for intangibles in the United States is sharper and the trends for the United Kingdom, United States and EU North are again strikingly similar—the market sector intangible investment rate stood between 17 and 18 per cent in these economic areas in 2019. The rate of intangible investment by market sector industries in EU Center countries remains lower than in these countries—it stood at 14.5 per cent in 2019. EU South looks relatively more dynamic here than in Chart 1, mainly due to the exclusion of laggard countries.

All told, the composition of investment, tangible versus intangible—and between intangibles included in national accounts versus those in Table 1's expanded list—varies across EU regions and across countries. Yet we see two major take aways

¹⁷ The exclusions drop Luxembourg from EU Center; Cyprus, Greece, and Malta from EU South; and Estonia, Croatia, Hungary, and Poland from EU East.]

Chart 2: Intangible and Tangible Investment as Share of GDP, Market Sector Industries, 1995-2019



Note: Data for the United Kingdom start in 1997. European aggregates are formed using PPP-adjusted values for GVA. EU Country groupings. EU Centre: Belgium, Germany, France, Luxembourg, Netherlands. EU East: Czech Republic, Lithuania, Latvia, Romania, Slovenia, Slovakia. EU North: Denmark, Finland, Sweden. EU South: Spain, Italy, Portugal; Malta. Note that tangible investment for Slovakia starts in 2000, affecting the start date of the EU East tangible investment aggregate.
Source: Author's elaboration of data from EU KLEMS & INTANProd (LLEE, 2023).

Table 2: Labour Productivity with Expanded Intangible Investment, PPP-adjusted constant 2015 international dollars per hours worked, 2019

Country/ Region	Expanded	Official	Percent Difference (%) (1)-(2)/(2)	Percent of US in (1)	Percent of US in (2)	Change (p.p) (1)-(2)
	(1)	(2)	(3)	(4)	(5)	(6)
1) EU27	52.0	48.4	7.6	71.8	73.1	-2.1
2) JP	49.5	47.9	3.4	67.5	72.3	-4.8
3) UK	54.4	48.8	11.5	74.2	73.7	0.5
4) US	73.2	66.2	10.7	100.0	100.0	–
5) EU North	62.1	56.7	9.6	84.8	85.6	-0.8
6) EU South	46.5	44.0	5.6	63.5	66.5	-3.1
7) EU East	34.0	31.3	8.7	46.4	47.3	-0.9
8) EU Center	66.0	61.1	8.0	90.2	92.4	-2.3

Note: Calculations use gross value added for total industry expressed in constant 2015 units of local currency (i.e., real output in basic prices) adjusted to constant 2015 international dollars using PPPs. Sources: Authors' elaboration of labour productivity from EU KLEMS & INTANProd (LLEE 2023) and PPPs from the Eurostat database (2024).

from these data. First, for most countries and regions, the rate of intangible investment rises from 1995 to 2019, with the rise rather sharper for market-dominated industries than that for the total including all industries. A consequence of this finding is that, cutting through cyclicity, the rate of tangible investment tends to fall on balance. A notable exception to this is the pattern in Japan where the intangible investment rate remains flat after 2009. Second, for the United Kingdom and United States, the rate of intangible investment notably exceeds that for tangibles since at least 2000. In the EU North and EU Center regions, a similar pattern emerges (i.e. of intangible investment exceeding that of tangible investment), but it happens much later, by 2010 and 2015, respectively.

Expansion of Intangibles: Impacts on the Level and Growth of Labour Productivity

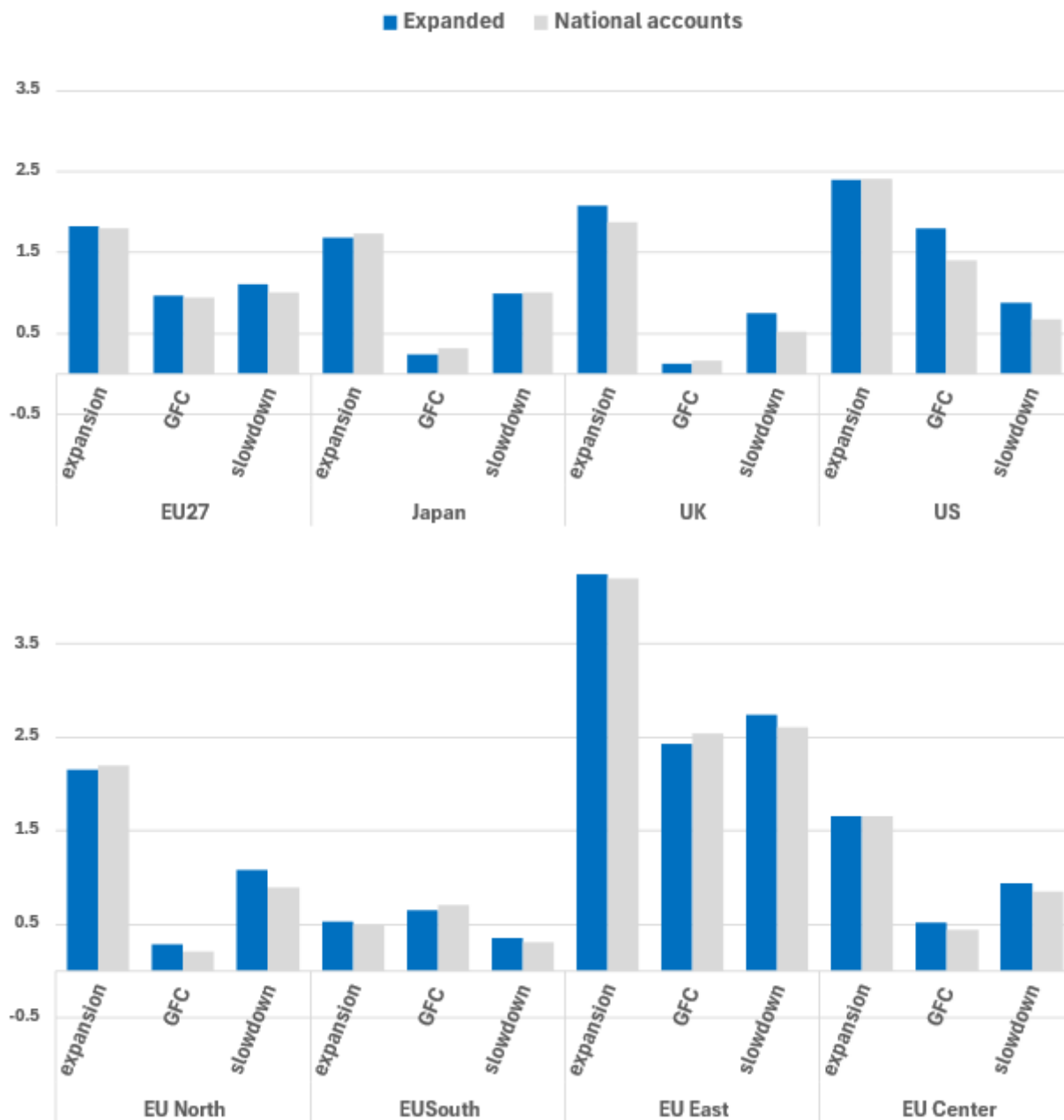
In the first section of the article we set out the simple algebra of the impact of cap-

italizing intangibles on GDP and labour productivity. Charts 1 and 2 have already suggested that the impact of capitalizing additional intangibles in the national accounts of an economy is an unambiguous boost to investment as a share of GDP (when measured for the aggregate economy) or Gross Value Added (when measured for a specific group of industries, such as the market economy. The move also boosts the level of real output and, consequently, the level of labour productivity for an economy. Expanding intangibles will also affect international comparisons of labour productivity levels.

A comparison of labour productivity levels for the major economic areas included in EU KLEMS & INTANProd is displayed in Table 2. Levels of labour productivity obtained from our “expanded” productivity accounts versus those obtained using the production boundary in “official” national accounts are shown using 2019 as the comparison year. The impacts on Japan and EU South are relatively the smallest.

The last set of columns in the table

Chart 3: Labour Productivity Growth with Expanded Intangible Investment in National Accounts, selected periods (all NACE activities), 1995- 2019



Note: The periods are as follows: Expansion is 1995 to 2007; GFC is 2007 to 2010; and slowdown is 2010 to 2019. For the United Kingdom, the expansion period begins in 1997. European aggregates are formed using constant PPP-adjusted values for real GVA.

Source: Authors' elaboration of EU KLEMS & INTANProd (LLEE 2023).

examine the expanded and official labour productivity levels relative to the United States. Looking at line 8, output per hour is relatively high in the EU Center countries, though the gap vis-à-vis the United States widens in the expanded measures. The level of labour productivity in EU North is affected less but still shows a widening of the gap with the United States. Only the United Kingdom moves closer to the United States in the expanded measure.

What about labour productivity growth? As also previously indicated, the impact of capitalizing additional intangibles depends in this instance on the relative growth rate of the new real investment—is it faster or slower than existing real GDP? The side-by-side bars of Chart 3 compare labour productivity growth after capitalizing all intangibles with labour productivity growth based on official GVA statistics for three periods in our data, which we label “expansion”, “GFC”, and “slowdown.” The definitions of these periods are spelled out in the note to Chart 3.

Chart 3’s side-by-side bars are generally very close to one another, though output per hour is boosted by more than 0.2 percentage points (rounded) in moving to an expanded boundary for intangible assets in some countries. For the United States and EU North this occurs in the post-crisis period when prices for intangible assets begin to fall in relative terms—and for these economic areas, the boost to labour productivity growth in the post-crisis period lessens the severity of the slowdown in labour productivity (defined as the difference between the pre- and post-crisis growth rates) by about 0.2 percentage points. In the United

Kingdom, labour productivity growth is boosted in both the pre- and post-crisis periods, with little net effect on the slowdown measured by the difference in growth between these two periods.

Growth Accounting

This section focuses on analyzing productivity decompositions of the group of industries in the non-agricultural market sector of advanced economies, listed in detail in appendix table A1. This limits the country coverage of the EU to nine member states with industry-level production accounts including intangibles from 1995 on. The discussion below focuses primarily on the interpreting the productivity performance of the advanced economies included in the EU KLEMS & INTANProd dataset in the 12 years since the onset of the global financial recession, i.e. from 2007 to 2019. It also looks at more recent growth performance since 2019. The pandemic year 2020 is reported separately.

Labour Productivity Growth Decompositions

Labour productivity growth decompositions based on results in EU KLEMS INTANProd are summarized in Tables 3 and 4, where the first five lines for each country/economic area shows information for analyzing the slowdown over the 12 years since the onset of the GFC, and the second four show the slowdown calibrated against recent growth. Our analysis primarily focusses on Table 3, which displays results for a European aggregate, Japan, the United Kingdom and the United States. Table 4

shows the four major European countries included in the EU aggregate in Table 3, namely, France, Germany, Italy and Spain. Together they account for about 85 per cent of the combined market sector GVA of the nine countries in the aggregate. Labour productivity growth decompositions for the other five European countries are found on Appendix Table A4.

Basic Takeaways

Labour productivity for each aggregate economy (column 1) is calculated as the chained sum of value-added weighted real industry output divided by aggregate hours and includes a reallocation effect (column 2). The reallocation effect is positive when hours is relatively faster in higher value-added industries (or vice versa). This effect was a massive positive in the pandemic year 2020, when hours growth in many low value-added industries, e.g. hotels and restaurants, plummeted while many high salary office workers and professionals were able to telework. The 2020 reallocation effect was largely reversed in the following year (not shown). Scanning down column (2) and ignoring 2020, the reallocation of hours across industries generally does not play an important or sustained role in labour productivity developments for the advanced economies shown in Table 3.

The growth decompositions shown in the remaining columns of Table 3 reflect within industry changes in labour productivity as measured by value-added weighted labour productivity growth at the industry level. As may be seen in column (3) on the lines labeled “slowdown,” the average rate of growth of this labour productivity dropped

dramatically in the United Kingdom and the United States (2.5 and 1.4 percentage points, respectively). The downshift is less in Japan, where labour productivity slowed 1.1 percentage point per year, and smaller still for the countries in the EU9 (0.7 percentage points). This cross-country variance in the severity of the slowdown in labour productivity stems largely from the variance in cross-country performance during the prior period used to calculate the slowdown. Once economic activity settled down after bubbles in some countries, convergence in others, and multiple crises, average labour productivity growth for the six years ending in 2019 (lines 7, 16, 25 and 34) varied less across the economic areas shown in Table 3, ranging from a low in Japan (0.75 per cent per year growth) to 1.1 per cent and 1.2 per cent for Europe and the United Kingdom, to 1.7 per cent per year in the United States.

Changes in labour composition (column 4) somewhat offset the slowdown in labour productivity in the EU9, but not elsewhere—indeed, the rate at which the within-industry composition of workers shifted to higher skilled (and higher paid) positions in other countries slowed. Moreover, the increased contribution of labour composition to labour productivity growth in Europe is widespread across its major countries (Table 4).

Let us make three additional points about the results shown on Table 3. First, more than half of the slowdown in labour productivity in Europe, United Kingdom and United States is directly accounted for by a slowdown in TFP (column 7). The TFP slowdown in Japan is both somewhat milder and accompanied by slowdowns in

Table 3: Decompositions of Labour Productivity Growth in the Nonagricultural Market Sector of the EU, Japan, UK and US (average annual change, selected periods)

	Aggregate LP growth	Re- allocation	Value-added weighted LP growth	Contributions (p.p) to value added-weighted LP growth			
				Labour Comp.	Tangible Capital Deepening	Intangible Capital Deepening	TFP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EU9							
1) 1996-2007	1.36	-0.15	1.51	0.10	0.71	0.42	0.28
2) 2008-2019	0.82	0.0	0.82	0.35	0.37	0.46	-0.35
3) 2020	1.61	2.1	-0.45	0.37	1.83	1.46	-4.10
Slowdown							
4) (lines 1-2)	0.54	-0.14	0.69	-0.25	0.34	-0.04	0.63
5) percent of col. (3)			100	-37	50	-6	92
6) 2008-2013	0.45	0.1	0.36	0.41	0.62	0.42	-1.09
7) 2014-2019	0.99	-0.2	1.14	0.25	0.13	0.44	0.32
Slowdown (recent growth)							
8) (lines 1-7)	0.38	0.01	0.37	-0.15	0.58	-0.03	-0.04
9) percent of col. (3)			100	-41	158	-7	-10
Japan							
10) 1996-2007	2.03	0.1	1.94	0.35	0.55	0.28	0.76
11) 2008-2019	0.78	0.0	0.81	0.11	0.21	0.15	0.35
12) 2020	-0.91	-0.2	-0.67	-0.93	1.02	0.87	-1.64
Slowdown							
(13) (lines 9-10)	1.25	0.1	1.13	0.24	0.35	0.13	0.42
(14) percent of col. (3)			100	21	31	11	37
(15) 2008-2013	0.79	-0.1	0.87	0.17	0.32	0.20	0.18
(16) 2014-2019	0.77	0.0	0.75	0.04	0.09	0.10	0.51
Slowdown (recent growth)							
(17) (lines 9-15)	1.54	0.10	1.19	0.30	0.46	0.18	0.25
(18) percent of col. (3)			100	25	39	15	21
United Kingdom							
(19) 1998-2007	2.91	-0.1	3.02	0.31	0.83	0.67	1.21
(20) 2008-2019	0.49	0.0	0.50	0.16	0.14	0.41	-0.22
(21) 2020	5.38	3.5	1.87	0.30	1.81	2.31	-2.55
Slowdown							
(22) (lines 18-19)	2.42	-0.10	2.52	0.15	0.69	0.25	1.43
(23) percent of col. (3)			100	6	27	10	57
(24) 2008-2013	0.05	0.3	-0.22	0.27	-0.06	0.35	-0.78
(25) 2014-2019	0.93	-0.3	1.22	0.05	0.35	0.48	0.34
Slowdown (recent growth)							
(26) (lines 18-23)	1.99	0.19	1.80	0.26	0.49	0.19	0.87
(27) percent of col. (3)			100	14	27	10	48
United States							
(28) 1996-2007	2.78	-0.1	2.87	0.34	0.91	0.72	0.90
(29) 2008-2019	1.47	0.0	1.49	0.24	0.36	0.79	0.11
(30) 2020	6.86	1.8	5.01	0.74	1.05	2.39	0.83
Slowdown							
(31) (lines 26-27)	1.31	-0.07	1.38	0.10	0.55	-0.06	0.79
(32) percent of col. (3)			100	7	40	-5	58
(33) 2008-2013	1.39	0.1	1.33	0.35	0.48	0.74	-0.24
(34) 2014-2019	1.54	-0.1	1.66	0.14	0.24	0.83	0.45
Slowdown (recent growth)							
(35) (lines 26-32)	1.24	0.03	1.21	0.21	0.66	-0.11	0.45
(36) percent of col. (3)			100	17	55	-9	37

Note: EU9 countries are CZ, DE, DK, ES, FI, FR, IT, NE, and SE. Annual changes are log changes multiplied by 100.
Source: Authors' elaboration of data from EUKLEMS & INTANProd (LLEE 2023)

Table 4: Decompositions of Labour Productivity Growth in the Nonagricultural Market Sector of Selected European Countries

	Aggregate LP growth	Re- allocation	Value-added weighted LP growth	Contributions (p.p) to value added-weighted LP growth			
				Labour Comp.	Tangible Capital Deepening	Intangible Capital Deepening	TFP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
France							
(1) 1996-2007	1.77	-0.16	1.93	0.23	0.73	0.50	0.46
(2) 2008-2019	0.63	-0.01	0.64	0.45	0.29	0.61	-0.71
(3) 2020	2.02	1.96	0.06	0.63	1.44	2.33	-4.34
Slowdown							
(4) (lines 1-2)	1.14	-0.15	1.28	-0.22	0.43	-0.10	1.17
(5) percent of col. (3)			100	-17	34	-8	91
(6) 2008-2013	0.30	0.03	0.27	0.55	0.33	0.59	-1.19
(7) 2014-2019	0.96	-0.06	1.02	0.35	0.25	0.63	-0.22
Slowdown (recent growth)							
(8) (lines 1-7)	0.80	-0.10	0.91	-0.12	0.47	-0.12	0.68
(9) percent of col. (3)			100	-14	52	-14	75
Germany							
(10) 1996-2007	1.79	0.17	1.62	-0.04	0.46	0.24	0.96
(11) 2008-2019	0.87	0.01	0.86	0.26	0.17	0.30	0.13
(12) 2020	0.65	0.94	-0.28	0.00	1.10	0.93	-2.31
Slowdown							
(13) (lines 9-10)	0.92	0.16	0.75	-0.30	0.29	-0.07	0.83
(14) percent of col. (3)			100	-40	38	-9	111
(15) 2008-2013	0.37	0.02	0.35	0.38	0.18	0.25	-0.46
(16) 2014-2019	0.01	0.00	0.01	0.00	0.00	0.00	0.01
Slowdown (recent growth)							
(17) (lines 9-15)			1.60	-0.04	0.46	0.23	0.95
(18) percent of col. (3)			100	-3	29	15	59
Italy							
(19) 1998-2007	0.55	-0.03	0.57	0.19	0.71	0.23	-0.56
(20) 2008-2019	0.28	-0.06	0.34	0.39	0.27	0.27	-0.58
(21) 2020	4.17	2.04	2.14	0.47	2.84	1.51	-2.69
Slowdown							
(22) (lines 18-19)	0.27	0.03	0.23	-0.19	0.45	-0.04	0.02
(23) percent of col. (3)			100	-83	191	-16	9
(24) 2008-2013	0.04	0.03	0.01	0.41	0.52	0.29	-1.20
(25) 2014-2019	0.51	-0.16	0.67	0.36	0.02	0.26	0.04
Slowdown (recent growth)							
(26) (lines 18-23)	0.03	0.13	-0.10	-0.17	0.69	-0.02	-0.60
(27) percent of col. (3)			100	173	-721	24	624
Spain							
(28) 1996-2007	-0.34	-0.37	0.03	0.01	0.62	0.27	-0.87
(29) 2008-2019	1.10	-0.17	1.27	0.44	0.82	0.42	-0.40
(30) 2020	-2.75	2.52	-5.27	0.59	3.40	1.10	-10.36
Slowdown							
(31) (lines 26-27)	-1.44	-0.20	-1.24	-0.43	-0.19	-0.15	-0.47
(32) percent of col. (3)			100	35	16	12	38
(33) 2008-2013	1.63	-0.12	1.75	0.67	1.70	0.63	-1.24
(34) 2014-2019	0.57	-0.22	0.79	0.22	-0.06	0.20	0.44
Slowdown (recent growth)							
(35) (lines 26-32)	-0.92	-0.15	-0.76	-0.21	0.69	0.07	-1.31
(36) percent of col. (3)			100	27	-90	-9	172

Note: Annual changes are log changes multiplied by 100.

Source: Authors' elaboration of data from EUKLEMS & INTANProd (LLEE 2023)

the other proximate factors, including in the contribution of intangible capital deepening.

Second, the contribution of tangible capital deepening slows dramatically in Europe, United Kingdom and United States, primarily reflecting the large slowdowns in TFP growth in these countries because of the endogeneity of capital to TFP, but also an apparent substitution away from equipment towards intangible assets (e.g. big data, AI tools).

Third, despite the slowing in TFP, the contribution of intangible capital deepening was maintained in the entire post-GFC period (except for the slowing in Japan between 2008-2013 and 2014-2019). This is not the flipside of the substitution point made immediately above. If there are increasing returns to intangibles in the form of social returns via diffusion, TFP growth would not be expected to slow in the face of steady rates of investment in intangibles and increases in intangible capital deepening (all else equal), a topic discussed later in this section.

The TFP Slowdown Relative to Trend Growth at the Frontier

This section reviews topics that help us interpret the recent slowdown in TFP growth. We have already suggested that one must look at the contribution of intangible capital in conjunction with TFP to “see” innovation in an economy. Here we

focus almost entirely on TFP, though still through the lens of the framework set out in the first section.

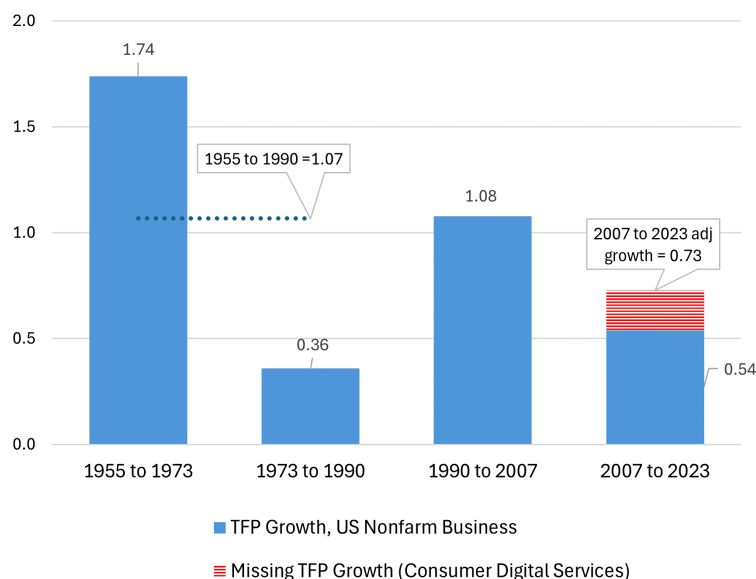
The widespread slowdown in productivity growth since 2007 has been labeled a “puzzle” and a subject of a growing number of studies. A slowdown is a period of slower growth compared to a prior period of faster growth. The prior period we use in this study begins in 1995 because that is the first populated data point in the industry-level EU KLEMS & INTANProd database. The “period of slower growth” typically includes the years since the onset of the GFC in 2007, which as a cyclical event ended in 2009, so sometimes the period from 2010 on is used as the “slower period” for analysis of the slowdown. The sovereign debt crisis in Europe that began soon after recovery from the GFC and did not end until early 2014 was another disruption heightening global investment uncertainty and the productivity performance of advanced economies. The 6-year period from 2013 to 2019 that followed was relatively quiescent, however, and hence that period, too, can be used as a “slower period” for analysis of the slowdown.

A Long-Term Perspective on the TFP Trend Growth

But how does the recent slowdown in TFP growth compare to long-term trends? For this we must focus on the United States, which may be regarded as the frontier country of productivity. In the

¹⁸ Fernald and Inklaar (2022) use this approach to analyze productivity developments in the United States. Consistent with this view, as they point out, the International Monetary Fund (2015, Box 3.2) finds a statistically significant link between changes in U.S. TFP growth and in TFP growth for other advanced economies using a cross-country panel data from 1970 to 2007. The peak effect occurs in three to four years.

Chart 4: Peak-to-peak Trends in Total Factor Productivity in the United States, Selected Periods (Average annual per cent change)



Note: The adjustment for mismeasurement in the 2007 to 2023 stacked bar applies to the years from 2007 to 2019.

Source: Authors' estimates and U.S. Bureau of Labor Statistics (2024).

neoclassical model of conditional convergence, TFP growth in the frontier country affects other countries with a lag.¹⁸ Recall that in a model with intangible capital TFP is endogenous, driven by the costless spread of innovations (or knowledge diffusion) and affected both by innovation policies as well as the growth and composition of intangible capital. By contrast, an economy's TFP is viewed as influenced Models of conditional convergence view an economy's TFP as influenced

An estimate of TFP for the US non-farm business sector is available from 1948 to 2023 from the Bureau of Labor Statistics (BLS, 2024), which we use to estimate TFP growth at the frontier

Simple peak-to-peak estimates of US

TFP growth are illustrated in Chart 4.¹⁹ Peak-to-peak averages reduce noise in the underlying series by calculating changes that eliminate business cycle effects. The first bar on the left combines the 1955 to 1968 and 1968 to 1973 peak-to-peak periods, which were both characterized by very high TFP growth.²⁰ The second bar shows the “slump” period from 1973 to 1990, and the third, the 1990 to 2007 period, which includes the IT-driven productivity boom. The blue portion of the final bar shows measured US TFP growth since the onset of the GFC to 2023, with the red-striped portion depicting our estimate of missing TFP growth due to a misstatement of price changes in paid-for consumer digital services in the official BLS statistics. Impor-

¹⁹ “Peak” refers to cyclical peaks in the level of the estimated index number for TFP.

²⁰ 1955 is used as the first cyclical peak because the peak for the 1948 to 1955 expansion is indeterminate. Note also that 1955 to 1973 period comprises two peak-to-peak episodes in TFP, as does the 1973 to 1990 period.

tantly, this misstatement has an inflection point in 2007, which affects TFP growth in subsequent years (through 2019).²¹

The US long-term series implies that there has been some slowing in frontier TFP growth since 2007, but also that the slowdown is rather small though consistent in direction. The performance of the adjusted post-GFC TFP estimate is relatively robust (0.73 per cent per year) though 0.35 percentage points below the average 1.08 per cent from 1990 to 2007 (and 0.34 percentage points below the average for the entire period from 1955 to 2007, which is 1.07 percent per year).

Our EU KLEMS & INTANProd series starts in 1995, with average US TFP growth from 1995 to 2007 boosted by the US “bubble growth” years from 1995 to 2005. Using these years as a basis for calculating the slowdown after 2007 therefore exaggerates the drop in sustainable TFP growth—there is no solid ground for using what is closer to a trough-to-peak year calculation to gauge a sustainable trend in a famously cyclical (and noisy) series.

The TFP estimates from EU KLEMS & INTANProd correct for a “missing intangibles” effect in the more typical calculations of TFP based on national accounts intangibles, such as those as shown in Chart 4. The analysis of the impact of capitalizing additional intangibles on measured TFP growth, as discussed earlier in this article, suggested that the missing intangibles

effect in EU KLEMS & INTANProd estimates of TFP is an empirical matter but that there were offsetting forces and that the effect is likely to be small. The precise size of the bias will differ across countries and the business cycle, so it is difficult to generalize. Corrado, Hulten, and Sichel (2009; Table 4), initially estimated that the inclusion of total intangibles lowered average US TFP growth by 0.25 percentage points per year from 1973 to 2003, with the average impact rising to 0.34 percentage points per year for the IT boom years, 1995 to 2003. Appendix A3 uses EU KLEMS & INTANProd to reexamine the missing intangibles effect and finds similar results, i.e. that capitalizing the missing intangibles per Table 1 lowers average TFP growth by 0.27 percentage points from 1995 to 2019.

All told, the estimates imply that the intangibles-adjusted growth trend in TFP at the frontier has been about 0.8 per cent per year but that growth of about 0.5 per cent per year may be more pertinent in the face of evidence that knowledge spillovers are presently weaker than in the past, which we will address in more detail later in this section.

The TFP Slowdown and Recent Growth: Redux

Though all countries/economic areas have seen a slowdown in TFP growth and

²¹ Official statistics miss major aspects of how consumers benefit from the digital economy. A primary example is the falling cost of consumer digital content delivery. The value that consumers obtain from their paid-for wireless data, internet, and video subscription services is not well-reflected in GDP. Available research quantifies (a) very fast drops in prices for paid-for consumer digital services, especially for mobile data and streaming services, and (b) increased shares of consumer spending allocated to subscriptions for these services. See, for example, Byrne and Corrado (2020, 2021).

labour productivity, there is heterogeneity in severity of the TFP slowdown and little correlation between its magnitude and the subsequent growth in TFP.

As noted previously (Table 3), Japanese TFP continued to expand at a solid 0.5 per cent per year in 2014-2019. And though the EU9 did not have an especially large slowdown in TFP growth after the onset of the GFC (0.6 percentage points), the slowdown pushed the EU9 post-GFC average annual change in TFP well into negative territory (-0.4 per cent), with an especially large average drop during 2008-2013 (-1.1 per cent per year). Adding to this, both labour productivity and TFP in the EU took especially hard hits in 2020, the pandemic year. Based on the EU9 aggregate shown in Table 3, as the EU entered the pandemic, its 2019 level of TFP stood nearly 4.1 per cent below that in 2007.²² There also was a large slowdown in TFP growth in the United Kingdom, pushing its post-GFC average annual change in TFP into negative territory and reducing the level of TFP in 2019 below that in 2007 by more than 2.5 per cent.

Productivity developments in the more recent—and more quiescent—period after 2013 are a relevant point of departure for assessing current trends and (possibly) revealing “green shoots” that hint at rates of future growth. Looking at the results on the lines showing the 2014-2019 average growth rates, we see that recent measured TFP growth for the countries and the EU

aggregate shown in Table 3 are positive and clustered in a narrow range at or slightly below the lower bound of the intangibles-adjusted growth of TFP of 0.5 per cent at the frontier—from 0.32 per cent and 0.34 per cent in the EU and United Kingdom at the low end to 0.45 per cent and 0.51 per cent in the United States and Japan at the high end.

Consider again the heterogeneity in magnitudes of the calculated slowdown and the clustering in recent growth in terms of the earlier analysis of using 1995 to 2007 as a baseline for calculating the slowdown in TFP growth. This analysis and the availability of long histories of TFP permit a refined assessment of the productivity slowdown in the United Kingdom and United States, i.e. we can adjust the baseline period used for the calculation of the TFP slowdown.²³ We can also reassess measured TFP growth after 2007 to account for misstated price change for consumer digital services due to the availability of a largely comparable study of consumer digital series for the United Kingdom (Abdihman *et al.* 2022) that obtained similar results to those found by Byrne and Corrado (2020) for the United States. We do not have a basis for adjusting the baseline for the productivity slowdown in the EU9 aggregate and Japan, though adjusting post-2007 TFP growth for price mis-measurement in the digital (services) economy also may be appropriate for these countries. There are no hard findings or

22 Calculated as the compound growth rate of the annual fall in TFP (-0.35 per cent) from 2008 to 2019.

23 For the United Kingdom we use estimates of market sector TFP produced by its Office of National Statistics that span from 1970 to 2022 (ONS, 2023) to examine the representativeness of 1995-2007 TFP growth as a base period for calculating the productivity slowdown.

Table 5: Adjusted TFP Growth for the UK and US selected periods, average annual change

Period	UK	US
1. Adjusted baseline	0.74	0.74
2. 2008-2019	0.03	0.36
Slowdown:		
3. (line 1 less line 2)	0.71	0.38
4. 2008-2013	-0.53	0.01
5. 2014-2019	0.59	0.70
Post aftermath slowdown:		
6. (line 1 less line 5)	0.15	0.04

Notes. Growth rates are log differences multiplied by 100. Line 3 and line 6 are point differences in growth rates. Adjusted baseline is growth in the period 1995-2007 from EUKLEMS & INTANProd, adjusted to represent the longer prior cycle in each country as detailed in Appendix Section A5. Lines 2, 4 and 5 are adjusted for mismeasurement of prices for consumer digital services from Byrne and Corrado (2020) Sources. Authors' elaboration of data from EU KLEMS & INTANProd (LLEE 2023); UK ONS (2023) and US BLS (2024).

available calibrations for these countries to determine a relevant magnitude of adjustment.

The adjusted results for the United Kingdom and United States are shown in Table 5. TFP growth remains very strong in the adjusted baseline (line 1) of both countries, and the productivity slowdown since then (line 3) is more moderate than shown in Table 3. That said, the slowdown for the United Kingdom is still large and exceeds that of other countries (United States, see Table 5.; EU9 and Japan, see Table 3). Nevertheless, amid the uncertainty prior to Brexit (line 4), its adjusted overall change does not dip into negative territory (line 2).

The fresh perspective on recent TFP growth in Table 5 underscores that there are indeed “green shoots” in recent productivity data. Adjusted average 2014-2019 TFP growth in the United Kingdom and the United States is estimated to have been 0.6 and 0.7 per cent per year, respectively, according to Table 5. Both rates of change

are squarely within the estimated bounds of growth in intangibles-adjusted TFP at the frontier of 0.5 to 0.8 per cent per year. As noted previously the same can be said for recent growth in Japan (without adjusting the EU KLEMS & INTANProd estimates of TFP for possible misstated measured consumer price change in that country) as well as in Spain (Table 4) and the EU North countries in the EU9 aggregate (Appendix Table A4).

The softer results for recent TFP growth in the EU9 aggregate is a cautionary tale, however. Recent productivity growth in the economies of Germany and France are very weak (Germany) or negative (France)—and this follows a decline in their TFP over the years of multiple crises. France has been investing heavily in intangible assets, though, and perhaps returns to these investments are yet to come.

Innovation and TFP

The conceptual framework in the first

section suggests that the origins of TFP growth are commercial knowledge spillovers and basic knowledge used to develop innovations embodied in intangible capital. We found that market sector intangible capital deepening remained steady through the ups and downs of multiple crises and that, since 2013, TFP growth has been at an average pace consistent with steady gains from the use and diffusion of technologies in three of the four major economic areas economies studied in this article. That said, the newer technologies are not boosting growth sufficiently to make up the losses incurred during the GFC, the European sovereign debt crisis and their aftermaths.

To put recent TFP growth in perspective, consider the two sources of knowledge spillovers in our model. The diffusion of commercially valuable knowledge is the primary and endogenous determinant of TFP in the intangible capital framework, but new basic knowledge flowing into upstream production in the market economy—the exogenous “freely available knowledge” depicted in the upper right corner of Figure 1—also affects measured TFP.

The TFP we have measured and discussed reflects contributions from both production sectors in the upstream/downstream model depicted in Figure 1. In this model total factor productivity may be expressed in terms of its two production sectors as:

$$da = s_Q^Y da^Y + s_Q^N da^N \quad (8)$$

i.e. the share-weighted sum of total factor productivity growth in each sector,

where the superscript Y denotes the downstream sector and N denotes the upstream sector. Ignoring trade and intermediates, the upstream production share s_Q^N is the market sector intangible investment rate displayed and analyzed in the previous section, i.e. it ranges from 8 to 18 per cent (Chart 3).

It is then natural to ask, which component of da in (8) might have slowed, and why? The concept of basic knowledge contributing to the production of commercially viable innovations is difficult to assess in its broadest meaning, but if we follow Bloom *et al.* (2020) and think of it as “ideas”, and if such ideas really are harder to find, then da^N falls—indeed because of its relatively low share, it must collapse to have a significant direct effect on da . All else equal, along with the direct effect of lower da^N on da , a collapse in da^N also lowers the rate of real intangible investment. The data in EU KLEMS & INTANProd contradict this, as do AI indicators (Maslej *et al.*, 2023).

Another indicator of freely available knowledge flowing into upstream production activity, is the growth in availability of open-source software, which has been strongly positive over the period of the productivity slowdown (Robbins *et al.*, 2022). In addition, the increase in the use of big data in upstream production processes improves efficiency and lowers the cost of producing intangibles, e.g. big data “greases the wheels” of supply chain logistics, improves the precision of marketing goods and services to customers, and likely enhances the probability of success in new product development. In fact, Corrado *et al.* (2024) estimated that the boost to da^N from the use of big data in marketing and

organization processes has been sufficient to exert downward pressure on the relative price of intangible assets that elevated labour productivity growth by about 0.1 to 0.2 percentage points since 2009.

On the other hand, a commonly used proxy for free basic knowledge is public R&D, which presents a mixed picture at first blush. Chart 5 illustrates comparative trends in non-market sector R&D from EU KLEMS & INTANProd. Non-market real R&D stocks in EU countries posted consistently strong growth over the last 20 years, whereas non-market R&D stocks elsewhere showed weak growth. In Japan, real stocks grew 0.7 per cent per year (a tad faster than the country's growth 0.5 per cent per year growth in real GDP). The United States and the United Kingdom posted little to no growth in R&D stocks in the aftermath of the GFC, largely in line with weak overall growth in economic activity in these countries.

It is of course unclear how the patterns shown in Chart 5 may have affected the flow of basic knowledge into the production of market sector intangibles. The production of market sector intangibles also includes the sector's conduct of own-funded R&D. In the United States, market sector R&D stocks (not shown) grew rapidly and relatively steadily from 2000 to 2020, and the measured flow of services from US total R&D stocks was apparently not affected by the period of slowdown in non-market stocks shown in Chart 5.

Recall that the full footprint of innovation in the market sector of an economy

consists of the returns to market sector intangible capital (whose asset price will reflect gains in da^N , sign reversed) plus the “costless” gains due to commercial knowledge spillovers. Seen from this perspective, the contribution of innovation to growth reflects the combined contributions of intangible capital and TFP.²⁴ In terms of labour productivity growth, this contribution in the post-2013 period is illustrated by summing up the contribution of columns (6) and (7) in Tables 3 and 4. As may be seen, the portion due to intangible capital deepening is substantial and did not change much over the slowdown period in the face of weakness (and in some cases, decline) in TFP during the crisis years.

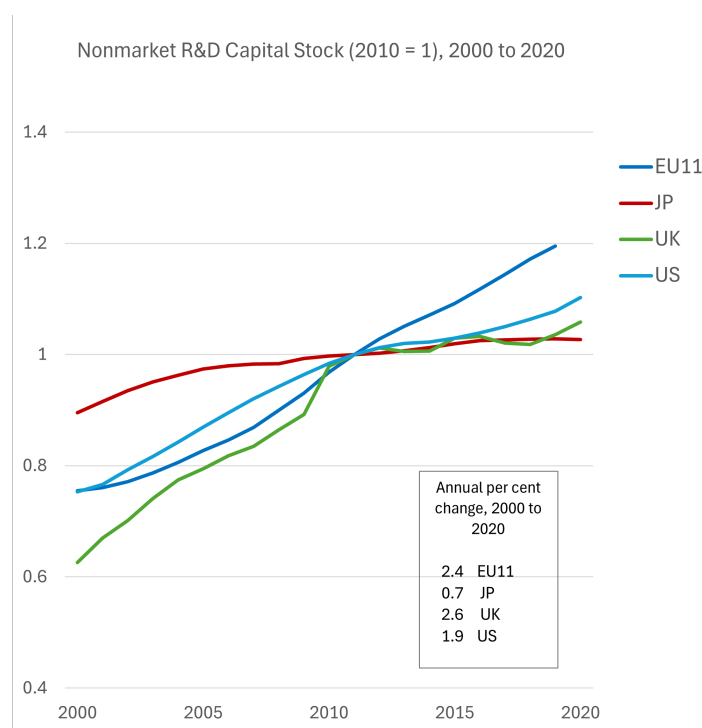
Our growth accounting results thus suggest that, while the social returns to market sector investments innovation (commercial knowledge spillovers) slowed after 2007, returns to private investments in innovation were generally maintained (on a per-hour basis). Moreover, as argued above, these returns were likely boosted by new efficiencies due to the increased use of data, open-source software and “free” knowledge about AI.

Reduced Commercial Knowledge Spillovers

Cross-country and firm-level econometric work has repeatedly estimated increasing returns, or knowledge spillovers, to market sector intangibles. In simple terms, the available works imply that the proportional relationship, $da \approx 0.2 dr$ could

²⁴ For further elaboration see Goodridge, Haskel and Wallis (2012) and Corrado *et al.* (2024).

Chart 5: Nonmarket R&D Capital Stocks (in 2010=1), 2000 to 2020



Note: EU aggregate is through 2019.

Source: EU KLEMS & INTANProd (LUISS 2023).

be used to represent the costless diffusion of commercially valuable knowledge (dr) in market economies.²⁵ As dr per hour worked did not materially slow along with TFP, the logical (endogenous) explanation for the slowdown in measured da is that factors driving these increased returns ceased to operate as strongly as they previously had.²⁶

The authors are engaged in an econometric study on productivity spillovers from market sector intangible capital and how they may have changed in recent years, but the study is incomplete, and results are pre-

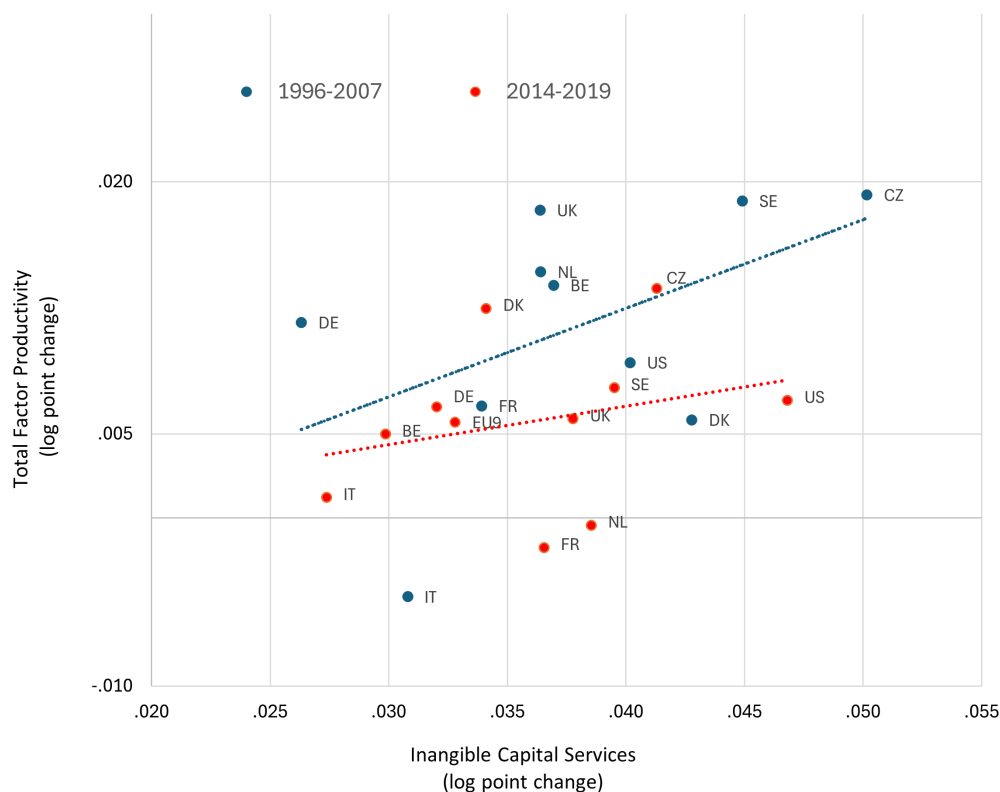
liminary. Chart 6 presents a story that we believe will emerge from that work. The blue dotted line in the chart shows a prima-facie association between the growth rates of TFP and intangible services, in line with the extant literature. But the figure also suggests that this relationship may have changed over time, with the slope of plot covering the more recent period (the red dots) lower than that of the plot for the pre-crisis period (the blue dots).

The flatter line for the 2014-19 period suggests there have been fewer productivity spillovers from intangible capital growth to

25 This refers to the aggregate implications of estimates for R&D spillovers reported by Griliches for manufacturing (e.g. Griliches 1992) and for intangible capital spillovers (excluding R&D and software) reported by Corrado, Haskel, and Jona-Lasinio (2017a). The latter study used a cross-country dataset consisting of European economies and the United States from the late 1990s to the onset of the GFC.

26 Though hours growth also slowed overall in the post-2007 years, hours growth during 2014-2019 was about the same as during 1996-2007 in the EU aggregate.

Chart 6: Changes in TFP and Intangible Capital, Selected Periods.



Note: Figures for post-2007 growth of TFP in the United Kingdom and the United States are adjusted for the misstatement of consumer digital prices.

Source: Authors' calculations from EU KLEMS & INTANProd database.

TFP growth in recent years. Why might this be? We have no definitive answers, but one possibility is around the commercial implementation of AI. As argued elsewhere (Corrado *et al.*, 2024), the large role that proprietary data play in the applications of AI technologies is consistent with a reduced pace of costless knowledge diffusion. Even if the AI algorithms are open source, the proprietary data companies use to train them for quantitative guidance deployed in business decisions are not. This creates a situation where new paid-for investments in data are needed for each replication of the technology, which slows its spread. The provision of more open data

by governments and policies that promote industry data sharing are needed to overcome this.

What might the quantitative contribution of the fall in spillovers be? Excluding Japan from the analysis, the average growth of intangible capital services after recovery from the GFC ranged from 3.2 per cent in Europe, to 3.6 per cent in the United Kingdom, and 4.5 per cent in the United States. If we suppose that spillovers of intangible capital were half of what they were prior to the GFC, then using the previously mentioned proportional relationship, reduced spillovers likely shaved 0.3 to 0.4 percentage points off TFP

growth—consistent with a lower prevailing intangibles-adjusted growth of TFP at the frontier. Referring to Tables 3 and 5, these are also large fractions of the measured TFP growth slowdowns. Further work on the hypothesis that spillovers have declined is worthwhile.

Summary and Conclusions

This article has used an updated and improved cross-country growth accounting dataset, EU KLEMS & INTANProd, to examine several macroeconomic performance issues. Before summarizing our results, let us put this workstream into context.

What is the point of integrating intangibles into macroeconomic data? Research has consistently indicated that (advanced) countries are increasingly investing in knowledge and relationship-style assets, or “intangible assets”. Such assets are typically ill-measured in company accounts, where company accountants are reluctant to ascribe any asset value to an asset without a clear market price, which many intangibles lack. That they lack a market price is itself of interest: this could be because intangibles are indivisible from the company itself (e.g. reputation) or being internally generated for secrecy reasons (e.g. business process engineering).

National accountants are gradually moving towards capitalizing more intangibles in line with national accounts principles: for purchased intangibles, a market price

is observable and for internally generated intangibles, a cost-of-production approach is adopted.²⁷ Thus, in our data, we treat intangible assets as a measured investment in the productive capital of an organization. When we include intangible assets in national accounts, we have more capital investment, changed measures for value-added output, capital income, and factor inputs. These changes have, in turn, consequences for calculations of the price-markup and the ex post rate of return to capital for economies.

In this article we first set out a framework for thinking about how the analysis of growth and productivity is affected by the inclusion of intangible capital. Intangible capital deepening not only becomes a source of growth in labour productivity in this framework, but also drives TFP growth via the diffusion of freely available, commercially valuable knowledge that the measure embodies.

The impact of the additional intangibles included in EU KLEMS & INTANProd on labour productivity levels and growth was calculated for the EU, EU regions, Japan, United Kingdom and United States, and we analyzed growth accounting results for the market sector. We also considered the impact on TFP growth of the misstatement of prices for consumer digital services and looked closely at comparative productivity growth in the relatively quiescent, recent period (2014-2019) for glimmers of an impact from newer technologies and implica-

²⁷ The 2025 SNA will recommend that data be capitalized as an asset in national accounts, but the SNA’s implementation guidance is unlikely to capture the breadth of what business analysts and technologists refer to as data assets, e.g., per discussions in Mayer-Schönberger and Cukier (2013) and Varian (2019). The conceptualization of data as an asset, its measurement, and its relationship to intangible capital is addressed in Corrado *et al.* (2024).

tions for the years ahead.

To put recent comparative developments as captured in the EU KLEMS database in perspective, we used an estimate of intangibles-adjusted TFP growth at the frontier, which we estimated to be between 0.5 and 0.8 percent per year—conditioned on recent trajectories for intangibles and knowledge spillovers. One of our most important findings is that recent TFP growth in Japan, and TFP growth in the United Kingdom and the United States adjusted for quantifiable price misstatement, are all within the range of growth at the frontier. TFP growth in Europe (unadjusted for price misstatement due to a lack of hard evidence) averaged 0.1 percentage point per year below the lower bound of the range. Nevertheless, these gains are not strong enough to make up for the accumulated shortfalls in TFP growth in Japan, United Kingdom, and Europe during 2008-2013.

In summary, while the story of the productivity slowdown in the intangible-intensive economies studied in this article is nuanced, intangible capital appears to have been well maintained throughout the ups and down of the post-2007 period. Our main message is that recent productivity growth suggests some green shoots from the combined contribution of intangible capital deepening and TFP growth, especially when taking into account adjustments for measurement error. This finding is consistent with gains from the take up of newer digital technologies, from mov-

ing computer and data processing to the cloud to incorporating AI into business processes—actions that have been accompanied by intangible investments.

The tempered enthusiasm regarding recent TFP growth comes from the fact that studies, including our own (Corrado *et al.* 2024), have found that the mechanisms that govern commercial knowledge diffusion are rather weaker since about 2010 than they have been in the past. We suggest that the impact of AI is weaker than generated by past waves of technical change, due in part to the fact that applications of AI in business processes rely on certain types of intangible assets (e.g., training data) that are held tightly and not replicable at low cost.²⁸ Other studies have documented diminished spillovers from R&D-based knowledge (Akcigit and Ates, 2021), an extraordinary concentration of advanced software tools in the hands of a few giant firms (Bessen, 2022) and evidence that protections of data (“compilations of information with commercial value”). This suggests that, unless policies to foster industry data sharing and digital technology extension restore the strength of prior diffusion mechanisms, the full potential of productivity growth-promoting spillovers from intangible capital will not be met.

28 Related, a recent study by Wang (2022) examined technology spillovers in the United States under the Uniform Trade Secrets Act (UTSA). The act protects data (“compilations of information with commercial value”) as intellectual property but is adopted on a state-by-state basis. The study exploited this feature, finding that technology spillovers between local firms and from peers in other states were 27 to 50 per cent lower in states adopting the UTSA than in states that did not.

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Appendix

A1. Industries in the EUKLEMS & INTANProd dataset

In the table below we also report the list of industries and industry aggregates that are covered in the EUKLEMS & INTANProd dataset. Aggregations and definitions are consistent throughout the database.

To maximize country coverage, this paper uses aggregates built using NACE one-digit (“letter level”) industries. This refers to the bolded industries in this table.

A2. Data Summary for EU Countries

Table A2 below (column 1) shows each EU country according to the regions used for analysis in section 2. The subsequent groups of columns summarize the availability of data on intangibles, labour productivity and total factor productivity according to individual country and time. Note that to measure national accounts intangibles and nonresidential tangible investment for market sector industries, a country needs to issue complete data on investment by asset type by industry. Thus, we may have tangible investment for the total of all industries in an economy but not for market sector industries, which are a subset of the total (as seen above in Table A1). The comparison of column (6) with (9) suggests that information on industry-level investment by asset type is not available for six countries.

A3. How is measured TFP growth affected by the inclusion of additional intangibles?

In section 3 we discuss how when intangibles are excluded from productivity analysis, measured TFP may be overstated, at least for a time. All told, the misstatement of TFP growth due to omitted intangibles in any given country is an empirical matter, depending on the investment and asset income dynamics described in box 2 in section 3, as well as changes over business cycles and in the relative prices of productive assets (tangible and intangible).

In Table A3 below we quantify the impact of the additional intangibles in EUKLEMS & INTANProd. As may be seen, for the conditions that prevail during the periods covered by the database, the inclusion of additional intangibles lowers estimates of TFP growth. Table A3, which currently is for the US only, sheds light on just how much TFP growth is lowered in this country by comparing the relevant line items in Table 3 of the main text with TFP calculated on using only those intangibles included in national accounts as shown in the table below.

Table A3 yields two findings. First, the table shows that US TFP growth is consistently lower using the expanded asset boundary. As shown in column (3, lines 1 and 2, and lines 4 and 5), the differences across the table’s selected periods are within a narrow range. Over the entire period 1996-2019 (line 7), TFP growth using the expanded asset boundary averages

Table A1: Industry Aggregates

Industry Code	Description
TOT	Total - all NACE activities (A-U)
TOT	Total (A-U)
TOT_IND	Total industries (A-S)
MARKT	Market economy (all industries excluding L, O, P, Q, T and U)
MARKxAG	Non-agricultural market economy (Market economy less industry A)
A	Agriculture, forestry and fishing
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Total manufacturing
C10-C12	... Food products, beverages and tobacco
C13-C15	... Textiles, wearing apparel, leather and related products
C16-C18	... Wood and paper products; printing and reproduction of recorded media
C19	...Coke and refined petroleum products
C20-C21	... Chemicals; basic pharmaceutical products
C20	... Chemicals and chemical products
C21	... Basic pharmaceutical products and pharmaceutical preparations
C22-C23	... Rubber and plastics products, and other non-metallic mineral products
C24-C25	... Basic metals and fabricated metal products, except machinery and equipment
C26-C27	... Computer, electronic, optical products; electrical equipment
C26	... Computer, electronic and optical products
C27	... Electrical equipment
C28	... Machinery and equipment n.e.c.
C29-C30	... Transport equipment
C31-C33	... Other manufacturing; repair and installation of machinery and equipment
D-E	Electricity, gas, steam; water supply, sewerage, waste management
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage; waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
G45	... Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	... Wholesale trade, except of motor vehicles and motorcycles
G47	... Retail trade, except of motor vehicles and motorcycles
H	Transportation and storage
H49	... Land transport and transport via pipelines
H50	... Water transport
H51	... Air transport
H52	... Warehousing and support activities for transportation
H53	... Postal and courier activities
I	Accommodation and food service activities
J	Information and communication
J58-J60	... Publishing, audio-visual and broadcasting activities
J61	... Telecommunications
J62-J63	... IT and other information services
K	Financial and insurance activities
L	Real estate activities
L68B	Real estate activities excluding imputed rents
L68A	Imputed rents of owner-occupied dwellings
M-N	Professional, scientific, technical, administrative and support service activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O-Q	Public administration, defence, education, human health and social work activities
O	Public administration and defence; compulsory social security
P	Education
Q	Health and social work
Q86	... Human health activities
Q87-Q88	... Residential care activities and social work activities without accommodation
R-S	Arts, entertainment, recreation; other services and service activities, etc.
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organizations and bodies

Note: NACE industry U is included for NACE definitional completeness, but data are not available for this concept.

Table A3: Impact of Expanded Asset Boundary on TFP growth, United States, selected periods (annual average change)

Period	(1) Expanded Boundary	(2) National Accounts	(3) Column (1) - Column (2)
1. 1996-2007	0.90	1.23	-0.33
2. 2008-2019	0.11	0.31	-0.20
3. Slowdown (level indicator) (lines 1-2)	0.79	0.92	-0.13
4. 2008-2013	-0.24	-.10	-0.14
5. 2014-2019	0.45	0.71	-0.26
6. Slowdown (growth indicator) (lines 1-5)	0.45	0.52	-0.07
Memo:			
7. 1996-2019	0.50	0.77	-0.27

Note: Growth rates are log differences multiplied by 100. Lines 3 and 6 and column (3) are point differences in growth rates.

Source: Authors' calculations using the EU KLEMS & INTANProd database (LUISS 2023). Column (1) above is from table 3.

about $\frac{1}{4}$ percentage point less than using the narrower group of intangibles treated as productive assets in national accounts. This estimate of the impact of the boundary expansion likely also applies to countries whose trajectory for investment in market sector intangibles is broadly like the pattern in the United States.

Second, table A3 suggest the estimated US productivity slowdown may be slightly more moderate using the expanded boundary (line 3). This finding stems from the pattern of differences across time in table 5, which while small when averaged across 12 years, are larger prior to the onset of the GFC (line 1) than after (line 2). To suggest that the productivity slowdown is diminished by about .1 percentage point when the asset boundary is extended to include all CHS intangibles implies that the same pattern shown in table A3 is found in other countries, which may be unlikely. Given the small size of the effect for the

US, the topic of whether there is a common cross-country pattern in the impact of the boundary extension on the productivity slowdown is left to future work.

The impact of the capitalization of additional intangibles on frontier TFP growth in the long run may or may not be in line with the average impact shown in table 5. For the interpretation of recent TFP growth and its slowdown after the onset of the GFC, however, we are comfortable using the average impact shown in the table to develop our notion of frontier TFP growth with all intangibles.

A4. Decompositions for five European Economies

Table A4 complements text table 4, showing decompositions of labour productivity growth in the remaining nine countries included in the European aggregate used in text Table 3.

Table A4. Decompositions of Labour Productivity Growth in the Market Sector of Selected European countries (average annual change, selected periods)

	Aggregate LP growth	Reallocation	Value-added weighted LP growth	Contributions (p.p) to value added-weighted LP Growth			
				Labour Comp.	Tangible Capital Deepening	Intangible Capital Deepening	TFP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Chezia							
1) 1996-2007	4.26	0.12	4.14	0.37	2.14	0.54	1.09
2) 2008-2019	1.56	0.22	1.34	0.30	0.60	0.41	0.03
3) 2020	1.27	1.62	-0.35	-0.03	2.32	1.30	-3.94
Slowdown							
4) (lines 1-2)	2.69	-0.11	2.80	0.07	1.54	0.14	1.06
5) percent of col. (3)			100	2	55	5	38
6) 2008-2013	0.20	0.26	-0.06	0.42	0.88	0.34	-1.71
7) 2014-2019	2.93	0.18	2.74	0.18	0.32	0.48	1.77
Slowdown (recent growth)							
8) (lines 1-7)	1.33	-0.07	1.40	0.19	1.82	0.07	-0.68
9) percent of col. (3)			100	14	130	5	-49
Denmark							
10) 1996-2007	1.60	-0.16	1.76	0.31	0.79	0.56	0.11
11) 2008-2019	1.55	-0.15	1.70	0.15	0.38	0.61	0.56
12) 2020	–	–	–	–	–	–	–
Slowdown							
13) (lines 9-10)	0.05	-0.01	0.06	0.16	0.41	-0.05	-0.45
14) percent of col. (3)			100	249	657	-85	-721
15) 2008-2013	0.91	0.13	0.78	0.36	0.36	0.60	-0.54
16) 2014-2019	1.79	-0.30	2.10	0.16	0.26	0.31	0.60
Slowdown (recent growth)							
17) (lines 9-15)			-0.34	0.14	0.53	0.24	-0.50
18) percent of col. (3)			100	-43	-157	-72	149
Finland							
19) 1998-2007	3.06	-0.38	3.45	0.08	-0.02	0.53	2.85
20) 2008-2019	0.14	-0.28	0.42	0.16	0.26	0.37	-0.37
21) 2020	1.23	1.25	-0.01	0.32	0.59	0.62	-1.54
Slowdown							
22) (lines (18-19)	2.92	-0.11	3.03	-0.08	-0.28	0.16	3.23
23) percent of col. (3)			100	-3	-9	5	107
24) 2008-2013	-0.67	-0.30	-0.37	0.18	0.27	0.50	-1.31
25) 2014-2019	0.96	-0.25	1.21	0.15	0.25	0.24	0.57
Slowdown (recent growth)							
26) (lines 18-23)	2.11	-0.13	2.24	-0.06	-0.27	0.28	2.28
27) percent of col. (3)			100	-3	-12	13	102
Netherlands							
28) 1996-2007	2.14	-0.24	2.37	0.27	0.50	0.48	1.13
29) 2008-2019	0.45	-0.28	0.73	0.38	0.19	0.58	-0.43
30) 2020	-0.57	1.56	-2.13	0.90	0.62	0.82	-4.47
Slowdown							
31) (lines 26-27)	1.69	0.04	1.65	-0.11	0.30	-0.10	1.56
32) percent of col. (3)			100	-7	18	-6	95
33) 2008-2013	0.65	0.05	0.61	0.48	0.17	0.66	-0.70
34) 2014-2019	0.21	-0.65	0.87	0.28	0.18	0.49	-0.08
Slowdown (recent growth)							
35) (lines 26-32)	1.92	0.42	1.51	-0.01	0.32	-0.02	1.21
36) percent of col. (3)			100	-1	21	-1	80
Sweden							
37) 1996-2007	3.50	-0.03	3.53	0.42	0.99	0.86	1.26
38) 2008-2019	1.26	-0.12	1.38	0.09	0.52	0.73	0.04
39) 2020	2.64	1.82	0.83	0.33	1.01	1.46	-1.97
Slowdown							
40) (lines 26-27)	2.24	0.09	2.15	0.32	0.47	0.13	1.22
41) percent of col. (3)			100	15	22	6	57
42) 2008-2013	0.79	-0.12	0.92	0.07	0.64	0.76	-0.55
43) 2014-2019	1.77	-0.24	2.01	0.13	0.42	0.78	0.68
Slowdown (recent growth)							
44) (lines 26-32)	1.73	0.22	1.52	0.29	0.58	0.08	0.57
45) percent of col. (3)			100	19	38	5	38

Note: Annual changes are log changes multiplied by 100.

Source: Authors' elaboration of data from EUKLEMS & INTANProd (LLEE 2023)

Are Intangibles Running out of Steam?

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Abstract

This article looks at the role of intangibles in explaining the slowdown in productivity growth for (the average of) nine EU countries, the United Kingdom and the United States from 2011 to 2019 compared to the period before the Global Financial Crisis (GFC). Using the 2023 version of the EUKLEMS-INTANProd industry-level database, we find that while intangible investment continues to increase as a share of nominal GDP, the growth rate of the intangibles capital stock has moderately slowed in real terms. The contribution of intangible capital deepening to labour productivity growth has remained positive though not strong enough to offset the effects of the large decline in tangible capital deepening. We also find a relatively strong slowdown in labour productivity growth for the most intangible-intensive industries, especially in the United Kingdom and the United States. Preliminary econometric analysis suggests little evidence of strong TFP spillovers from intangible capital deepening, there is mixed evidence of interaction effects for business innovation-related intangibles and ICT and non-ICT tangibles. While intangibles have not run out of steam, we conclude that the impact of intangibles on productivity growth has become more complex, especially as business innovation-related investments seem highly complimentary with other types of capital. We advocate for policies focused on broad-based investment in both tangible and intangible assets to facilitate the diffusion of new technologies and knowledge.

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We are living in a world of rapid technological change and slowing productivity growth. While a new generation of technologies is emerging, ranging from new information and communication technologies (ICT), artificial intelligence (AI) and robots to nano- and biotechnologies, productivity growth has not responded to the changes in the way one might have expected - at least not at the macroeconomic level. Over the past two decades average productivity growth for advanced economies has slowed to the lowest rate since World War Two (van Ark, de Vries and Pilat, 2024).

There are many potential explanations for the productivity slowdown, including the drag from the Global Financial Crisis (GFC) because of low demand, weak investment, resource misallocation, an erosion in catch-up growth in emerging markets which has also affected advanced economies, and the mismeasurement of outputs and inputs in an increasingly digital and intangible economy (Goldin *et al.*, 2024).

In earlier work, we have stressed the importance of time lags in the adoption of new technologies and the increased complexity in generating productivity growth from the latest round of new digital technologies since the early 2010s. These new technologies include the transition toward mobile, ubiquitous access to broadband, the rise of cloud technologies and advances in AI and robotics (van Ark, 2016; van Ark, de Vries and Erumban, 2021). We have argued that the “new digital economy” might still be its “installation phase” and that broad-based productivity effects will only occur once the technology enters the “de-

ployment phase” (Perez, 2002). Brynjolfsson, Rock and Syverson (2019) have formalised this idea by way of their “Productivity J-curve” which describes how initial investments in intangible assets (such as data, skills, management, and organisational improvements) which are complementary to new digital technologies, do not show productivity effects until later.

Indeed, the rise in intangible investment has played an important role in facilitating the transition to those new technologies. There is widespread evidence that investment in intangible assets, as conceptualized by Corrado, Hulten and Sichel (2005) has outpaced tangible investment as a share of GDP in the United States (since the 1990s), the United Kingdom (since the early 2000s) and the EU (since the 2010s) (van Ark *et al.*, 2009; Corrado *et al.*, 2016). There is also ample evidence that intangible capital has contributed positively to productivity growth (Corrado *et al.*, 2022).

However, there are some reasons to be concerned about the changing role of investment in intangibles as a contributor to productivity growth in recent times. First, in some countries, the growth rates of intangible investment have begun to slow down since the 2010s, potentially reducing the contribution of intangibles to productivity growth compared to previous decades (Haskel and Westlake, 2022; Goldin *et al.*, 2024).

Second, in addition to the possibility of a weaker direct contribution of intangibles to labour productivity growth, the productivity spillovers from intangibles, measured by their impact on total factor productivity (TFP) growth, may also have begun to lose steam (Bloom *et al.*, 2020; Goldin *et*

al., 2024; Bontandini *et al.* 2024).

Third, a specific reason for the weakening of spillovers may be the increased complexity in combining different types of intangible investment, pointing at the sensitivity of TFP growth to the complementarity of intangibles (Brynjolfsson, Rock and Syverson, 2019; Coyle, 2023). In addition to different mechanisms through which the impact of intangibles on productivity may have changed, there may also be different experiences between countries, and – as we will investigate in this article – between different types of intangible capital.

In this article, we aim to contribute to answering the question to what extent the slowdown in market-sector productivity growth may be attributed to a weakened performance of intangible capital.² Using the 2023 version of the EUKLEMS & INTANProd database, we look at the performance of intangibles for 11 advanced economies (nine member states of the European Union, the United Kingdom and the United States) before and after the GFC (1996-2007 and 2011-2019). We are using the Global Financial Crisis (2008-2010) as a proxy for the segmentation between the rapid productivity growth period of the 1990s and early 2000s and the slower growth period since.³ However, this does not imply that we see the GFC as the main reason for the productivity slowdown, ac-

knowledging the evidence suggesting that the slowdown in many countries seems to have begun before the start of the GFC (Fernald, Inklaar and Ruzic, 2023).

We build on the earlier literature, referred to above, by adding some new elements to the discussion.

First, we compare the evidence for three different measures of intangibles, namely intangibles as a share of value added (measured in nominal and gross terms), the growth rate of real intangible capital investment, and the growth rate the intangibles capital stock.

Second, as EUKLEMS & INTANProd provide data for different types of intangible, we distinguish between those which are included in current measures of GDP and those which are not. We suggest that the intangibles which are included in GDP (such as R&D, software and databases) can be marked as directly related to the production and use of new technologies. Those which are not part of GDP (including market research and branding, operating models, and employer-provided training) are especially important for the broader organisation's business innovation process. We also look separately at ICT-related and other tangible capital in relation to intangibles.

Third, we add an industry dimension to the analysis by dividing the market sec-

2 Throughout this article we focus on the market economy, excluding public administration (NACE Sector O), education (P), health care (Q), activities of households (T) and extra-territorial organization (U), as well as real estate (L).

3 We do not think that there are that many conclusions to draw on the long-term trend of intangibles and productivity from the volatile movements in economic indicators during the GFC or the disruption in the trend when COVID-19 pandemic emerged in 2020. When including the crisis, the breakpoint in the series is rather sensitive to the choice of year impacting the comparisons of the pre- and post GFC trends. The data for 2008-2010 period are provided in the online Appendix (https://csls.ca/ipm/46/vanArk_Appendix.pdf).

tor up into two groups of industries. The first group is classified as the above-median (“intensive”) users of intangible capital and the second group as below-median (“less intensive”) users of intangible capital.

Fourth, we undertake a preliminary econometric analysis of the relationship between the growth in capital deepening and TFP before and after the GFC to look for pointers indicating changes in spillover effects from different types of tangible and intangible capital on TFP as well as the effects from interactions between different types of capital.

Our main findings can be summarized as follows. First, even though the share of intangible investment in nominal value added in the market-sector has continued to increase since the GFC, the growth of real investment for “technology-related” intangibles slowed, whereas that for “business innovation-related” intangibles picked up. There is a more consistent albeit still modest slowdown visible in the growth rate of the intangible capital stock between the pre- and post GFC periods.

Second, even though the slowdown in TFP growth has been the main culprit of the productivity problem since the GFC, weaker capital deepening has also played a large role. While the contribution of intangible capital deepening has remained positive during the post-GFC period, it has not been strong enough to offset the large decline in the contribution of tangible capital deepening to productivity growth.

Third, industries which are relatively intangible-intensive (that is, those with intangible investment shares above the median of all industries) contributed more to the slowdown in productivity growth than

those that are less intangible-intensive, most strongly so in the United Kingdom and to a lesser extent in the United States.

Fourth, we find rather mixed and weak evidence of spillover effects from intangible capital deepening on TFP growth. However, there are some signs of positive effects from combining different types of capital, perhaps mostly so between business innovation-related intangibles and ICT or non-ICT tangibles. This evidence hints at the importance of a broad-based investment strategy focused on tangibles and intangibles.

Taken together, we find that even though intangibles have not run out of steam in terms of growth, the rates of growth of the intangible stock and the contribution of intangible capital deepening to productivity growth have slowed somewhat, especially in countries (like the United Kingdom and the United States) that were the most intangible-intensive early on. The impact of intangibles on productivity growth seems to have become more complex, especially as the importance of business innovation-related intangibles tends to be increasingly dependent on other types, including tangible capital.

The article proceeds as follows. In the first section we review the evidence on the changing shares of tangible and intangible investment in market sector value added, the growth trends in real investment and those of the stock of tangible and intangible capital. Next, we use the data from the extended growth accounting framework as presented in EUKLEMS & INTANProd to look at the extent to which intangible capital contributed to the slowdown in labour productivity growth at the ag-

gregate level. The third section provides an industry perspective by comparing the growth accounts between intangible- and less intangible-intensive industries. In the fourth part of the article, we investigate the spillover effects from intangible and tangible capital deepening on TFP growth and the extent to which interactions different types of intangibles and tangibles also play a role. The concluding section makes a number of suggestions for policy directions that may help in strengthening the role of intangibles for productivity growth.

Pre- and Post-GFC Trends in Intangible Investment and Capital

In recent decades the importance of intangible capital in advanced economies has increased strongly, but there are some signs of a moderation in the growth rate of intangibles. For example, comparing recent intangible investment data up to 2017 against the pre-2007 trend, Haskel and Westlake (2022:51-52) see “a decline in the growth of ‘intangible’ capital services, including and excluding software. The pace of growth slowed in the 2010s onwards, particularly excluding software.” Goldin *et al.* (2024) also find a large slowdown in the growth of capital services from intangibles in the United States and in Germany, but a stable picture for the United Kingdom and a moderate improvement in France.

To investigate the recent trends in more detail, we make a distinction between dif-

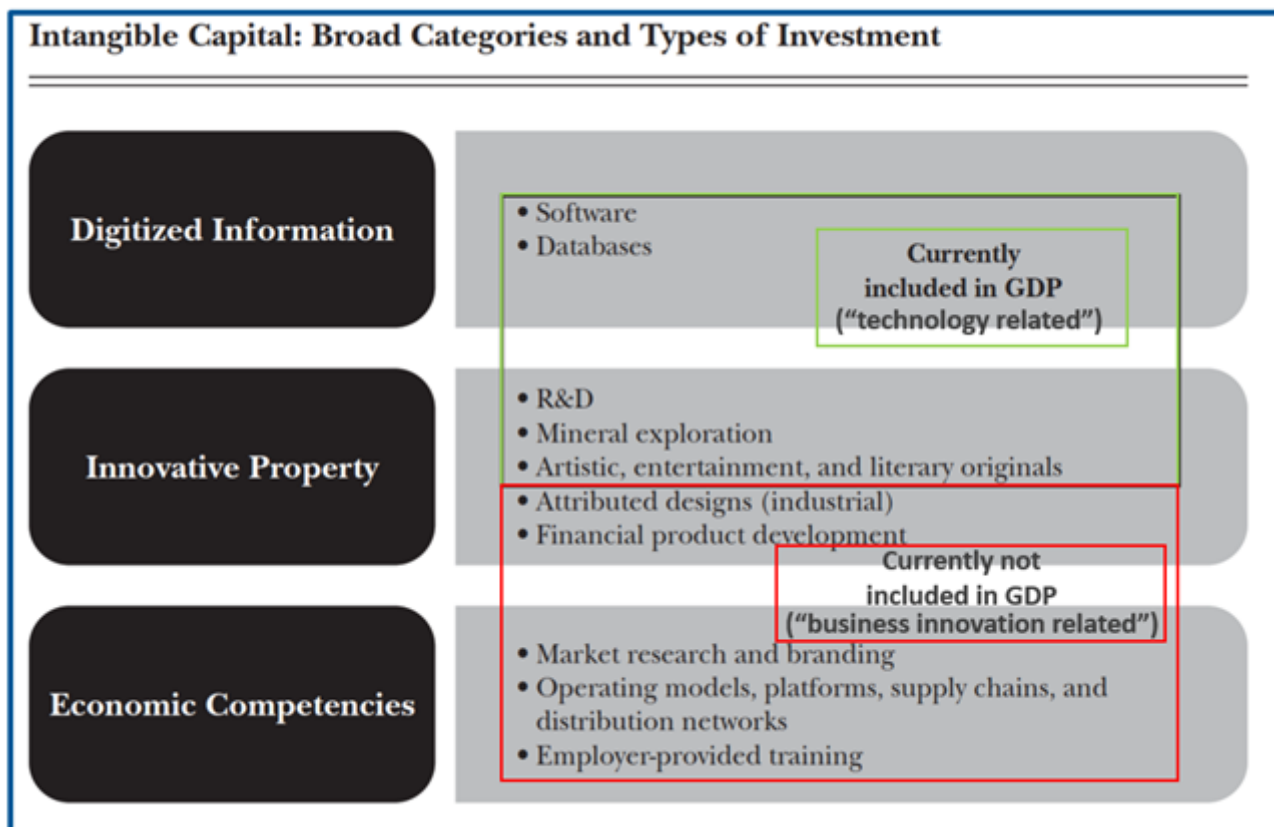
ferent components of tangible and intangible capital. With regard to tangible capital, we separate ICT capital, including computer hardware and telecommunication equipment, which grew rapidly before the GFC (though from a low base) from other tangibles, such as non-ICT machinery and equipment and non-residential structures, which have grown much more slowly.⁴

Regarding intangibles, we distinguish between intangibles which are included in current measures of GDP and those that are not (Figure 1). Investments in the first group (including software, databases, R&D, etc.), which are fully capitalized in the national accounts, are mainly intangibles directly related to the creation and use of technology. We will therefore refer to those as “technology-related” intangibles. The second group of intangibles, which are currently expensed as intermediate inputs in the national accounts, are more broadly related to an organization’s business process. These include activities which, on the whole, are not of a technological nature, such as financial product development, market research and branding and organizational capital. However, they add important value to the innovation capabilities of the organization.

Our data are obtained from the latest version of the EUKLEMS & INTANProd – Release 2023 database by the LUISS Lab of European Economics. It merges the original EUKLEMS Growth and Productivity Accounts with the latest estimates on in-

⁴ Residential structures are not included as the EUKLEMS-INTANProd database allocates all investment in dwellings to the Real Estate industry (NACE L), which we exclude from our figures for the market sector.

Figure 1



Source: based on Corrado *et al.* (2022).

tangible capital. The database includes 30 countries for 38 industries.⁵

In this article, we base our analysis on 11 of the 30 countries included in EU-KLEMS & INTANProd, namely those for which we could obtain complete data series for the period 1996-2019.⁶ Nine countries are member states of the European

Union (Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden), which we present here as a single group using GDP-weighted country averages (results of individual countries are presented in an on-line Appendix).⁷ We also look separately at the data for the United Kingdom and the United States as both

⁵ Bontandini *et al.* (2024), who have produced the latest EUKLEMS-INTANProd Database, provides an extensive description of the features of the intangible capital measures included in EUKLEMS-INTANProd. They also present a useful framework for addressing how innovation, intangibles and TFP growth relate, including their own analysis of how intangibles relate to labour productivity.

⁶ We are not using the 2020 data as these are not available in full for all countries. In addition, 2020 represents the first year of the COVID-19 pandemic, which would seriously distort the long-term trend analysis in this article.

⁷ In an earlier version of this article, presented at the 7th World KLEMS conference in 2022, we looked at data for six countries (France, Germany, Italy, Spain, the United Kingdom and the United States). Here we use a later vintage of the data, released in 2023, allowing us to cover nine EU economies. The number of countries is too small, however, to divide up into sub-regions like North and Southern Europe, although we do provide analysis of individual countries where significant for the average of the EU average.

economies have exhibited a relatively rapid growth in intangibles.⁸

Table 1 presents the summary results for the investment shares of tangibles and intangibles in nominal gross value added (GVA), the growth rates of real investment and of the capital stock for the market sector for the periods 1996-2007 and 2011-2019. Columns (1)-(3) show that intangible investment shares have continued to increase for all three areas. During the 2011-2019 period, the value-added share of intangibles exceeded that of tangibles for all three areas, even though tangible investment still accounted for a larger share than intangibles in three EU economies (Austria, Italy and Spain).⁹

The United Kingdom and the United States clearly exhibited higher GVA shares for intangibles than the EU, even though there has been a narrowing of the gap between the EU and the United Kingdom, which was largely driven by an increase in the share of “technology-related” intangibles (R&D and software) in the EU. Technology-related intangibles in the United Kingdom account for one of the lowest shares in value added (around 4 per cent), comparable to Germany, Italy and Spain, but much lower than for France and the United States (around 7 per cent). In contrast, the United Kingdom accounts for

the highest GVA share of all eleven countries in “business innovation-related” intangibles (11.9 per cent).

The increase in the investment shares in columns (1)-(3) are, in part, due to the slower growth of the denominator (nominal GDP in the market-sector), which has increased more slowly from 2011-2019 compared to 1996-2007. Focusing on the numerator only, and adjusting investment for investment prices, columns (4)-(6) in Table 1 show that the real growth rate of technology-related intangible investment slowed in the United Kingdom and the United States while it substantially accelerated for business innovation-related intangibles. In contrast, the growth of intangible investment showed no acceleration in Europe across either category.¹⁰

The picture becomes somewhat more sobering, when moving from the growth in investment to that of stock of capital, reflecting the accumulated investments in net terms over time (columns (7)-(9) in Table 1). The growth of the intangible capital stock weakened across all three areas between 1997-2007 and 2011-2019. For the United States and the United Kingdom, we find a comparatively strong slowdown in “technology-related” intangible capital stocks (as we did for investment). A deeper analysis of the data (not shown here) sug-

⁸ For the United Kingdom we have also access to intangibles data with greater industry detail from Goodridge and Haskel (2023), but for the sake of comparability, we use the EUKLEMS-INTANProd version for the United Kingdom here. The online Appendix provides a comparison between the two datasets for the United Kingdom.

⁹ See Appendix Table 1 in the online Appendix. This table shows that tangible investment was also more important as a share of GVA in Germany from 1996-2007. However, the share of intangibles has overtaken that of tangibles since, possibly reflecting the growth of intangible-intensive service industries relative to the manufacturing sector, which has traditionally been quite strong in Germany.

¹⁰ This result is caused to a large extent by large a slowdown in Spain and Italy since the GFC (see Appendix Table 1).

Table 1: Nominal Investment Share in Value Added, Real Investment and Capital Stock Growth, Tangible and Intangibles, Market Economy, 1996-2007 and 2011-2019

	1996 -2007	2011 -2019	change: 2011 -2019 less 1996-2007	1996 -2007	2011 -2019	slowdown: 2011-2019 less 1996-2007	1996 -2007	2011 -2019	slowdown: 2011-2019 less 1996-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
European Union (9)	Investment value added/ share (%)			Real Investment (average annual % growth)			Real Capital Stocks(average annual% growth)		
Tangibles	13.5	11.9	-1.6	3.2	2.3	-0.9	1.7	0.4	-1.3
Non-ICT tangibles	12.3	11.0	-1.2	2.6	2.2	-0.4	1.5	0.4	-1.1
ICT tangibles	1.2	0.8	-0.4	7.2	3.8	-3.4	6.3	2.8	-3.5
Intangibles	11.4	13.6	2.2	3.0	3.0	0.0	2.6	2.4	-0.2
Technology-related	4.1	5.2	1.1	3.7	3.5	-0.1	3.0	2.8	-0.2
Business innovation-related	7.3	8.3	1.0	2.6	2.6	0.0	2.6	2.3	-0.3
TOTAL	24.8	25.4	0.6	3.1	2.6	-0.5	1.9	0.9	-1.0
United Kingdom	Investment value added/ share (%)			Real Investment (average annual % growth)			Real Capital Stocks(average annual% growth)		
Tangibles	11.7	9.9	-1.8	3.0	2.9	-0.1	2.7	1.1	-1.6
Non-ICT tangibles	10.1	9.1	-1.1	1.7	3.8	2.1	2.2	1.2	-1.0
ICT tangibles	1.5	0.8	-0.8	10.4	-0.5	-10.8	11.8	-0.1	-11.9
Intangibles	14.9	16.2	1.3	3.8	4.3	0.5	3.7	3.5	-0.2
Technology-related	4.2	4.3	0.1	3.0	2.7	-0.2	3.8	3.1	-0.7
Business innovation-related	10.8	11.9	1.1	4.0	4.8	0.8	3.7	3.4	-0.3
TOTAL	26.6	26.1	-0.6	3.4	3.8	0.3	3.0	1.8	-1.2
United States	Real Investment (average annual % growth)			Real Investment (average annual % growth)			Real Capital Stocks(average annual% growth)		
Tangibles	11.2	10.1	-1.1	5.0	5.0	0.0	2.7	1.8	-0.9
Non-ICT tangibles	9.0	8.5	-0.5	2.3	4.6	2.3	2.0	1.5	-0.5
ICT tangibles	2.3	1.6	-0.6	13.8	7.1	-6.7	11.7	8.8	-2.9
Intangibles	15.1	17.7	2.6	4.3	5.0	0.7	3.5	3.2	-0.3
Technology-related	5.6	7.1	1.5	6.5	5.1	-1.4	4.0	2.9	-1.1
Business innovation-related	9.5	10.6	1.1	3.1	5.0	1.9	4.0	4.1	0.1
TOTAL	26.3	27.8	1.5	4.6	5.0	0.4	2.9	2.3	-0.6

Notes: European Union (9) includes Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden and are weighted by their GDP. Market economy definition: see footnote 1. Growth rates are averages of annual log changes, and the difference between periods is expressed in percentage points. Technology-related intangibles are measured as part of GDP in the national accounts; business-innovation intangibles are not included in GDP, and value added is therefore adjusted to include the output contribution from the latter (see Figure 1). The volume changes in investment for tangible ICT assets for the UK for the period 2011-2019 have been recalculated by the authors using the ICT investment price index for the aggregate economy rather than for individual industries, due to some irregularities in the industry-level source data.

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-illee.luiss.it/>). For EU country detail see Appendix Table 1.)

gests this was especially driven by a softer growth of software. However, even the growth of “business innovation-related” intangible stocks did not hold up in the United Kingdom during the post-GFC period due to a decline in financial product development.

The reason for the slowdown in the stock compared to any modest growth in intangible investment is due to the compound-

ing effects of the latest additions to the stock, especially from assets for which depreciation rates are relatively high, as is the case for many intangibles compared to most tangible assets. Even if the investment growth rates of intangibles increase more rapidly than for tangibles, intangibles also drop out of the stock more quickly, which affects the growth rate of the capital stock negatively when they are not replen-

ished at a faster pace than tangibles.

In sum, while the choice of metric and the type of intangible matters, we conclude that on balance there has been a modest weakening in the growth of intangibles. However, when looking beyond intangible capital, Table 1 clearly points out that the big story for the slowdown in capital stock growth is related to tangible assets.

The slowdown in growth in tangible assets, which on average dropped much more sharply across the EU, the United Kingdom and the United States than intangibles, is especially large for ICT-tangibles (such as computer hardware and telecom equipment). The latter has of course been growing from a much lower base than non-ICT tangible capital during the pre-GFC period and the growth rate therefore often exhibits a trend towards levelling off. However, the slowdown may also reflect a shift from ICT hardware towards intangible ICT assets such as big data and AI tools. Indeed, the reader is reminded here that our sample period ends in 2019, whereas some of the larger impacts of those recent technologies may only have begun to appear since 2020, on which we comment in the concluding section of the article.

Intangibles, Tangibles and Productivity Trends

During the aftermath of the GFC, advanced countries have widely experienced a slowdown in productivity growth which, according to several studies, already began a few years before the GFC (Fernald and Inklaar, 2022). Table 2 shows that annual labour productivity growth slowed by 0.5 percentage points in the EU, more than triple that in the United States (1.7 points) and quadruple that in the United Kingdom (2 points).¹¹ The latter two countries experienced significantly faster productivity growth than the EU during the pre-GFC period. During the post-GFC period, EU and US labour productivity annual growth rates were about the same (1.1 and 1.2 per cent respectively). At 0.7 per cent, the UK productivity growth rate fell well below that of the EU and the United States.¹²

Table 2 provides the results from the standard Jorgensonian growth accounting framework extended with intangibles includes, as explained by Bontandini *et al.* (2024). Before discussing the direct contributions of capital deepening to labour productivity group, we note that weaker TFP growth accounted for the bulk of the labour productivity slowdown after the GFC, that is, half in the United Kingdom (52 per cent) and the United States (50 per cent) to three-quarters in the EU (73 per cent) (column 6). However, in absolute terms the TFP growth was much bigger in

11 Note that labour productivity growth rates have been adjusted to reflect the inclusion of the business-innovation intangibles which are not measured as part of GDP according to the System of National Accounts. According to EUKLEMS-INTANProd, the slowdown in labour productivity without the intangibles not in the SNA would have been slightly larger at 0.6 points in the EU, 2 points in the US, and 2.3 points in the UK. See EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-lee.luiss.it/>)

12 Only Finland (which also had high productivity growth rates from 1996-2007) was at par with the UK post-GFC growth rate while Italy and the Netherlands showed even slower productivity growth rates than the United Kingdom (0.5 per cent) (see Appendix Table 2).

Table 2: Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Market Economy, 1996-2007 and 2011-2019

	1996 -2007	2011 -2019	slowdown: 2011-2019 less 1996-2007	1996 -2007	2011 -2019	contribution to the slowdown: 2011-2019 less 1996-2007
	(1)	(2)	(3)	(4)	(5)	(6)
European Union (9)	Absolute Contributions to Labour Productivity Growth (%)			Relative Contributions to Labour Productivity Growth (%)		
Labour productivity growth	1.6	1.1	-0.5	100	100	100
Labour composition	0.2	0.4	0.2	11	38	-44
Tangible capital deepening	0.6	0.2	-0.4	36	14	81
Non-ICT	0.4	0.1	-0.3	24	10	52
ICT	0.2	0.1	-0.2	13	5	29
Intangible capital deepening	0.3	0.4	0.1	21	36	-10
Technology-related	0.2	0.2	0.0	13	20	-2
Business innovation-related	0.1	0.2	0.0	8	16	-8
Total Factor Productivity	0.5	0.1	-0.4	32	11	73
United Kingdom	Absolute Contributions to Labour Productivity Growth (%)			Relative Contributions to Labour Productivity Growth (%)		
Labour productivity growth	2.7	0.7	-2.0	100	100	100
Labour composition	0.3	0.2	-0.2	13	29	7
Tangible capital deepening	0.7	0.1	-0.6	25	11	29
Non-ICT	0.4	0.1	-0.3	13	8	15
ICT	0.3	0.0	-0.3	12	3	15
Intangible capital deepening	0.5	0.3	-0.2	19	46	11
Technology-related	0.1	0.0	-0.1	4	0	5
Business innovation-related	0.4	0.3	-0.1	15	46	5
Total Factor Productivity	1.2	0.1	-1.1	43	14	52
United States	Absolute Contributions to Labour Productivity Growth (%)			Relative Contributions to Labour Productivity Growth (%)		
Labour productivity growth	2.8	1.2	-1.7	100	100	100
Labour composition	0.4	0.2	-0.2	13	15	11
Tangible capital deepening	0.8	0.2	-0.6	27	15	34
Non-ICT	0.3	0.0	-0.2	9	3	13
ICT	0.5	0.2	-0.4	18	14	21
Intangible capital deepening	0.7	0.6	-0.1	24	52	4
Technology-related	0.4	0.3	-0.1	15	25	8
Business innovation-related	0.3	0.3	0.1	9	26	-3
Total Factor Productivity	1.0	0.2	-0.8	36	17	50

Note: European Union includes Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden (see Appendix Table 2). Growth are averages of annual log changes. Market economy definition: see footnote 1. “Intangibles –technology-related” are measured as part of GDP and included in the national accounts; “intangibles – business-innovation related” are not included in GDP in the national accounts (see Figure 1). Value added is adjusted to include the output contribution from intangibles not included in the System of National Accounts. Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-illee.luiss.it/>). For EU country detail see on-line Appendix Table 2 to this paper.

the United Kingdom (1.1 points) and the United States (0.8 points) than in the EU (0.4 points) (column 3).¹³

Despite the modest slowdown in the growth of the intangible capital stock, discussed in the previous section, intangible capital deepening (measured as the capital services from intangibles per hour worked) accounted for a small part of the aggregate labour productivity slowdown between the pre- and post-GFC periods. In the United States, intangibles only contributed 0.1 points to the 1.7 points slowdown in labour productivity, and in the United Kingdom it accounted for 0.2 points of the 2 points slowdown in labour productivity growth. In the EU, the contribution of intangible capital deepening even strengthened modestly by 0.1 points hence partly offsetting the 0.5 points slowdown in labour productivity growth.¹⁴

Compared to intangibles, the slowdown of the growth in tangible investment and capital has contributed much more to the slowdown in labour productivity growth. Column (6) in Table 2 shows that tangible capital deepening accounted for 34 per cent of the productivity slowdown in the United States (compared to 4 per cent for intangible capital), and for 29 per cent in the United Kingdom (compared to 11 per cent for tangible capital). While intangible capital had somewhat come to the rescue in the EU, tangible capital deepening

accounted for four fifths (81 per cent) of the EU's slowdown in labour productivity growth.¹⁵

The weakening in the contribution of tangible capital deepening to productivity is not only driven by ICT hardware, but is also reflected in the decline in other machinery, equipment and structures. Hence this is not just an ICT story in terms of a shift away from computers and telecommunication equipment to the greater use of ICT software and data during the most recent period.

In summary, compared to the slowdown in TFP growth across all three areas, the slowdown in capital deepening across the three areas has played a small role in explaining the slowdown in labour productivity growth during the post-GFC period. The latter is primarily driven by the decline in tangible capital deepening. Despite its positive contribution to labour productivity growth, intangible capital deepening has not been strong enough to offset the negative contribution from tangible capital to the labour productivity slowdown. We will return to this observation later in the article.

Productivity in Intangible-intensive Industries

In our earlier work (van Ark, de Vries and Erumban, 2021), we have stressed the

13 Within the EU, Finland (2.4 points) and the Netherlands (1.6 points) exhibited the largest TFP slowdowns as both countries – like the United Kingdom and the United States – benefited rather strongly from the deployment of digital technology during the 1990s and early 2000s (see Appendix Table 2).

14 Only Denmark, Finland, Sweden and Italy saw a modest weakening in the contribution of intangible capital in the EU (see Appendix Table 2).

15 Only Finland saw a small positive contribution from tangible capital deepening, which arose from a recovery in non-ICT capital (see Appendix Table 2).

importance of time lags in the adoption of new technologies. Based on Perez (2002), we have argued the “new digital economy” might still be in its “installation phase” with broad-based productivity effects occurring only once the technology enters the “deployment phase”.

One way to test the time lag hypothesis is by making a distinction between industries which are characterized as early or late adopters of technology. Here we replicate our earlier analysis by, which was based on an OECD industry taxonomy for digital intensity, but by applying a slightly different taxonomy based on intangible investment intensity. We based the industry taxonomy on the intangible investment shares in value added (in nominal terms) by industry in the market-sector for six of the eleven economies in our study (France, Germany, Italy, Spain, the United Kingdom and the United States). Industries above the median intangible investment share, which is 12.7 per cent of value added, are called “intangible-intensive industries” whereas those below are called “less intangible-intensive” industries.

Table 3 provides an overview of the industries in each group. Many manufacturing industries are classified as intangible-intensive mainly because of their relatively

high R&D intensity.¹⁶ In contrast only three, albeit quite large, services industries are identified as intangible-intensive: information and communication services (J), financial and insurance activities (K) and profession, scientific and technical activities (M-N).¹⁷

Next, we exploit the industry detail in the EUKLEMS-INTANProd database by comparing the performance of industries that are intensive users of intangible capital vis-à-vis industries which are less intensive users. Table 4 explores some of the key metrics for each group, including their share in nominal value added and total hours worked, the relative nominal level of labour productivity and the contribution of each industry group to the average growth rate of labour productivity.

Even though the share in value added is fairly equally between the two industry groups, the less-intangible-intensive industries dominate in terms of the share in working hours. The implication is that productivity levels in the intangible-intensive industry group are much higher than in the less intangible-intensive industry group, that is, about 65 per cent higher in the EU, 63 per cent in the United Kingdom and 89 per cent in the United States.

The last few rows of Table 4 show

16 Van Ark, de Vries and Erumban (2021) investigate the comparative performance of industries characterised as early adopters of digital technologies vis-à-vis industries that are less intensive digital users, based on an industry taxonomy for digital intensity by industry from the OECD (Calvino *et al.*, 2018). Our intangibles taxonomy is largely comparable to the OECD digital intensity taxonomy, but there are also some differences. In manufacturing several industries which are intangible-intensive are not digital intensive, such as petroleum products (C19), chemicals and pharmaceuticals (C20-21), rubber and plastic products (C22-23). In contrast, retail and wholesale Trade (G), arts, entertainment and recreation (R) and other service activities (S) were classified as digital intensive industries but not as intangible-intensive industries.

17 The median value is affected by the number of industries (some of which are much larger than others) we were able to look at which was constrained by data availability. However, the manufacturing industries, which are mostly smaller in size than the larger service sector, show more heterogeneity with regard to their investment/value added shares.

Table 3: Industry Taxonomy for Intangible-Intensive and Less Intangible-Intensive Industries

NACE	INTANGIBLE -INTENSIVE INDUSTRIES	NACE	LESS INTANGIBLE-INTENSIVE INDUSTRIES
B	Mining and quarrying	A	Agriculture, forestry and fishing
C10-C12	Manufacture of food products, beverages and tobacco products	C13-C15	Manufacture of textiles, wearing apparel, leather and related products
C19	Manufacture of coke and refined petroleum products	C16-C18	Manufacture of wood, paper, printing and reproduction
C20-C21	Manufacture of Chemicals and basic pharmaceutical products	C24-C25	Manufacture of basic metals and fabricated metal products, except for machinery and equipment
C22-C23	Manufacture of rubber and plastic products and other non-metallic mineral products	D	Electricity, gas, steam and air conditioning supply
C26-C27	Manufacture of computer, electronic, optical products; electrical equipment	E	Water supply; sewerage, waste management and remediation activities
C28	Manufacture of machinery and equipment n.e.c.	F	Construction
C29-C30	Manufacture of motor vehicles, trailers, semi-trailers and of other transport equipment	G	Wholesale and retail trade; repair of motor vehicles and motorcycles
C31-C33	Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment	H	Transportation and storage
J	Information and communication	I	Accommodation and food service activities
K	Financial and insurance activities	R	Arts, entertainment and recreation
M-N	Professional, scientific and technical activities; administrative and support service activities	S	Other service activities

Note: “intangible-intensive industries” refers to the top-half of industries with the highest investment/nominal value added shares the market economy.

that labour productivity growth in the intangible-intensive industry group contributed substantially more to aggregate productivity growth than the less intangible-intensive industry group. This was true by a large margin in the United Kingdom and the United States, though less in the EU (and only for the period 1996-2007).¹⁸ However, strikingly, industries which are relatively intangible-intensive also contributed more to the slowdown in productivity growth since the GFC than those that are less intangible-intensive. In the EU-9 the difference is

relatively small, namely a slowdown of 0.3 points in the intangible-intensive group versus 0.1 points in the less intangible-intensive group. However, in the United States the slowdown was 1 point in the intensive group versus 0.6 points in the less intensive group, and the gap was even larger in the United Kingdom at 1.5 points in the intensive group and 0.5 points in the less intensive group.

Table 5 presents a growth accounting decomposition for the two industry groups. It shows that most of the change in the contributions of capital deepening is con-

¹⁸ In particular, Germany and Spain contributed to the relatively weak performance of intangible-intensive industry group.

Table 4: Value Added and Total Hours Worked Shares, Labour Productivity Levels and Average Growth Rates, Intangible-Intensive and Less Intangible Intensive Industry Groups, Market Economy, 1996-2007 and 2011-2019

	1996 -2007	2011 -2019	difference: 2011 -2019 less 1996 -2007	1996 -2007	2011 -2019	difference: 2011 -2019 less 1996-2007	1996 -2007	2011 -2019	difference: 2011 -2019 less 1996-2007
	European Union (9)			United Kingdom			United States		
Share in total value added (%)									
Intangible intensive industries	48.2	48.5	0.3	52.4	52.7	0.3	55.3	55.8	0.6
Less Intangible intensive industries	51.8	51.5	-0.3	47.6	47.3	-0.3	44.7	44.2	-0.6
Share in total hours worked (%)									
Intangible intensive industries	35.9	36.4	0.5	40.3	40.5	0.2	40.0	40.0	0.0
Less Intangible intensive industries	64.1	63.6	-0.5	59.7	59.5	-0.2	60.0	60.0	0.0
Relative level of labour prod. (=100%)									
Intangible intensive industries	166	165	-1.2	163	163	0.7	185	189	4.2
Less Intangible intensive industries	100	100	0.0	100	100	0.0	100	100	0.0
Agg. labour prod growth (%)	1.5	1.1	-0.4	2.7	0.7	-2.0	2.8	1.2	-1.7
Labour productivity growth, of which:	1.4	1.0	-0.4	2.7	0.7	-2.0	2.9	1.2	-1.6
Intangible intensive industries (%-point)	0.8	0.5	-0.3	2.0	0.6	-1.5	2.0	1.0	-1.0
Less Intangible intensive industries (%-point)	0.6	0.5	-0.1	0.6	0.2	-0.5	0.9	0.2	-0.6

Notes: European Union (9) includes Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden and are weighted by their GDP. Market economy definition: see footnote 1. See Table 3 for the taxonomy of intangible-intensive and less intangible-intensive industries. Average of relative level of labour productivity calculated on the basis of current prices. Growth rates are averages of annual log changes. The small differences between “aggregate labour productivity growth” and “labour productivity growth” is due to industry reallocation effects. Value added and labour productivity growth are adjusted to include the output contribution from intangibles not included in the System of National Accounts.

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-llee.luiss.it/>). For EU country detail see on-line Appendix Table 2.

centrated in the intangible-intensive industry group. While TFP growth was the main source of the slowdown in this industry group, we find that for the United States the weakening in tangible capital deepening (and especially in that of ICT tangibles) played a larger role than intangible capital deepening, whereas the opposite was the case for the United Kingdom. For the EU, we do not find very large differences between the two groups in the contri-

butions of either capital deepening or TFP probably because productivity growth has been quite weak all along.

While a more detailed industry analysis is beyond the scope of this article, the source data from EUKLEMS & INTANProd actually suggest the slowdown to be quite broad-based, though some sectors shows a disproportionately large slowdown in TFP. In the EU and the United States TFP growth in the electronics/computer

Table 5: Decomposition of Labour Productivity Growth into Contributions of Capital and TFP, Intangible-Intensive and Less Intangible Intensive Industry Groups (average annual % growth), 1996-2007 and 2011-2019.

	Intangible-intensive industries			Less intangible-intensive industries			Total		
	1996 -2007	2011 -2019	slowdown: 2011-2019 less 1996-2007	1996 -2007	2011 -2019	slowdown: 2011-2019 less 1996-2007	1996 -2007	2011 -2019	slowdown: 2011-2019 less 1996-2007
European Union (9)									
Labour prod. growth	0.8	0.5	-0.3	0.6	0.5	-0.1	1.4	1.0	-0.4
Labour composition	0.0	0.2	0.1	0.1	0.2	0.1	0.1	0.3	0.2
Tangible capital deepening	0.3	0.1	-0.2	0.3	0.1	-0.2	0.6	0.2	-0.4
Non-ICT	0.2	0.0	-0.1	0.2	0.1	-0.2	0.4	0.1	-0.3
ICT	0.1	0.0	-0.1	0.1	0.0	-0.1	0.2	0.1	-0.1
Intangible capital deepening	0.3	0.3	0.0	0.1	0.1	0.0	0.3	0.4	0.1
Technology-related	0.2	0.2	0.0	0.0	0.1	0.0	0.2	0.2	0.0
Business innovation-related	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.2	0.0
Total Factor Prod.	0.2	0.0	-0.2	0.1	0.1	-0.1	0.4	0.1	-0.3
United Kingdom									
Labour prod. growth	2.0	0.6	-1.5	0.6	0.2	-0.5	2.7	0.7	-2.0
Labour composition	0.3	0.1	-0.2	0.1	0.1	0.0	0.3	0.1	-0.2
Tangible capital deepening	0.3	0.2	-0.1	0.4	0.0	-0.3	0.6	0.2	-0.4
Non-ICT	0.1	0.0	0.0	0.2	0.0	-0.2	0.3	0.1	-0.3
ICT	0.2	0.1	-0.1	0.1	0.0	-0.1	0.3	0.1	-0.2
Intangible capital deepening	0.4	0.2	-0.2	0.2	0.2	0.0	0.6	0.4	-0.2
Technology-related	0.1	0.0	-0.1	0.0	0.0	0.0	0.1	0.1	-0.1
Business innovation-related	0.3	0.2	-0.1	0.2	0.1	0.0	0.5	0.4	-0.1
Total Factor Prod.	1.0	0.1	-0.9	0.0	-0.2	-0.2	1.1	0.0	-1.1
United States									
Labour prod. growth	2.0	1.0	-1.0	0.9	0.2	-0.6	2.9	1.2	-1.6
Labour composition	0.2	0.1	-0.1	0.1	0.1	-0.1	0.3	0.2	-0.2
Tangible capital deepening	0.6	0.2	-0.4	0.3	0.0	-0.2	0.9	0.2	-0.7
Non-ICT	0.2	0.0	-0.2	0.2	0.0	-0.1	0.4	0.0	-0.3
ICT	0.4	0.1	-0.3	0.1	0.0	-0.1	0.5	0.2	-0.3
Intangible capital deepening	0.5	0.5	-0.1	0.2	0.2	0.1	0.7	0.7	0.0
Technology-related	0.4	0.3	-0.1	0.1	0.1	0.0	0.4	0.3	-0.1
Business innovation-related	0.2	0.2	0.0	0.1	0.2	0.1	0.3	0.4	0.1
Total Factor Prod.	0.6	0.2	-0.4	0.3	-0.1	-0.4	1.0	0.2	-0.8

Notes: European Union (9) includes Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden and are weighted by their GDP. Market economy definition: see footnote 1. See Table 3 for the taxonomy of intangible-intensive and less intangible-intensive industries. Growth rates are averages of annual log changes, and the difference between periods is expressed in percentage points. “Intangibles –technology-related” are measured as part of GDP in the national accounts; “intangibles – business-innovation related” are not included in GDP, and productivity growth rates are therefore adjusted to include the output contribution from the latter (see Figure 1).

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-lee.luiss.it/>). For EU country detail see Appendix Table 3.

manufacturing industry has slowed dramatically, but several other manufacturing industries (which are mostly part of the intangible-intensive group) have also weakened. The information and communication sector saw stronger TPF growth in the United States, but a weakening in the EU and the United Kingdom. In the United Kingdom, financial and business services experienced negative TFP growth during

the post-GFC period, contributing to the TFP slowdown in the intangible-intensive group. In contrast, the retail and wholesale trade sector contributed to the slowdown in the less intangible industry group in the United States. The latter results also suggest that there may be other structural reasons unrelated to adoption effects that could explain differences in productivity growth between industries.

Taken together, the results suggest that the slowdown in productivity should not only be interpreted as a problem of low adoption of new intangible-intensive practices by lagging industries, which are concentrated in the less intangibles-intensive group. There are also clear challenges in industries at the productivity frontier, which are mostly in the intangibles-intensive group. Large requirements for upfront investment in intangibles may have caused concentration effects, slowed the diffusion of technology and weakened the overall impact of intangibles on productivity growth.

While the time lag hypothesis has been well researched for earlier technologies (David, 1990), recent evidence suggests this could also be a powerful explanation for the current productivity slowdown. For example, McElheran *et al.* (2023) show that in 2018 only 6 percent of United States firms used AI-related technologies. Recent figures from the US Census Bureau (2023) for late 2023 suggest that figure has barely moved even though there are large differences between sectors.

Building on the productivity J-curve hypothesis mentioned earlier, the upfront business investments in intangibles to adopt the latest technologies may be larger than before in particular related to skill needs, data and organisational capital (Coyle 2023). Bessen (2022) has pointed at the importance of large-scale investment in proprietary information systems, which may have increased concentration and lack of diffusion, even though this may become less of a constraint as more off-the-shelf business solution come available. Still, the complexity in combining different types of

intangible investment might point at the sensitivity of TFP growth to the complementarity of intangibles – a topic we will address further in the next section.

The Role of TFP Spillovers from Intangibles

So far, this article has primarily focused on the capital contribution channel to labour productivity growth. While we have seen that the slowdown in TFP growth has been the major source of the productivity slowdown since 2011-2019, growth accounting decompositions do not allow for an adequate analysis of how investment affects TFP growth. If the true elasticity of intangible capital deepening is larger than the measured income shares (as assumed in the growth accounts), this effect is captured by measured TFP growth (Stiroh, 2002). In other words, the measured growth (or slowdown) of TFP may in part be due to spillovers from the use of intangible capital.

There is some evidence that a weakening of productivity spillovers from intangibles, captured by TFP, may have contributed to intangibles running out of steam. Corrado *et al.* (2020) find a rather sharp decline in TFP growth related to the slowdown in intangible capital services growth in the United States from 2008-2016 relative to 1999-2007. Goldin *et al.* (2024) find weakening effects from intangibles on TFP growth for France, Germany and the United Kingdom. Bontandini *et al.* (2024) show that spillover effects from intangible capital on TFP in the last five years before the pandemic (2014-2019) are positive but are still weaker than before the GFC (1996-2007).

A weakening in spillover effects from intangibles may be caused by slower technical change as postulated by the hypothesis that “ideas are getting harder to find” (Bloom *et al.*, 2020.) It also could be that, even if technological progress itself has remained strong, transmission channels of intangibles to productivity growth have been clogging up. This can be due to a variety of headwinds, ranging from a decline in the effectiveness of innovation diffusion, the lack of adequate workforce skills to adopt new technologies, or geopolitical developments reducing the incentives for firms to invest and innovate (van Ark, de Vries and Erumban, 2021; van Ark, de Vries and Pilat, 2024). Corrado, Haskel and Jona-Lasinio (2017) have provided estimates of spillover effects from intangible capital from 1998-2007 (see footnote 13 on page 19).

There may also be reasons specific to changes in how intangibles impact TFP growth. For example, the interaction between intangibles (say, different types of software applications) and tangibles (say, different types of ICT equipment) may have been changed because of the nature of the technology. For this we need a closer look at how spillover effects arise, and how it may have changed over time. We conducted econometric analysis examining the relationships between TFP growth and two types of tangibles and two types intangible capital deepening. We also include several interaction effects aiming to capture possible complementarities, which could provide additional pointers indicating changes

in the strength of spillover effects.¹⁹ The results are preliminary because an analysis of spillover effects from capital on TFP growth needs to consider a potential endogeneity bias that can downwardly bias the impact of capital deepening on TFP.

We use a simple fixed effects panel data regression analysis which exploit the EUKLEMS-INTANProd data for 24 industries over the period 1996-2019, separately for the EU, the United Kingdom and the United States:

$$\begin{aligned}\Delta \ln TFP_{j,t} = & \beta_0 + \beta_1 \Delta \ln TEC_{j,t}^{INT} \\ & + \beta_2 \Delta \ln BUS_{j,t}^{INT} + \beta_3 \Delta \ln ICT_{j,t}^{TAN} \\ & + \beta_4 \Delta \ln nICT_{j,t}^{TAN} \\ & + \beta_5 \left(\Delta \ln TEC_{j,t}^{INT} \times \Delta \ln BUS_{j,t}^{INT} \right) \\ & + \beta_6 \left(\Delta \ln ICT_{j,t}^{TAN} \times \Delta \ln TEC_{j,t}^{INT} \right) \\ & + \beta_7 \left(\Delta \ln ICT_{j,t}^{TAN} \times \Delta \ln BUS_{j,t}^{INT} \right) \\ & + \beta_8 \left(\Delta \ln nICT_{j,t}^{TAN} \times \Delta \ln TEC_{j,t}^{INT} \right) \\ & + \beta_9 \left(\Delta \ln nICT_{j,t}^{TAN} \times \Delta \ln BUS_{j,t}^{INT} \right)\end{aligned}$$

Where $\Delta \ln TFP_{j,t}$ is the growth rate of TFP in industry j in year t for the given country or region (the United States, the United Kingdom, and the EU.), $\Delta \ln TEC_{j,t}^{INT}$ and $\Delta \ln BUS_{j,t}^{INT}$ are respectively the growth rates of capital deepening (capital per hour worked) in technology-related intangibles and business-innovation related intangibles in industry j in year t . $\Delta \ln ICT_{j,t}^{TAN}$ and $\Delta \ln nICT_{j,t}^{TAN}$ are the

¹⁹ This approach is based on Stiroh (2002), where the difference between the observed factor share and the unobserved elasticity is used as a measure of the spillover effect. A similar estimation strategy, based on Stiroh (2002), is used by Strobel (2016), who estimated spillover effects from ICT intermediate inputs.

growth rates of capital deepening in ICT and non-ICT tangible assets. β_1 to β_4 represent the partial impact of capital deepening in individual assets on TFP growth.

A positive and significant estimate of β_1 to β_4 would indicate likely presence of positive spillover effects from capital deepening in the given asset. β_5 represents the impact of the interaction between two types of intangible assets. β_6 to β_9 represent the impact of the interaction between tangible and intangible capital deepening. Thus β_5 to β_9 are informative of whether the combined effect of these different asset combinations is synergistic or diminishing on TFP growth. Finally, μ_j is the industry fixed effects, and $e_{j,t}$ is the random error term. The regression is estimated separately for the United States, United Kingdom, and EU aggregate, both pre-and post-crisis years.

Table 6 presents the coefficients from the spillover effects for intangible capital deepening (measured as the growth of capital stock per hour worked for each capital asset) for the periods 1996-2007 and 2011-2019 for the EU (columns 1-2), the United Kingdom (columns 3-4) and the United States (columns 5-6). While the results of this analysis need to be treated with caution, they generally show mixed and rather weak spillover effects.

Two observations stand out from the ta-

ble. First, the coefficients of the spillover effects of individual capital asset groups are only significant in a few cases, and in several cases even indicating negative spillovers. The EU shows strong positive and significant spillover effects for both types of intangibles during the pre-GFC period from 1996-2007 (lines 1 and 2) even though the positive effect was retained only for technology-related intangibles from 2011-2019. The only other significant positive effect from intangibles was for UK business-innovation related intangibles during the pre-crisis period, which turned weakly negative during the 2011-2019 period (line 2). In the United States, the spillover effects are generally not significant, except for a negative effect from business-innovation related intangibles in the post-crisis period (line 2). These results may suggest that when countries or regions at the lower end of the share of intangibles in value added, such as the EU, the spillover effects from either group of intangibles (technology-related or business innovation-related) are relatively important but lose that impact as the economy gets to higher levels of intangible intensity, such as for the United Kingdom and the United States.²⁰

Second, the interactions between different types of capital also present mixed evidence regarding their combined impact on

20 Corrado, Haskel and Jona-Lasinio (2017) also provide estimates of spillover effects from intangible capital, which are partially consistent with our observations though not directly comparable. Their findings indicate a relatively strong positive spillover effect from total intangible assets for a sample of 10 European countries, including the United Kingdom, between 1998 and 2007. They specify TFP as a function of input growth rates, distinguishing between ICT tangible, non-ICT tangible, and intangible capital (single asset vs. distinction between two types of intangible assets). Their estimation approach utilized a difference-in-differences method, and also using lagged effects of intangibles on TFP, which are not attempted here. The difference-in-difference approach is argued to enhance the identification of causal effects and reduce the bias from omitted variables and unobserved heterogeneity.

Table 6: Regression of TFP Growth on the Growth of the Capital Stock per Hour Worked, Market Economy, 1996-2007 and 2011-2019

	European Union		United Kingdom		United States	
	(1)	(2)	(3)	(4)	(5)	(6)
	1996-2007	2011-2019	1996-2007	2011-2019	1996-2007	2011-2019
Spillover effects from individual assets						
(1) Technology Intangibles (Tech.INT)	.9569*** (.279)	.911*** (.3036)	-.2645*** (.077)	.3553 (.2497)	-.0422 (.1038)	.2112 (.181)
(2) Business innovation intangibles (Bus.INT)	1.5028*** (.398)	-.3602 (.4489)	.6328*** (.2094)	-.3952* (.2114)	.1438 (.1109)	-.3669*** (.0973)
(3) ICT tangibles (ICT.tan)	.0682 (.1231)	-.0862 (.2804)	-.0376 (.0368)	.0199 (.0797)	.0354 (.0729)	-.0333 (.1081)
(4) Non-ICT tangibles (nICT.tan)	-2.4151*** (.3823)	-.6463 (.6124)	.0771 (.1781)	.465* (.2454)	.1989 (.1779)	.2676 (.2248)
Interaction effects						
(5) (Tech.INT) x (Bus.INT)	-.3244*** (.0733)	-.0835 (.1043)	-.0189 (.0133)	.0619** (.0285)	.0142* (.0077)	.0038 (.0236)
(6) (ICT.tan) x (Tech.INT)	-.0517* (.0278)	-.1558** (.0694)	.0093*** (.0027)	.0099 (.0093)	-.0019 (.006)	-.0204 (.0203)
(7) (ICT.tan) x (Bus.INT)	.0833** (.0333)	.409*** (.0815)	-.0106 (.0083)	.0039 (.0084)	-.0319*** (.0087)	.0365** (.0185)
(8) (nICT.tan) x (Tech.INT)	.1182 (.0955)	-.3253*** (.1238)	.0186 (.0139)	-.136*** (.0265)	.0062 (.0154)	-.0082 (.0268)
(9) (nICT.tan) x (Bus.INT)	.2151*** (.0805)	.221* (.1287)	.0304 (.0281)	.1078*** (.0293)	-.0061 (.0254)	-.035 (.0347)
Constant	-2.3242*** (.8217)	-1.6012 (1.1543)	.4232 (.7727)	-.4576 (1.1346)	1.5727* (.8311)	.7685 (.5816)
Observations	276	207	276	207	276	207
R-squared	.3843	.5317	.1476	.3813	.0825	.1131

Note: *** p<.01, ** p<.05, * p<.1. Explanation of variables: see text under equation (1). European Union includes Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden. Market economy definition: see footnote 1. Source: Authors' calculation using data from Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-llee.luiss.it/>).

TFP growth. Technology-related and business innovation-related intangibles are not strongly related in a positive way in general, except for the post-crisis period in the United Kingdom and pre-crisis period in the United States (line 5). However, there seems more interaction between some of the intangibles capital assets on the one hand, and tangible assets on the other. For example, the interaction between technology-related intangibles (including software and data) and ICT tangibles (computers and equipment) is positive and significant in the United Kingdom from 1996-2007, while it is negative and weakly significant in the EU and insignificant in the United States (line 6).

In contrast, business innovation-related intangibles interact positively with ICT tangibles in the EU during both periods

and in the United States during the period 2011-2019, but not in the United Kingdom (line 7). The interaction of business innovation-related intangibles with non-ICT tangibles is also significant in the EU (in both periods) as well as in the United Kingdom (positive in both periods, but only significant in the post-crisis period), but not in the United States, where it is negative and insignificant (line 9). One implication of the collapse in tangible capital deepening during the post-crisis period might therefore have been that it has become more difficult to translate intangible capital deepening into broad-based productivity growth across the economy.

However, more econometric analysis is needed to determine to what extent the importance of complementarities may have become a constraint on TFP growth.

Overall, our preliminary econometric analysis suggests that there is mixed evidence on how increases in the two types of intangible capital per worker, individually or in combination, contribute to measured TFP growth. There is some weak evidence of a greater degree of complexity on how intangibles impact on TFP growth in the later period. These results are in accordance with the possibility of an increase in non-rivalry and excludability (or appropriability) of intangibles, especially through the role of data, reducing incentives to invest in intangibles (Corrado *et al.*, 2023, Crouzet *et al.*, 2024). Others have pointed at the decline in business dynamism and increase in market power as sources of declining productivity in the intangible economy (De Ridder, 2023). Finally, as indicated in our earlier discussion, the increased complexity in combining different types of tangible and intangible investment in the process of business innovation and knowledge diffusion (Brynjolfsson, Rock and Syverson, 2019; Coyle, 2023).

Concluding Observations and Some Policy Implications

Taken together, we conclude that the evidence shows that the growth rates of the intangible stock and the contribution of intangible capital deepening to productivity growth have somewhat slowed, especially in countries (like the United Kingdom and the United States) that became the most intangible-intensive early on. However, the relative contribution to labour productivity growth has remained unmistakably positive, and from that viewpoint, intangibles have not run out of steam, at least not in

terms of directly contributing to productivity growth.

Nevertheless, the positive contribution from intangible capital deepening has been insufficient to offset the strongly declining contribution of tangible capital deepening to productivity growth, especially in the United Kingdom and the United States. Given its higher rates of depreciation, intangible capital has “to work harder” than tangible capital to make a direct positive contribution to labour productivity growth.

Previous evidence has pointed at positive spillovers from intangible capital on TFP growth, but our preliminary econometric analysis of the latest data does not show much evidence of strengthening spillovers, which seems in line with evidence from other studies (e.g. Corrado *et al.*, 2022; Bontandini *et al.*, 2024; Goldin *et al.*, 2024). We find some evidence of increased interaction effects, which suggests that the impact of intangibles on productivity growth seems to have become more complex. Specifically, there is some support for the idea that business innovation-related intangibles interact with other types of capital, including ICT- and non-ICT tangible capital in creating TFP gains.

It is possible that the time lag hypothesis of technology adoption, which we tested at the industry level in the fourth section of this article, and which is temporary in its nature, will ultimately lead to a renewed strengthening of the contribution of intangibles once lagging industries are beginning to catch up in investment in intangibles.

However, we have some reasons for concern. First, the relatively large productiv-

ity slowdown in intangible-intensive industries makes it clear that the productivity slowdown is not just a matter of lagging industries, but points at problems in industries at the productivity frontier. Possibly large requirements for up-front investment in intangibles may have caused concentration effects, slowed diffusion and weakened the overall impact of intangibles on productivity growth.

Second, we find there is a slowdown in the growth rate of “technology-related” intangible capital, and not much evidence of spillovers effects from capital deepening in software and database on TFP, and mixed evidence on interactions with other tangibles and intangibles. This points at the possibility that new digital technologies, such as AI have not been producing much steam in terms of faster productivity growth at least through 2019.

In contrast, we find that “business innovation-related” intangibles are on the whole growing on a more sustained basis, and in several instances even strengthening in terms of spillovers through complementarities with tangible capital. On the one hand, this may be a sign of maturing, as technologies are increasingly commercialized, requiring more business innovation-related intangibles. On the other hand, the collapse in tangible capital deepening can indeed be one reason why it has become more difficult to translate intangible capital deepening into broad-based productivity growth across the economy.

Policies which help to strengthen broad-based investment by combining different types of capital, especially those that generate complementaries such as “business innovation-related” intangible capital,

are important to realize direct (through capital deepening) and indirect (through spillovers) effects on productivity growth. Second, the need for high upfront investment in intangibles to absorb the latest technologies productivity, might cause concentration effects of productivity gains in the largest firms, requiring competition policies and market redesign that facilitate diffusion across the economy. Finally, even if the latest technologies are being available and affordable to lagging firms and industries, support through business innovation programmes can help to successfully adopt those technologies that are critical to realize the productivity gains from the intangibilisation of the economy.

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APPENDIX

Are Intangibles Running out of Steam?

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(https://csls.ca/ipm/46/IPM_46_Vanark.pdf)

Appendix Table 1 – Investment/Value Added Shares, Real Investment Growth and Capital Stock Growth, Tangible and Intangibles, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007
	Investment/value Added share (%)				Real Investment (average annual % growth)				Real Capital Stocks (average annual % growth)			
Austria												
Tangibles	17.1%	14.6%	15.1%	-2.0%	1.8%	-5.0%	3.5%	1.8%	2.0%	0.8%	1.2%	-0.8%
Non-ICT tangibles	15.0%	13.2%	13.7%	-1.3%	1.7%	-5.5%	3.5%	1.8%	1.9%	0.9%	1.2%	-0.7%
ICT tangibles	2.0%	1.4%	1.4%	-0.7%	0.8%	-1.1%	4.2%	3.4%	2.8%	-0.1%	1.6%	-1.2%
Intangibles	7.8%	9.2%	10.6%	2.8%	5.4%	1.8%	4.0%	-1.4%	5.6%	3.9%	4.3%	-1.3%
Intangibles - technology-related	3.8%	4.6%	6.0%	2.2%	7.2%	3.0%	6.1%	-1.0%	5.9%	4.5%	5.2%	-0.7%
Intangibles - business innovation-related	4.0%	4.5%	4.6%	0.6%	3.9%	0.6%	1.3%	-2.6%	5.0%	2.7%	2.0%	-3.0%
TOTAL	24.9%	23.8%	25.7%	0.8%	2.9%	-2.4%	3.7%	0.8%	2.0%	0.8%	1.2%	-0.8%
Germany												
Tangibles	13.1%	12.2%	11.6%	-1.6%	1.9%	-2.7%	2.5%	0.6%	1.0%	0.3%	0.2%	-0.8%
Non-ICT tangibles	11.6%	11.2%	10.7%	-0.8%	0.7%	-2.9%	2.5%	1.8%	0.7%	0.1%	0.2%	-0.5%
ICT tangibles	1.6%	1.0%	0.8%	-0.7%	9.1%	0.5%	1.9%	-7.2%	6.8%	3.1%	0.6%	-6.2%
Intangibles	10.2%	10.7%	11.6%	1.5%	2.2%	0.3%	3.7%	1.4%	2.1%	1.5%	2.8%	0.7%
Intangibles - technology-related	3.7%	4.1%	4.4%	0.7%	2.5%	1.7%	4.2%	1.7%	2.2%	2.1%	2.8%	0.6%
Intangibles - business innovation-related	6.5%	6.6%	7.2%	0.8%	2.1%	-0.6%	3.4%	1.3%	2.3%	0.8%	3.1%	0.8%
TOTAL	23.3%	22.9%	23.2%	-0.1%	2.1%	-1.3%	3.1%	1.0%	1.2%	0.5%	0.8%	-0.4%
Denmark												
Tangibles	15.6%	12.9%	12.4%	-3.2%	3.0%	-11.3%	3.5%	0.5%	1.8%	0.3%	0.7%	-1.1%
Non-ICT tangibles	13.8%	11.9%	11.3%	-2.4%	2.2%	-12.2%	3.1%	0.8%	1.6%	0.4%	0.6%	-1.0%
ICT tangibles	1.9%	1.1%	1.1%	-0.8%	7.6%	-9.8%	8.3%	0.8%	5.9%	-2.4%	6.1%	0.2%
Intangibles	13.1%	15.5%	15.3%	2.3%	4.8%	0.5%	3.5%	-1.4%	4.1%	2.5%	2.3%	-1.8%
Intangibles - technology-related	4.6%	6.4%	6.4%	1.8%	7.0%	8.4%	2.6%	-4.4%	5.6%	5.7%	2.3%	-3.3%
Intangibles - business innovation-related	8.4%	9.2%	8.9%	0.5%	3.8%	-4.5%	4.1%	0.3%	3.3%	0.7%	2.6%	-0.7%
TOTAL	28.7%	28.5%	27.8%	-0.9%	3.9%	-5.0%	3.5%	-0.4%	2.2%	0.8%	1.1%	-1.1%
Spain												
Tangibles	17.4%	14.4%	13.3%	-4.1%	5.4%	-13.1%	2.8%	-2.6%	4.1%	1.7%	0.9%	-3.2%
Non-ICT tangibles	16.5%	13.7%	12.6%	-3.9%	5.0%	-13.2%	2.6%	-2.5%	4.1%	1.6%	0.8%	-3.3%
ICT tangibles	0.9%	0.6%	0.7%	-0.2%	6.9%	-10.9%	5.4%	-1.5%	4.0%	1.3%	3.5%	-0.5%
Intangibles	7.0%	8.4%	9.7%	2.7%	5.5%	0.4%	2.6%	-2.9%	5.1%	3.5%	2.4%	-2.7%
Intangibles - technology-related	2.1%	3.0%	4.1%	2.0%	7.4%	4.9%	3.3%	-4.1%	6.3%	5.7%	4.0%	-2.3%
Intangibles - business innovation-related	5.0%	5.4%	5.7%	0.7%	4.7%	-2.2%	2.1%	-2.6%	4.7%	1.8%	1.1%	-3.6%
TOTAL	24.4%	22.8%	23.0%	-1.4%	5.4%	-8.1%	2.7%	-2.7%	4.3%	1.9%	1.1%	-3.2%

Appendix Table 1 (continued) – Investment/Value Added Shares, Real Investment Growth and Capital Stock Growth, Tangible and Intangibles, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007
	Investment/value Added share (%)				Real Investment				Real Capital Stocks (average annual % growth)			
Finland												
Tangibles	11.3%	10.0%	10.3%	-1.1%	3.7%	-6.7%	3.2%	-0.5%	0.3%	-0.1%	0.4%	0.1%
Non-ICT tangibles	10.5%	9.2%	9.5%	-1.0%	3.2%	-7.1%	3.1%	-0.1%	0.0%	-0.3%	0.2%	0.2%
ICT tangibles	0.8%	0.8%	0.8%	0.0%	13.2%	-0.9%	4.9%	-8.2%	17.0%	11.9%	7.0%	-10.0%
Intangibles	14.4%	16.7%	16.6%	2.2%	4.4%	-0.6%	0.9%	-3.5%	4.2%	1.2%	0.2%	-4.1%
Intangibles - technology-related	5.4%	6.7%	5.6%	0.1%	6.8%	-1.0%	-1.8%	-8.6%	6.3%	1.7%	-2.4%	-8.8%
Intangibles - business innovation-related	9.0%	10.0%	11.0%	2.0%	3.1%	-0.3%	2.4%	-0.7%	3.0%	1.1%	2.5%	-0.5%
TOTAL	25.7%	26.7%	26.8%	1.1%	4.1%	-2.9%	1.6%	-2.4%	1.3%	0.3%	0.3%	-1.0%
France												
Tangibles	10.5%	10.6%	10.8%	0.3%	4.7%	-4.2%	2.9%	-1.8%	1.8%	0.3%	0.9%	-0.9%
Non-ICT tangibles	9.8%	10.0%	10.2%	0.4%	4.7%	-4.5%	2.7%	-2.0%	1.4%	0.2%	0.8%	-0.6%
ICT tangibles	0.7%	0.6%	0.6%	-0.1%	6.2%	1.4%	7.3%	1.1%	6.5%	2.6%	5.8%	-0.7%
Intangibles	16.1%	17.5%	19.1%	3.0%	2.8%	2.2%	3.3%	0.5%	2.1%	2.2%	2.9%	0.8%
Intangibles - technology-related	6.0%	6.6%	7.4%	1.4%	3.6%	2.8%	3.9%	0.3%	2.0%	2.6%	2.9%	0.9%
Intangibles - business innovation-related	10.1%	10.9%	11.8%	1.6%	2.3%	1.9%	2.9%	0.6%	2.4%	2.0%	3.1%	0.7%
TOTAL	26.6%	28.1%	29.9%	3.3%	3.5%	-0.4%	3.2%	-0.4%	1.9%	1.0%	1.7%	-0.2%
Italy												
Tangibles	14.4%	13.8%	12.5%	-1.9%	3.0%	-5.9%	0.2%	-2.8%	2.1%	0.3%	-0.6%	-2.7%
Non-ICT tangibles	13.3%	12.9%	11.6%	-1.8%	2.8%	-6.3%	0.1%	-2.6%	1.9%	0.3%	-0.7%	-2.6%
ICT tangibles	1.0%	0.9%	0.9%	-0.1%	6.7%	1.0%	1.8%	-4.9%	7.0%	-0.2%	1.8%	-5.2%
Intangibles	9.9%	10.5%	11.2%	1.3%	2.4%	-1.5%	1.7%	-0.7%	2.4%	0.1%	1.1%	-1.2%
Intangibles - technology-related	3.3%	3.6%	4.1%	0.7%	2.8%	1.0%	2.9%	0.1%	3.0%	1.5%	2.2%	-0.8%
Intangibles - business innovation-related	6.6%	6.9%	7.2%	0.6%	2.2%	-2.7%	1.0%	-1.2%	2.0%	-0.7%	0.4%	-1.6%
TOTAL	24.3%	24.3%	23.8%	-0.6%	2.8%	-4.1%	0.8%	-1.9%	2.1%	0.3%	-0.3%	-2.4%
Netherlands												
Tangibles	11.2%	9.1%	10.0%	-1.2%	2.8%	-3.8%	5.1%	2.3%	1.2%	0.2%	1.0%	-0.2%
Non-ICT tangibles	10.3%	8.4%	9.2%	-1.1%	1.5%	-4.3%	5.2%	3.7%	0.9%	0.1%	1.0%	0.1%
ICT tangibles	0.9%	0.7%	0.7%	-0.2%	18.9%	0.9%	6.5%	-12.4%	17.2%	7.7%	4.5%	-12.7%
Intangibles	13.2%	13.4%	15.5%	2.4%	4.9%	-4.2%	4.9%	-0.1%	3.4%	1.1%	3.4%	0.0%
Intangibles - technology-related	3.9%	4.1%	5.2%	1.3%	10.5%	-11.4%	11.7%	1.3%	4.5%	0.8%	3.7%	-0.8%
Intangibles - business innovation-related	9.3%	9.3%	10.4%	1.1%	2.6%	0.8%	3.8%	1.1%	2.9%	1.4%	3.4%	0.5%
TOTAL	24.4%	22.5%	25.5%	1.1%	4.0%	-4.3%	4.7%	0.7%	1.7%	0.4%	1.7%	-0.1%

Appendix Table 1 (continued) – Investment/Value Added Shares, Real Investment Growth and Capital Stock Growth, Tangible and Intangibles, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996- 2007
	Investment/value Added share (%)				Real Investment				Real Capital Stocks (average annual % growth)			
Sweden												
Tangibles	14.0%	14.0%	13.2%	-0.8%	5.3%	-2.1%	3.5%	-1.8%	2.8%	2.8%	2.0%	-0.9%
Non-ICT tangibles	11.4%	12.2%	11.8%	0.4%	4.0%	-2.1%	3.3%	-0.7%	2.4%	2.6%	2.0%	-0.4%
ICT tangibles	2.6%	1.7%	1.4%	-1.2%	8.6%	-3.1%	5.2%	-3.5%	9.4%	6.8%	3.3%	-6.1%
Intangibles	17.2%	17.9%	19.1%	1.9%	3.1%	1.6%	3.5%	0.4%	3.7%	2.6%	3.3%	-0.3%
Intangibles - technology-related	8.6%	8.8%	8.5%	-0.1%	4.1%	0.5%	2.3%	-1.8%	5.0%	2.4%	2.1%	-2.8%
Intangibles - business innovation-related	8.5%	9.1%	10.6%	2.1%	2.2%	2.7%	4.6%	2.4%	2.1%	3.1%	5.1%	2.9%
TOTAL	31.2%	31.8%	32.3%	1.1%	4.0%	-0.1%	3.5%	-0.5%	3.0%	2.7%	2.4%	-0.7%
United Kingdom												
Tangibles	11.7%	9.0%	9.9%	-1.8%	3.3%	-7.7%	3.1%	-0.2%	2.8%	0.0%	1.1%	-1.6%
Non-ICT tangibles	10.1%	8.3%	9.1%	-1.1%	2.0%	-7.8%	4.0%	2.0%	2.2%	-0.1%	1.2%	-1.0%
ICT tangibles	1.5%	0.8%	0.8%	-0.8%	12.0%	-8.3%	0.0%	-12.0%	12.7%	2.0%	-0.1%	-12.9%
Intangibles	14.9%	15.2%	16.2%	1.3%	4.0%	-1.6%	4.4%	0.4%	3.8%	1.3%	3.5%	-0.3%
Intangibles - technology-related	4.2%	4.1%	4.3%	0.1%	3.6%	2.6%	2.8%	-0.9%	3.8%	2.2%	3.1%	-0.7%
Intangibles - business innovation-related	10.8%	11.1%	11.9%	1.1%	4.2%	-3.0%	5.0%	0.8%	3.8%	0.9%	3.5%	-0.3%
TOTAL	26.6%	24.2%	26.1%	-0.6%	3.6%	-4.2%	3.9%	0.3%	3.0%	0.4%	1.9%	-1.2%
United States												
Tangibles	11.2%	9.4%	10.1%	-1.1%	5.3%	-5.1%	5.2%	-0.1%	2.8%	0.9%	1.8%	-0.9%
Non-ICT tangibles	9.0%	7.7%	8.5%	-0.5%	2.5%	-8.0%	4.8%	2.3%	2.0%	0.5%	1.5%	-0.5%
ICT tangibles	2.3%	1.8%	1.6%	-0.6%	15.5%	8.7%	7.4%	-8.1%	12.5%	9.9%	9.2%	-3.3%
Intangibles	15.1%	16.8%	17.7%	2.6%	4.5%	-0.5%	5.2%	0.7%	3.6%	1.2%	3.3%	-0.3%
Intangibles - technology-related	5.6%	6.5%	7.1%	1.5%	6.8%	0.9%	5.3%	-1.5%	4.1%	2.1%	2.9%	-1.2%
Intangibles - business innovation-related	9.5%	10.2%	10.6%	1.1%	3.2%	-1.4%	5.1%	1.9%	4.1%	0.6%	4.2%	0.1%
TOTAL	26.3%	26.2%	27.8%	1.5%	4.8%	-2.3%	5.2%	0.4%	3.0%	1.0%	2.3%	-0.7%

Note: Market economy excludes public administration (NACE Sector O), education (P), health care (Q), activities of households (T) and extra-territorial organisation (U), as well as real estate (L). “Intangibles –technology-related” are measured as part of GDP and included in the national accounts; “intangibles – business-innovation related” are not included in GDP in the national accounts (see Figure 1).

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-illee.luiss.it/>)

Appendix Table 2 – Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	contribution to the slowdown: 2011-2019 minus 1996-2007
	Absolute Contributions to Labour Productivity Growth (average annual % growth)				Relative Contributions to Labour Productivity Growth (%)			
Austria								
Labor productivity growth	2.5%	0.1%	1.0%	-1.5%	100%	100%	100%	100%
Labor composition	0.3%	0.2%	-0.1%	-0.4%	13%	367%	-7%	25%
Tangible capital deepening	0.5%	0.5%	0.2%	-0.3%	22%	867%	20%	23%
Non-ICT tangible capital deepening	0.4%	0.4%	0.1%	-0.2%	14%	667%	11%	16%
ICT tangible capital deepening	0.2%	0.1%	0.1%	-0.1%	8%	217%	10%	6%
Intangible capital deepening	0.4%	0.5%	0.4%	0.0%	17%	817%	42%	1%
Technology-related intangible capital deepening	0.3%	0.3%	0.4%	0.1%	11%	567%	39%	-7%
Business innovation-related intangibles capital deepening	0.1%	0.2%	0.0%	-0.1%	6%	250%	3%	7%
Total Factor Productivity	1.2%	-1.2%	0.4%	-0.8%	49%	-1967%	45%	51%
Germany								
Labor productivity growth	1.9%	-0.7%	1.5%	-0.4%	100%	100%	100%	100%
Labor composition	-0.1%	0.5%	0.2%	0.3%	-4%	-64%	15%	-67%
Tangible capital deepening	0.6%	0.3%	0.1%	-0.5%	32%	-44%	10%	107%
Non-ICT tangible capital deepening	0.3%	0.2%	0.1%	-0.2%	17%	-32%	7%	53%
ICT tangible capital deepening	0.3%	0.1%	0.0%	-0.2%	14%	-11%	3%	53%
Intangible capital deepening	0.3%	0.2%	0.3%	0.1%	13%	-29%	23%	-21%
Technology-related intangible capital deepening	0.1%	0.1%	0.2%	0.1%	5%	-19%	10%	-12%
Business innovation-related intangibles capital deepening	0.2%	0.1%	0.2%	0.0%	8%	-10%	13%	-9%
Total Factor Productivity	1.1%	-1.7%	0.8%	-0.4%	59%	237%	52%	84%
Denmark								
Labor productivity growth	1.8%	0.7%	1.6%	-0.3%	100%	100%	100%	100%
Labor composition	0.5%	0.7%	0.2%	-0.3%	24%	94%	10%	103%
Tangible capital deepening	0.6%	0.8%	0.1%	-0.5%	33%	113%	5%	183%
Non-ICT tangible capital deepening	0.3%	0.8%	0.0%	-0.2%	14%	108%	1%	83%
ICT tangible capital deepening	0.3%	0.0%	0.1%	-0.3%	18%	4%	3%	100%
Intangible capital deepening	0.6%	0.9%	0.5%	-0.1%	32%	131%	30%	41%
Technology-related intangible capital deepening	0.4%	0.7%	0.3%	-0.1%	19%	93%	18%	24%
Business innovation-related intangibles capital deepening	0.2%	0.3%	0.2%	-0.1%	13%	38%	11%	21%
Total Factor Productivity	0.2%	-1.7%	0.9%	0.7%	12%	-238%	56%	-224%

Appendix Table 2 (continued) – Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	contribution to the slowdown: 2011- 2019 minus 1996- 2007
	Absolute Contributions to Labour Productivity				Relative Contributions to Labour Productivity Growth (%)			
Spain								
Labor productivity growth	0.1%	1.9%	0.9%	0.8%	100%	100%	100%	100%
Labor composition	0.1%	0.7%	0.5%	0.3%	118%	39%	52%	43%
Tangible capital deepening	0.6%	1.6%	0.3%	-0.3%	527%	85%	29%	-41%
Non-ICT tangible capital deepening	0.5%	1.5%	0.2%	-0.3%	409%	81%	22%	-32%
ICT tangible capital deepening	0.1%	0.1%	0.1%	-0.1%	118%	4%	7%	-9%
Intangible capital deepening	0.2%	0.7%	0.3%	0.1%	182%	37%	34%	14%
Technology-related intangible capital deepening	0.2%	0.4%	0.3%	0.1%	136%	20%	28%	13%
Business innovation-related intangibles capital deepening	0.1%	0.3%	0.1%	0.0%	45%	17%	7%	1%
Total Factor Productivity	-0.8%	-1.2%	-0.1%	0.7%	-718%	-62%	-16%	82%
Finland								
Labor productivity growth	3.3%	-0.7%	0.7%	-2.6%	100%	100%	100%	100%
Labor composition	0.2%	0.2%	0.2%	0.0%	7%	-20%	28%	1%
Tangible capital deepening	-0.1%	0.4%	0.1%	0.2%	-2%	-55%	18%	-7%
Non-ICT tangible capital deepening	-0.2%	0.3%	0.1%	0.2%	-5%	-39%	9%	-9%
ICT tangible capital deepening	0.1%	0.1%	0.1%	-0.1%	3%	-16%	8%	2%
Intangible capital deepening	0.5%	0.6%	0.1%	-0.4%	15%	-74%	16%	14%
Technology-related intangible capital deepening	0.3%	0.3%	-0.1%	-0.4%	10%	-38%	-9%	16%
Business innovation-related intangibles capital deepening	0.2%	0.3%	0.2%	0.0%	4%	-36%	26%	-2%
Total Factor Productivity	2.7%	-1.9%	0.3%	-2.4%	80%	251%	38%	92%
France								
Labor productivity growth	2.0%	-0.1%	1.1%	-0.9%	100%	100%	100%	100%
Labor composition	0.3%	0.6%	0.6%	0.3%	16%	-475%	60%	-36%
Tangible capital deepening	0.6%	0.3%	0.2%	-0.4%	29%	-283%	16%	45%
Non-ICT tangible capital deepening	0.5%	0.3%	0.1%	-0.3%	24%	-242%	12%	37%
ICT tangible capital deepening	0.1%	0.1%	0.1%	-0.1%	6%	-42%	5%	7%
Intangible capital deepening	0.4%	0.6%	0.6%	0.2%	22%	-508%	54%	-16%
Technology-related intangible capital deepening	0.3%	0.4%	0.3%	0.1%	13%	-292%	30%	-7%
Business innovation-related intangibles capital deepening	0.2%	0.3%	0.3%	0.1%	9%	-217%	24%	-9%
Total Factor Productivity	0.7%	-1.7%	-0.3%	-1.0%	34%	1375%	-30%	108%

Appendix Table 2 (continued) – Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	contribution to the slowdown: 2011- 2019 minus 1996- 2007
	Absolute Contributions to Labour Productivity				Relative Contributions to Labour Productivity Growth (%)			
Italy								
Labor productivity growth	0.7%	-0.3%	0.5%	-0.2%	100%	100%	100%	100%
Labor composition	0.3%	0.4%	0.5%	0.3%	34%	-128%	100%	-118%
Tangible capital deepening	0.6%	0.6%	0.1%	-0.5%	82%	-214%	16%	236%
Non-ICT tangible capital deepening	0.4%	0.5%	0.0%	-0.4%	59%	-186%	2%	191%
ICT tangible capital deepening	0.2%	0.1%	0.1%	-0.1%	23%	-28%	14%	45%
Intangible capital deepening	0.3%	0.3%	0.2%	-0.1%	37%	-97%	43%	23%
Technology-related intangible capital deepening	0.2%	0.2%	0.2%	0.0%	26%	-72%	31%	14%
Business innovation-related intangibles capital deepening	0.1%	0.1%	0.1%	0.0%	11%	-24%	10%	14%
Total Factor Productivity	-0.4%	-1.6%	-0.3%	0.1%	-52%	538%	-59%	-36%
Netherlands								
Labor productivity growth	2.1%	0.4%	0.5%	-1.7%	100%	100%	100%	100%
Labor composition	0.3%	0.3%	0.5%	0.1%	15%	58%	92%	-8%
Tangible capital deepening	0.3%	0.4%	0.1%	-0.2%	13%	86%	10%	13%
Non-ICT tangible capital deepening	0.0%	0.3%	0.0%	0.0%	2%	65%	2%	2%
ICT tangible capital deepening	0.2%	0.1%	0.0%	-0.2%	11%	21%	8%	12%
Intangible capital deepening	0.4%	0.4%	0.5%	0.1%	20%	86%	96%	-3%
Technology-related intangible capital deepening	0.3%	0.2%	0.2%	-0.1%	13%	37%	45%	3%
Business innovation-related intangibles capital deepening	0.2%	0.2%	0.3%	0.1%	7%	51%	51%	-5%
Total Factor Productivity	1.1%	-0.6%	-0.5%	-1.6%	53%	-130%	-98%	98%
Sweden								
Labor productivity growth	3.6%	0.1%	1.7%	-2.0%	100%	100%	100%	100%
Labor composition	0.5%	0.1%	0.2%	-0.3%	14%	163%	10%	17%
Tangible capital deepening	0.9%	0.6%	0.4%	-0.6%	26%	725%	21%	30%
Non-ICT tangible capital deepening	0.5%	0.5%	0.3%	-0.3%	14%	563%	16%	13%
ICT tangible capital deepening	0.4%	0.1%	0.1%	-0.3%	12%	163%	5%	17%
Intangible capital deepening	0.8%	0.5%	0.6%	-0.2%	22%	625%	39%	8%
Technology-related intangible capital deepening	0.7%	0.3%	0.2%	-0.4%	18%	313%	13%	22%
Business innovation-related intangibles capital deepening	0.1%	0.3%	0.4%	0.3%	4%	313%	25%	-15%
Total Factor Productivity	1.4%	-1.1%	0.5%	-0.9%	38%	-1425%	31%	45%

Appendix Table 2 (continued) – Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Market Economy, 1996-2007 and 2011-2019

	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	contribution to the slowdown: 2011-2019 minus 1996-2007
	Absolute Contributions to Labour Productivity				Relative Contributions to Labour Productivity Growth (%)			
United Kingdom								
Labor productivity growth	2.7%	0.0%	0.7%	-2.0%	100%	100%	100%	100%
Labor composition	0.3%	0.2%	0.2%	-0.2%	13%	2400%	29%	7%
Tangible capital deepening	0.7%	0.5%	0.1%	-0.6%	25%	5400%	11%	29%
Non-ICT tangible capital deepening	0.4%	0.5%	0.1%	-0.3%	13%	5100%	8%	15%
ICT tangible capital deepening	0.3%	0.0%	0.0%	-0.3%	12%	400%	3%	15%
Intangible capital deepening	0.5%	0.4%	0.3%	-0.2%	19%	4400%	46%	11%
Technology-related intangible capital deepening	0.1%	0.2%	0.0%	-0.1%	4%	1700%	0%	5%
Business innovation-related intangibles capital deepening	0.4%	0.3%	0.3%	-0.1%	15%	2700%	46%	5%
Total Factor Productivity	1.2%	-1.2%	0.1%	-1.1%	43%	-12100%	14%	52%
United States								
Labor productivity growth	2.8%	2.5%	1.2%	-1.7%	100%	100%	100%	100%
Labor composition	0.4%	0.5%	0.2%	-0.2%	13%	20%	15%	11%
Tangible capital deepening	0.8%	0.9%	0.2%	-0.6%	27%	37%	15%	35%
Non-ICT tangible capital deepening	0.3%	0.6%	0.0%	-0.2%	9%	22%	3%	13%
ICT tangible capital deepening	0.5%	0.4%	0.2%	-0.4%	18%	15%	14%	21%
Intangible capital deepening	0.7%	1.1%	0.6%	-0.1%	24%	46%	52%	4%
Intangible capital deepening - national accounts	0.4%	0.7%	0.3%	-0.1%	15%	28%	25%	8%
Intangibles capital deepening - non-national accounts	0.3%	0.5%	0.3%	0.1%	9%	18%	26%	-3%
Total Factor Productivity	1.0%	-0.1%	0.2%	-0.8%	36%	-3%	17%	50%

Note: Market economy excludes public administration (NACE Sector O), education (P), health care (Q), activities of households (T) and extra-territorial organisation (U), as well as real estate (L). “Intangibles –technology-related” are measured as part of GDP and included in the national accounts; “intangibles – business-innovation related” are not included in GDP in the national accounts (see Figure 1).

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-ilee.luiss.it/>)

Appendix Table 3 – Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Intangible-Intensive and Less Intangible Intensive Industry Groups, Absolute Contributions to Labour Productivity Growth (average annual % growth), 1996-2007 and 2011-2019

	Intangible-intensive industries				Less intangible-intensive industries			
	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007
	Absolute Contributions to Labour Productivity Growth (average annual % growth)				Absolute Contributions to Labour Productivity Growth (average annual % growth)			
Austria								
Labor productivity growth	1.3%	0.1%	0.5%	-0.8%	1.0%	-0.5%	0.2%	-0.7%
Labor composition	0.1%	0.0%	-0.2%	-0.3%	0.1%	0.1%	-0.1%	-0.2%
Tangible capital deepening	0.3%	0.3%	0.1%	-0.2%	0.3%	0.2%	0.1%	-0.2%
Non-ICT tangible capital deepening	0.2%	0.2%	0.1%	-0.2%	0.2%	0.1%	0.0%	-0.2%
ICT tangible capital deepening	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%
Intangible capital deepening	0.3%	0.3%	0.3%	0.0%	0.2%	0.2%	0.1%	0.0%
Technology-related intangible capital deepening	0.2%	0.3%	0.3%	0.1%	0.1%	0.1%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.1%	0.0%	0.0%	-0.1%	0.1%	0.1%	0.0%	0.0%
Total Factor Productivity	0.7%	-0.6%	0.3%	-0.3%	0.4%	-1.0%	0.1%	-0.4%
Germany								
Labor productivity growth	0.7%	-0.3%	0.8%	0.0%	0.9%	-0.3%	0.5%	-0.3%
Labor composition	-0.1%	0.3%	0.1%	0.2%	0.0%	0.2%	0.1%	0.1%
Tangible capital deepening	0.2%	0.1%	0.0%	-0.2%	0.2%	0.2%	0.1%	-0.1%
Non-ICT tangible capital deepening	0.1%	0.1%	0.0%	-0.1%	0.1%	0.1%	0.1%	-0.1%
ICT tangible capital deepening	0.2%	0.1%	0.0%	-0.1%	0.1%	0.0%	0.0%	-0.1%
Intangible capital deepening	0.2%	0.2%	0.3%	0.1%	0.1%	0.1%	0.1%	0.0%
Technology-related intangible capital deepening	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Business innovation-related intangibles capital deepening	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%
Total Factor Productivity	0.4%	-1.0%	0.4%	0.0%	0.6%	-0.7%	0.3%	-0.3%
Denmark								
Labor productivity growth	1.1%	-0.1%	0.9%	-0.2%	0.7%	-0.1%	0.8%	0.1%
Labor composition	0.2%	0.3%	0.1%	-0.1%	0.1%	0.3%	0.1%	-0.1%
Tangible capital deepening	0.3%	0.1%	0.2%	-0.1%	0.4%	0.3%	0.0%	-0.4%
Non-ICT tangible capital deepening	0.1%	0.1%	0.2%	0.1%	0.2%	0.2%	0.0%	-0.3%
ICT tangible capital deepening	0.2%	0.0%	0.0%	-0.2%	0.2%	0.0%	0.0%	-0.1%
Intangible capital deepening	0.4%	0.5%	0.4%	0.1%	0.2%	0.3%	0.1%	0.0%
Technology-related intangible capital deepening	0.3%	0.5%	0.3%	0.0%	0.1%	0.1%	0.0%	-0.1%
Business innovation-related intangibles capital deepening	0.1%	0.1%	0.1%	0.0%	0.1%	0.2%	0.1%	0.0%
Total Factor Productivity	0.2%	-1.0%	0.1%	-0.1%	0.0%	-0.8%	0.6%	0.6%

Appendix Table 3 (continued)– Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Intangible-Intensive and Less Intangible Intensive Industry Groups, Absolute Contributions to Labour Productivity Growth (average annual % growth), 1996-2007 and 2011-2019

	Intangible-intensive industries				Less intangible-intensive industries			
	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007
	Absolute Contributions to Labour Productivity Growth (average annual % growth)				Absolute Contributions to Labour Productivity Growth (average annual % growth)			
Spain								
Labor productivity growth	0.5%	0.0%	0.3%	-0.2%	-0.3%	1.7%	0.6%	1.0%
Labor composition	-0.1%	0.2%	0.2%	0.2%	0.1%	0.3%	0.2%	0.2%
Tangible capital deepening	0.2%	0.3%	0.1%	-0.2%	0.4%	1.3%	0.3%	-0.1%
Non-ICT tangible capital deepening	0.2%	0.3%	0.0%	-0.1%	0.4%	1.3%	0.3%	-0.1%
ICT tangible capital deepening	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Intangible capital deepening	0.2%	0.4%	0.2%	0.0%	0.1%	0.3%	0.1%	0.0%
Technology-related intangible capital deepening	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.1%	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%
Total Factor Productivity	0.1%	-0.7%	-0.1%	-0.2%	-0.9%	-0.3%	0.0%	0.9%
Finland								
Labor productivity growth	2.2%	-0.2%	0.3%	-1.9%	1.2%	-0.3%	0.5%	-0.6%
Labor composition	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%
Tangible capital deepening	0.1%	0.2%	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%
Non-ICT tangible capital deepening	0.0%	0.1%	0.0%	0.0%	-0.1%	0.2%	0.2%	0.2%
ICT tangible capital deepening	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%
Intangible capital deepening	0.5%	0.8%	0.1%	-0.4%	0.1%	0.2%	0.2%	0.1%
Technology-related intangible capital deepening	0.4%	0.5%	0.0%	-0.4%	0.1%	0.1%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.1%	0.3%	0.1%	0.0%	0.1%	0.1%	0.2%	0.1%
Total Factor Productivity	1.6%	-1.3%	0.1%	-1.5%	1.0%	-0.7%	0.1%	-0.9%
France								
Labor productivity growth	1.1%	0.2%	0.6%	-0.5%	0.8%	-0.4%	0.4%	-0.4%
Labor composition	0.1%	0.2%	0.2%	0.1%	0.1%	0.3%	0.2%	0.1%
Tangible capital deepening	0.4%	0.2%	0.1%	-0.3%	0.3%	0.2%	0.2%	-0.1%
Non-ICT tangible capital deepening	0.3%	0.2%	0.1%	-0.3%	0.3%	0.2%	0.1%	-0.1%
ICT tangible capital deepening	0.1%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
Intangible capital deepening	0.5%	0.5%	0.4%	-0.1%	0.0%	0.2%	0.2%	0.1%
Technology-related intangible capital deepening	0.3%	0.3%	0.2%	-0.1%	0.0%	0.1%	0.1%	0.1%
Business innovation-related intangibles capital deepening	0.1%	0.2%	0.2%	0.0%	0.1%	0.1%	0.1%	0.0%
Total Factor Productivity	0.2%	-0.8%	-0.1%	-0.2%	0.3%	-1.0%	-0.2%	-0.5%

Appendix Table 3 (continued)– Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Intangible-Intensive and Less Intangible Intensive Industry Groups, Absolute Contributions to Labour Productivity Growth (average annual % growth), 1996-2007 and 2011-2019

	Intangible-intensive industries				Less intangible-intensive industries			
	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007
	Absolute Contributions to Labour Productivity Growth (average annual % growth)				Absolute Contributions to Labour Productivity Growth (average annual % growth)			
Italy								
Labor productivity growth	0.2%	-0.2%	0.2%	0.0%	0.3%	-0.2%	0.3%	0.0%
Labor composition	0.1%	0.1%	0.2%	0.2%	0.1%	0.2%	0.2%	0.1%
Tangible capital deepening	0.3%	0.3%	0.1%	-0.2%	0.4%	0.4%	0.0%	-0.4%
Non-ICT tangible capital deepening	0.1%	0.2%	0.0%	-0.1%	0.4%	0.3%	0.0%	-0.4%
ICT tangible capital deepening	0.1%	0.1%	0.1%	-0.1%	0.1%	0.0%	0.0%	-0.1%
Intangible capital deepening	0.1%	0.2%	0.2%	0.0%	0.1%	0.1%	0.1%	0.0%
Technology-related intangible capital deepening	0.1%	0.2%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%
Total Factor Productivity	-0.2%	-0.8%	-0.3%	-0.1%	-0.3%	-0.9%	0.1%	0.4%
Netherlands								
Labor productivity growth	1.4%	0.5%	0.2%	-1.2%	1.0%	-0.1%	0.6%	-0.4%
Labor composition	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%
Tangible capital deepening	0.3%	0.2%	0.1%	-0.2%	0.2%	0.2%	0.0%	-0.2%
Non-ICT tangible capital deepening	0.2%	0.2%	0.1%	-0.1%	0.1%	0.2%	0.0%	-0.1%
ICT tangible capital deepening	0.1%	0.1%	0.0%	-0.1%	0.1%	0.0%	0.0%	-0.1%
Intangible capital deepening	0.3%	0.3%	0.4%	0.0%	0.1%	0.1%	0.2%	0.1%
Technology-related intangible capital deepening	0.2%	0.1%	0.1%	-0.1%	0.1%	0.1%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Total Factor Productivity	0.5%	-0.2%	-0.5%	-1.0%	0.6%	-0.5%	0.2%	-0.4%
Sweden								
Labor productivity growth	2.2%	0.3%	1.0%	-1.3%	1.3%	-0.4%	0.7%	-0.5%
Labor composition	0.3%	0.1%	0.1%	-0.3%	0.1%	0.0%	0.1%	0.0%
Tangible capital deepening	0.4%	0.2%	0.2%	-0.2%	0.6%	0.4%	0.2%	-0.3%
Non-ICT tangible capital deepening	0.2%	0.1%	0.1%	-0.1%	0.3%	0.3%	0.2%	-0.1%
ICT tangible capital deepening	0.2%	0.1%	0.1%	-0.1%	0.2%	0.1%	0.0%	-0.2%
Intangible capital deepening	0.6%	0.5%	0.5%	-0.2%	0.2%	0.3%	0.4%	0.2%
Technology-related intangible capital deepening	0.5%	0.4%	0.3%	-0.3%	0.1%	0.1%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.1%	0.1%	0.2%	0.1%	0.0%	0.2%	0.3%	0.3%
Total Factor Productivity	0.9%	-0.5%	0.3%	-0.6%	0.4%	-1.1%	0.1%	-0.4%

Appendix Table 3 (continued)– Growth Accounting Decomposition of Labour Productivity into Contributions of Tangible and Intangible Capital and Total Factor Productivity, Intangible-Intensive and Less Intangible Intensive Industry Groups, Absolute Contributions to Labour Productivity Growth (average annual % growth), 1996-2007 and 2011-2019

	Intangible-intensive industries				Less intangible-intensive industries			
	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007	1996-2007	2008-2010	2011-2019	slowdown: 2011-2019 minus 1996-2007
	Absolute Contributions to Labour Productivity Growth (average annual % growth)				Absolute Contributions to Labour Productivity Growth (average annual % growth)			
United Kingdom								
Labor productivity growth	2.0%	0.2%	0.6%	-1.5%	0.6%	-0.4%	0.2%	-0.5%
Labor composition	0.3%	0.2%	0.1%	-0.2%	0.1%	0.1%	0.1%	0.0%
Tangible capital deepening	0.3%	0.0%	0.2%	-0.1%	0.4%	0.2%	0.0%	-0.3%
Non-ICT tangible capital deepening	0.1%	0.0%	0.0%	0.0%	0.2%	0.2%	0.0%	-0.2%
ICT tangible capital deepening	0.2%	0.0%	0.1%	-0.1%	0.1%	0.0%	0.0%	-0.1%
Intangible capital deepening	0.4%	0.4%	0.2%	-0.2%	0.2%	0.1%	0.2%	0.0%
Technology-related intangible capital deepening	0.1%	0.1%	0.0%	-0.1%	0.0%	0.1%	0.0%	0.0%
Business innovation-related intangibles capital deepening	0.3%	0.3%	0.2%	-0.1%	0.2%	0.1%	0.1%	0.0%
Total Factor Productivity	1.0%	-0.3%	0.1%	-0.9%	0.0%	-0.9%	-0.2%	-0.2%
United States								
Labor productivity growth	2.0%	1.7%	1.0%	-1.0%	0.9%	0.5%	0.2%	-0.6%
Labor composition	0.2%	0.3%	0.1%	-0.1%	0.1%	0.2%	0.1%	-0.1%
Tangible capital deepening	0.6%	0.5%	0.2%	-0.4%	0.3%	0.3%	0.0%	-0.2%
Non-ICT tangible capital deepening	0.2%	0.2%	0.0%	-0.2%	0.2%	0.3%	0.0%	-0.1%
ICT tangible capital deepening	0.4%	0.3%	0.1%	-0.3%	0.1%	0.1%	0.0%	-0.1%
Intangible capital deepening	0.5%	0.8%	0.5%	-0.1%	0.2%	0.2%	0.2%	0.1%
Technology-related intangible capital deepening	0.4%	0.6%	0.3%	-0.1%	0.1%	0.1%	0.1%	0.0%
Business innovation-related intangibles capital deepening	0.2%	0.2%	0.2%	0.0%	0.1%	0.2%	0.2%	0.1%
Total Factor Productivity	0.6%	0.2%	0.2%	-0.4%	0.3%	-0.3%	-0.1%	-0.4%

Note: See Table 3 for taxonomy of intangible-intensive and less intangible-intensive industries. Market economy excludes public administration (NACE Sector O), education (P), health care (Q), activities of households (T) and extra-territorial organisation (U), as well as real estate (L). “Intangibles –technology-related” are measured as part of GDP and included in the national accounts; “intangibles – business-innovation related” are not included in GDP in the national accounts (see Figure 1).

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-illee.luiss.it/>)

Differences between EUKLEMS & INTANProd – Release 2023 and Goodridge & Haskel (2023) for the UK

This note relies on source data from [EUKLEMS & INTANProd \(Release 2023\)](#) – hereafter referred to as EUKLEMS. For comparison we also looked at recent data from [Goodridge and Haskel \(2023\)](#) – hereafter referred to as GH – used to construct vintages of industry level national accounts and growth accounting data for the UK.

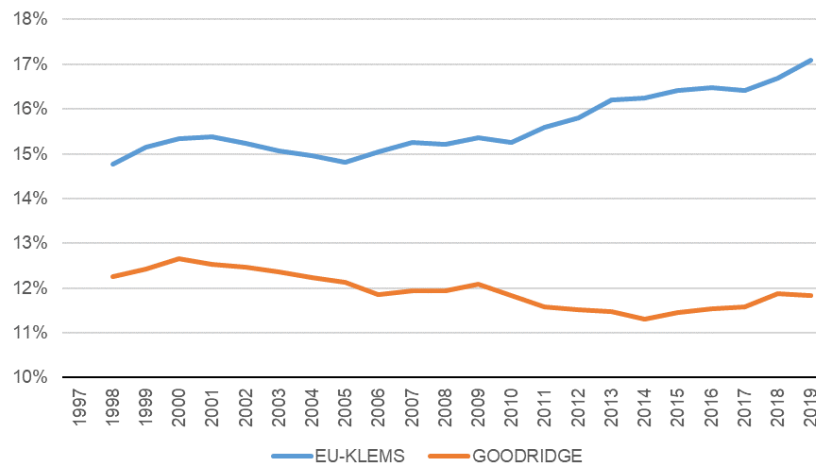
Both datasets rely on the Corrado-Hulten-Sichel framework to identify intangible assets, both use different somewhat different sources. GH relies entirely on (in part, experimental) data from the Office of National Statistics, whereas EUKLEMS is largely based on data from Eurostat (only including official ONS data) as well as slightly different computations by the KLEMS team in order to better harmonise data across countries and industries.

The aggregate level of nominal intangible investment as a share of value added is substantially higher in EUKLEMS data than in GH, and the EUKLEMS share also increased whereas it slightly declined according to GH. EUKLEMS shows particularly higher levels of intangible investment for Brand, Design, and Organizational Capital, where GH show higher levels of training investment data.

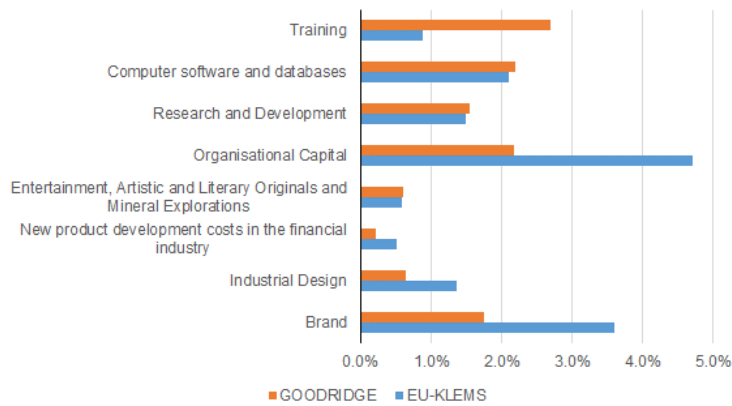
The growth rates of real investment in intangibles are also different between the two datasets. Overall real intangible investment grew on average 1.6 percent per year between 1998 and 2019 according to GH, versus a much faster 3.3 percent growth rates in the EUKLEMS dataset. The differences are largest for design, organizational capital and training where EUKLEMS shows much faster growth (in the latter case GH even shows a decline); while New Product Development costs in the financial industry show much faster growth according to GH. With regards to real intangible investment growth by industry, EUKLEMS shows faster growth in all sectors, except for C13-15 (textiles and apparel).

On balance, the weaker growth performance on intangible capital according to GH would have further reduced its contribution to UK labour productivity growth. While this may have slightly lessened the paradoxical situation of a relatively large contribution of intangible capital in the context of weakening productivity growth, the observation that intangible capital has been insufficient in supporting productivity growth during the post-GFC period is maintained.

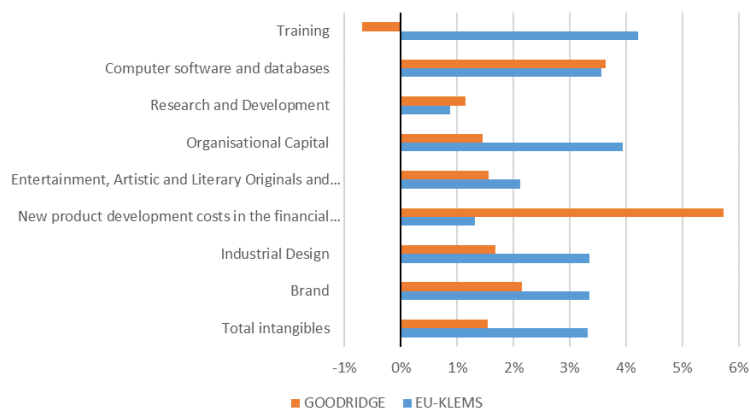
Nonfarm market sector intangible investment share



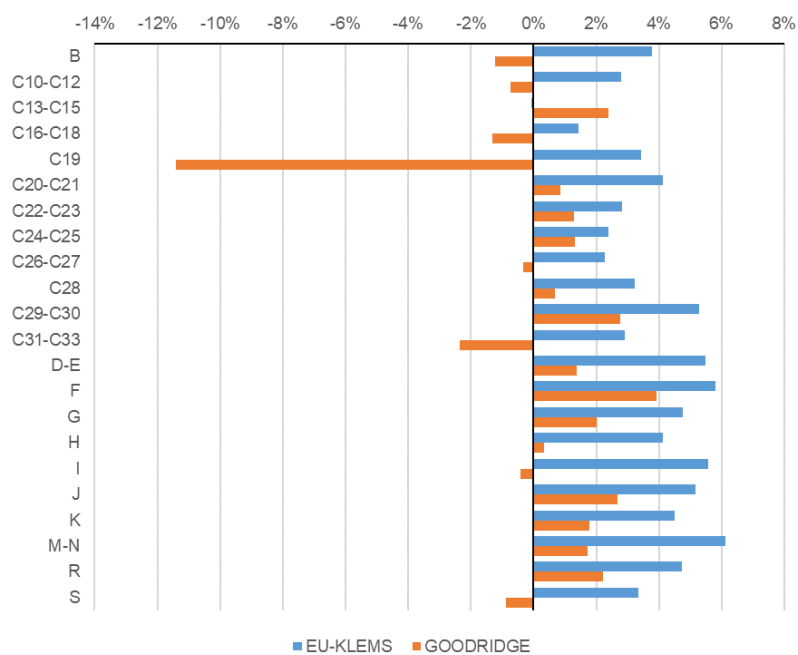
Nonfarm market sector intangible investment share, 2010



Nonfarm market sector real intangible investment growth, 1998-2019 (average annual % change)

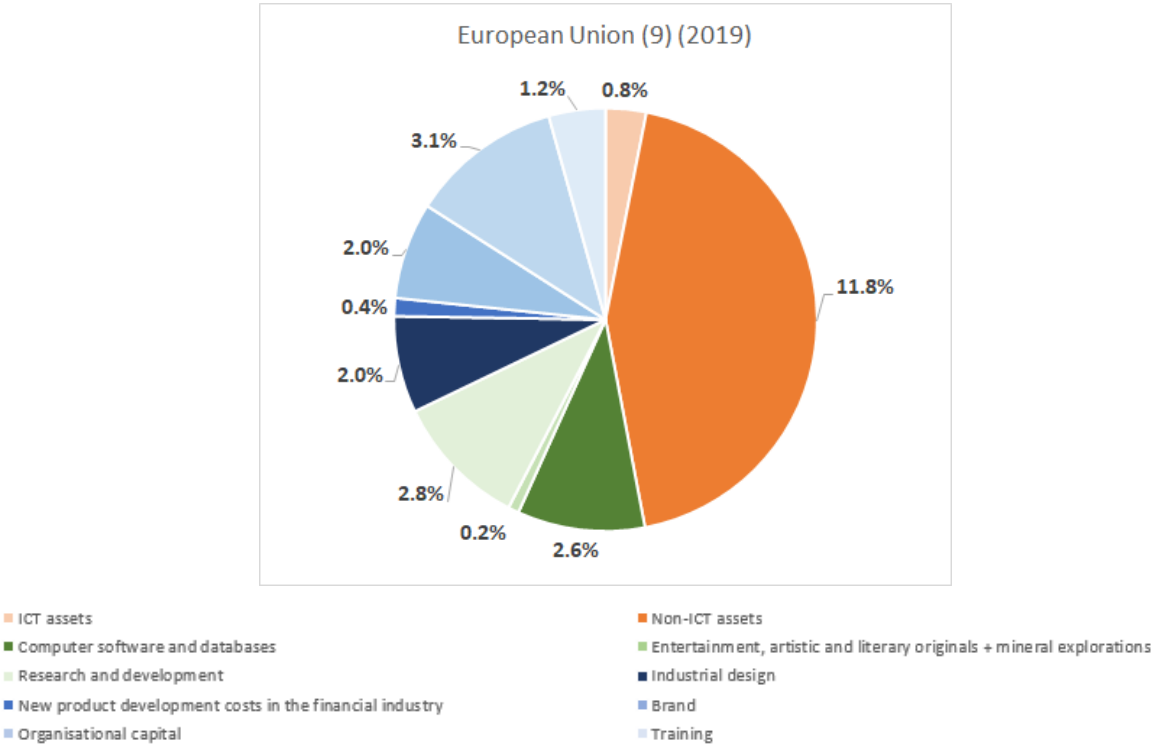


Real intangible investment growth, 1998-2019 (average annual % change)

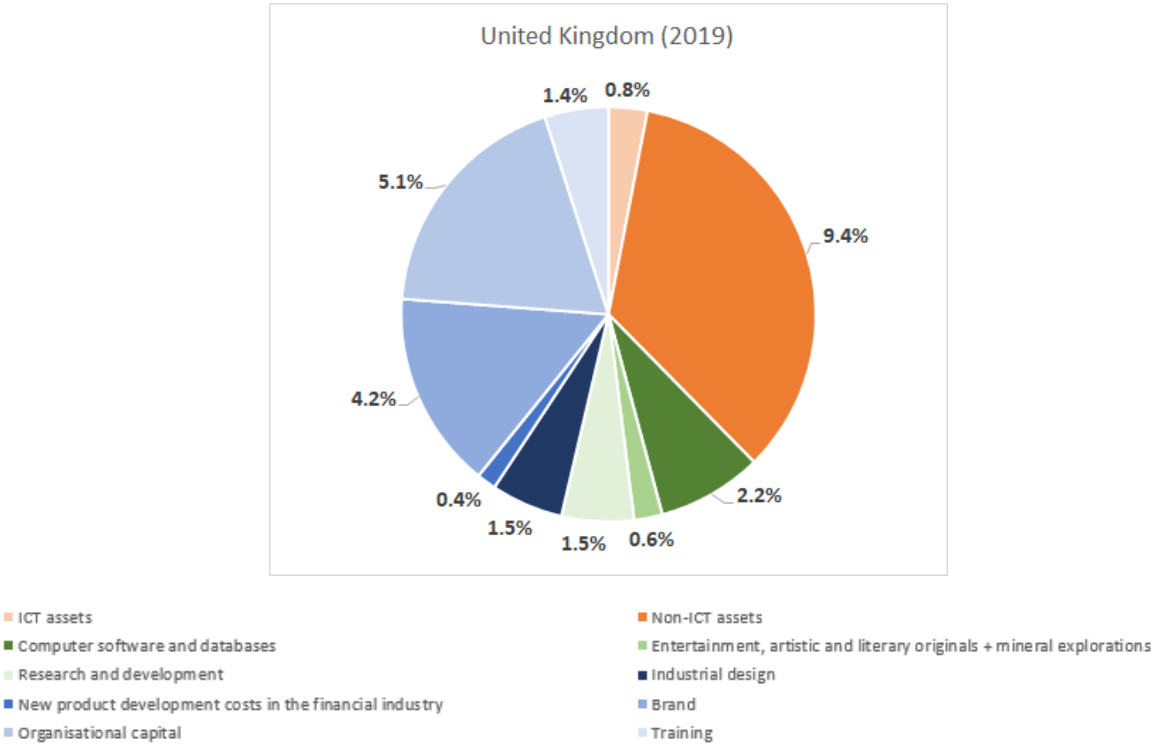


Appendix Chart 1: Nominal Investment Share in Value Added, Market Economy, 2019

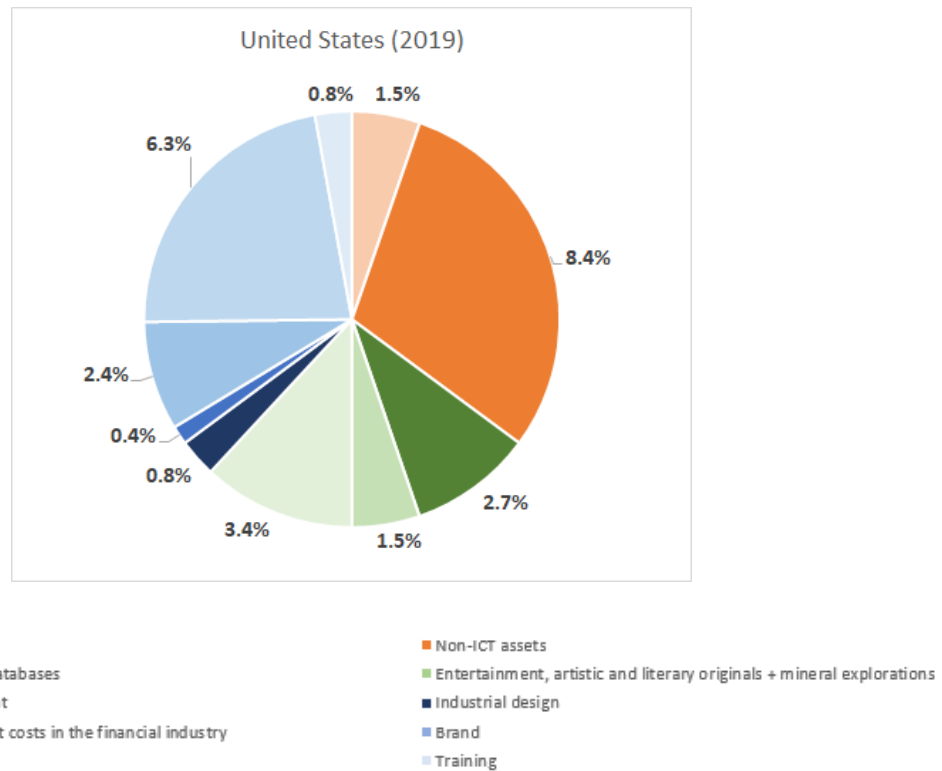
Panel A: European Union (9)



Panel B: United Kingdom



Panel C: United States



Notes: European Union (9) includes Austria, Germany, Denmark, Finland, France, Italy, Netherlands, Spain and Sweden and are weighted by their GDP. Market economy excludes public administration (NACE Sector O), education (P), health care (Q), activities of households (T) and extra-territorial organization (U), as well as real estate (L).

Source: EUKLEMS-INTANProd, 2023 (<https://euklems-intanprod-ilee.luiss.it/>).

Cracking the Productivity Code: An International Comparison of UK Productivity

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LSE and MIT

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Abstract

We examine the growth and level of UK productivity compared to France, Germany and the United States. There has been a marked slowdown in labour productivity growth: comparing the dozen years before and after the Global Financial Crisis. The average annual growth of the UK's real value added per hour in the market economy has fallen from 2.5 per cent to 0.5 per cent. Just over half of this two percentage point slowdown is due to slower TFP growth, which is broadly similar in magnitude across countries. Britain experienced a much larger slowdown in the growth of capital intensity than other countries and it is this (alongside a smaller contribution from slow skills growth) which accounts for the particularly severe 'productivity puzzle'. The level of UK labour productivity is also low compared to peers, especially the United States. In 2019, lower tangible and intangible capital intensity accounted for about half of this gap. These findings suggest that UK policy should focus on the problem of chronic under-investment

Since the Global Financial Crisis (GFC), the United Kingdom has been struggling with slow productivity growth. Total economy annual GDP per hour growth between 2007Q4 and 2023Q3 was about 0.4 per cent. Focusing on the market economy,² the average growth rate of output per hour between 2007 and 2019 was about the same at 0.5 per cent per year, showing that this pattern is not simply due to the turmoil

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² The market economy excludes hard-to-measure government-related sectors like health and education. Specifically, it excludes real estate (industrial division L), public administration and defence (O), education (P), human health and social work (Q), the self-employed (T), and activities of extraterritorial organizations (U).

over the COVID pandemic and Russia's invasion of Ukraine. Moreover, although just about every country experienced a post-crisis slowdown, the United Kingdom was hit particularly severely. In the dozen years before the financial crisis, UK productivity growth was over 2.5 per cent per year, so this implies a huge two percentage point fall post versus pre-crisis. In contrast, the slowdown in the United States, France and Germany over the same period was only 1.6, 1.5 and 1.0 percentage points respectively.

The consequences of low productivity growth are profound. Real wage growth relies on productivity growth in the long run. So it is not surprising that average UK real wages today are similar to their level in 2005. On some measures, this is the longest stagnation for centuries and the cause of a host of political and social problems.

In this article, we investigate productivity from an international perspective, comparing the United Kingdom to the United States, France, and Germany. We use the most recent comparable data (primarily from KLEMS) to examine the UK's market economy productivity growth compared to its peers. We also look at Britain's relative productivity level. We focus on decomposing the components of productivity into different capital inputs and the unexplained residual component (Total Factor Productivity, TFP). We look at various types of capital: human capital (skills) and fixed capital (e.g. equipment and buildings); tangible versus intangible capital (such as software and Research and Development,

R&D); and Information and Communication Technology (ICT) capital vs. non-ICT capital.

Our conclusions can be succinctly summarized. Britain's substantial post-crisis fall in productivity growth relative to other countries is primarily due to a large fall in capital accumulation rate. All countries experienced a broadly similar fall in TFP growth after the GFC, but the slowdown in capital intensity was particularly severe in the United Kingdom. In terms of productivity levels, both low investment in capital and TFP contribute significantly to the gap with other countries. The exact magnitudes on levels are more sensitive to assumptions than growth accounting, but in 2019, roughly half of the overall UK productivity gap was due to lower tangible and intangible capital.

The article is structured as follows. Section one briefly summarizes the data and methods employed. Section two compares productivity growth, focusing on the dozen years before and after the financial crisis. Section three analyses productivity levels. This section offers some extensions that looks at alternative labour composition measures, industry breakdowns, post-2019 performance, the role of hours worked, labour markets, and alternative decomposition methods. Section four concludes with policy discussions. The online appendix deals with data (Appendix A) and provide some further results (Appendix B).³

3 The Appendix is found at https://csls.ca/ipm/46/Van_Reenen_Online_Appendix.pdf.

Data and Methods

To ensure valid comparisons, we require consistent volume measures of input and output across countries. Although there has been some harmonization in recent decades, it is still the case that different National Statistics Institutes (NSIs) use different methods to construct their national accounts. The variation in data construction across countries presents a challenge for productivity level comparisons, although it is less of an issue for our growth analysis due to its internal consistency over time. To address this concern, we employ two primary data sources: EUKLEMS & INTANProd 2023 (Bontadini *et al.*, 2023) and OECD productivity statistics (OECD, 2014). For output and capital input data, we rely on EUKLEMS & INTANProd 2023, which reconstructs the capital stock data in national accounts using a consistent approach across countries. This harmonized capital data is available only through the most recent 2023 release.

For labour input data, we have substituted the data on hours worked in national accounts with the hours data from the OECD productivity statistics (OECD, 2014), which harmonizes the methodology for constructing the working hours data. This is particularly important for compar-

ing productivity levels because UK hours are calculated in a different way to those in other countries.⁴ The difference in methods causes aggregate UK hours to appear artificially higher and, in turn, UK output per hour to appear artificially lower. Unless these are corrected, the UK's TFP gap in levels is overstated (although we show it makes little difference to growth rates).

As the main interest of this article is in understanding UK productivity performance relative to its international counterparts, we normalize the level accounting such that UK=100. However, alternative comparisons employing different base countries can be made by substituting the United Kingdom with any country of interest.

We follow a standard production function approach, decomposing country i 's labour productivity as:

$$\ln \left(\frac{Y_i}{H_i} \right) = \ln A_i + \alpha_i \ln LC_i + (1 - \alpha_i) \ln \left(\frac{K_i}{H_i} \right) \quad (1)$$

where Y_i is real gross value added (GVA), K_i is the capital stock, H_i is total hours worked, LC_i is labour composition ("skills" - the labour quality of the workforce,⁵ and A_i is Total Factor Productivity (TFP). The

⁴ This is detailed in the Appendix. Essentially, the United Kingdom relies on employee surveys of hours worked from the Labour Force Survey whereas the other countries primarily use adjusted administrative data.

⁵ Detailed methods for constructing labour composition measures are discussed in section 3. In short, KLEMS uses age-education-gender-industry cells which are tracked from different surveys such as the Labour Force Survey. Average hourly wages are used to proxy productivity, and the fractions of labour compensation allocated to each cellular division are tracked over time. For example, if the fraction of labour compensation for middle-aged men with college degrees increases relative to middle-aged men with only high school qualifications, this will imply an improvement in average skills or labour composition.

⁶ We are implicitly assuming constant returns to scale in the production function.

parameter α_i is measured as the share of labour costs in value added, and $1 - \alpha_i$ is the capital share.⁶ We can then express a country's labour productivity relative to the United Kingdom:

$$\ln \frac{(Y_i/H_i)}{(Y_{uk}/H_{uk})} = \ln \frac{A_i}{A_{uk}} + \tilde{\alpha}_i \ln \frac{LC_i}{LC_{uk}} + (1 - \tilde{\alpha}_i) \ln \frac{(K_i/H_i)}{(K_{uk}/H_{uk})} \quad (2)$$

To conduct a cross-sectional multilateral comparison of labour productivity, we take the average of the country i 's labour share and a base invariant labour share, denoted by $\tilde{\alpha}_i$. The base invariant labour share is the average labour share over all possible country choices.

To analyse the drivers of labour productivity growth, we follow the growth accounting method by Solow (1957). This approach decomposes labour productivity growth into contributions from factor inputs and TFP:

$$\Delta \ln \left(\frac{Y_{i,t}}{H_{i,t}} \right) = \Delta \ln A_{i,t} + \alpha_{i,t} \Delta \ln LC_{i,t} + (1 - \alpha_{i,t}) \Delta \ln \left(\frac{K_{i,t}}{H_{i,t}} \right) \quad (3)$$

where $\Delta \ln X_{i,t} = \ln X_{i,t} - \ln X_{i,t-1}$ denotes the growth rate of variable X in country i and year t .⁷ Labour shares and capital

shares of value added (i.e. $\alpha_{i,t}$ and $1 - \alpha_{i,t}$) are averaged over periods t and $t - 1$ for each country i .

Labour Productivity Growth

To analyze productivity growth over time, we focus on the 1995 to 2019 period, a dozen years before and after the financial crisis (i.e. 1995-2007 versus 2007-2019). There are two reasons for this time frame. First, our primary data source, EUKLEMS & INTANProd 2023 KLEMS23 only goes back to 1995. Second, we conclude our analysis in 2019, just before the outbreak of the COVID-19 pandemic, which severely disrupted economic activities.⁸

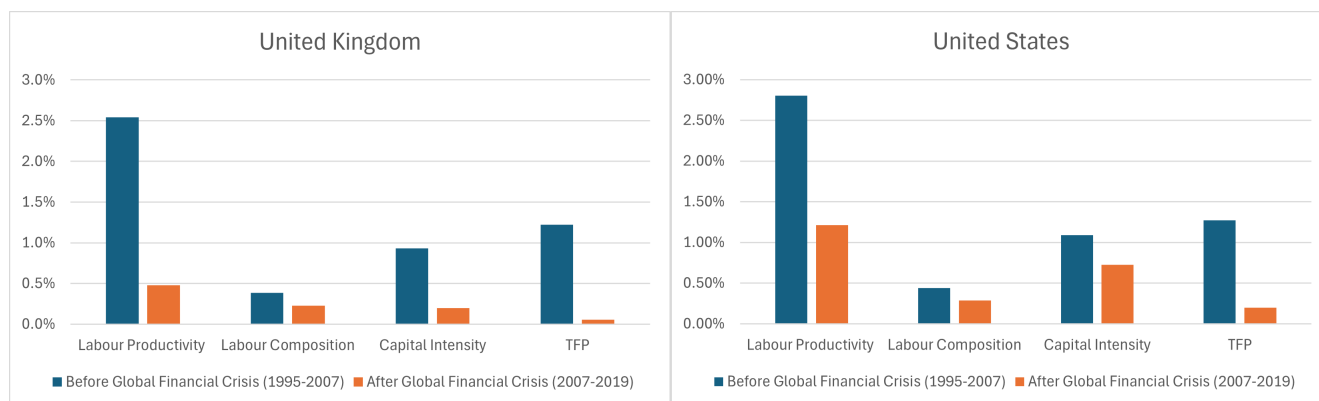
Chart 1 compares labour productivity growth rates before and after the financial crisis (with underlying numbers in Appendix Table C11). Beginning with the UK panel, we see that the UK labour productivity was growing at 2.5 per cent per year pre-crisis but fell to 0.5 per cent p.a. afterwards. This was a worse collapse than in the other countries. The UK productivity was growing faster pre-crisis than France (2.0 per cent) and Germany (1.9 per cent) and only slightly worse than the United States during its “productivity miracle” period (2.8 per cent). Post-crisis, all four economies experienced slowdowns, but the United Kingdom fared the worst, with a 2.1 per cent slowdown compared to 1.6 per cent in the United States, 1.5 per cent in

⁷ In our main analysis, TFP growth is defined based on Equation 3, which is the aggregate value added growth not explained by the revenue-share-weighted input growth. In section 3, we explored an alternative growth accounting model.

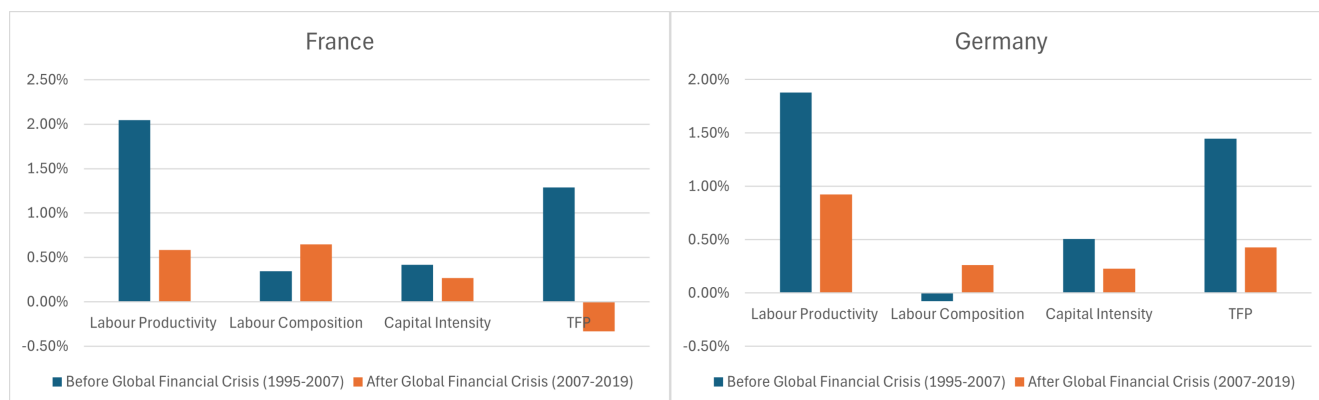
⁸ Section 4 looks at other years. For example, Appendix Table C13 has alternative cutoff years for the pre-GFC and post-GFC periods - these yield similar results.

Chart 1: Growth Accounting Before and After the Global Financial Crisis, SNA Market Economy, Per cent or Percentage Point Contributions per Year

Panel A: United Kingdom and United States



Panel B: France and Germany



Note: Growth accounting is estimated based on Equation 3. The left bar of each variable (labour productivity, labour composition, capital intensity and TFP) is the average weighted annual growth rate in the pre-GFC period (1995-2007), and the corresponding right bar is the average weighted annual growth rate in the post-GFC period (2007-2019). For the United States, the pre-GFC period starts in 1996 due to data limitations. See Appendix Table C11 for growth accounting results. Source: EUKLEMS & INTANProd 2023 (Bontadini *et al.*, 2023); OECD productivity statistics (OECD, 2014).

France, and 1.0 per cent in Germany.

We decompose labour productivity growth into the contributions from capital deepening, skills and TFP in Chart 1 and Chart 2. Chart 2, Panel A indicates that there was a general slowdown in TFP growth with the United Kingdom no worse than other countries. Britain's TFP growth slowed by 1.2 percentage points, accounting for over half of the overall labour productivity slowdown. The TFP slowdown was 1.1 percentage points in the United States, 1.6 percentage points in

France and 1.0 percentage points in Germany.

Of the (roughly) other half of the UK labour productivity slowdown (0.9 percentage points), four-fifths was due to slower capital deepening (0.73 percentage points) with a smaller fraction ascribed to labour composition (0.16 percentage points). This slowdown in capital intensity growth was particularly large, both in absolute terms Chart 1 and relative to other countries Chart 2. The weighted decline in capital intensity growth is only -0.36 percent-

age points in the United States (half of that in the United Kingdom), -0.28 in Germany and -0.15 in France. In addition, the United Kingdom had the largest fall in labour composition growth (-0.16 per cent versus -0.15 per cent in the United States). In contrast, labour composition growth actually improved in France and Germany.

In Chart 2, Panel B we break down the deceleration of capital deepening into three subcategories: ICT tangible capital, non-ICT tangible capital, and intangible capital. Across these asset classes, tangible capital emerges as the primary driver of the overall decline in capital deepening across all countries. Specifically, the slowdown in ICT tangible capital deepening was the most significant contributor in the United Kingdom and United States, whereas non-ICT tangible capital deepening mattered more in Europe. The United Kingdom has the largest slowdown in ICT capital and intangibles deepening, whereas its slowdown in non-ICT capital deepening is more comparable to other EU countries.

We also looked at the broader notion of intangibles (Appendix Chart B7 and Chart B9). Broadly, in Chart 3, the conclusions do not change that much. The UK's labour productivity slowdown remains at almost 2 percentage points with TFP contributing 1.2 percentage points, and this TFP slowdown is similar across countries. The contribution of intangibles is -0.11 percentage points in the United Kingdom, slightly less than the -0.17 percentage points under the SNA framework. But the main differentiating factor is still lower capital investment. In summary, the United Kingdom had the worst contraction in labour productivity growth across the four countries we study

after the financial crisis. Britain's fall in TFP growth was similar to that experienced across other nations. What stands out is the sharper drop in capital accumulation and (to a lesser extent) a slowdown in skill accumulation. Thus the picture in growth rates is qualitatively similar to that in levels: the UK's productivity problem is related to lower investment levels in fixed and human capital.

The UK Productivity Gap in Levels

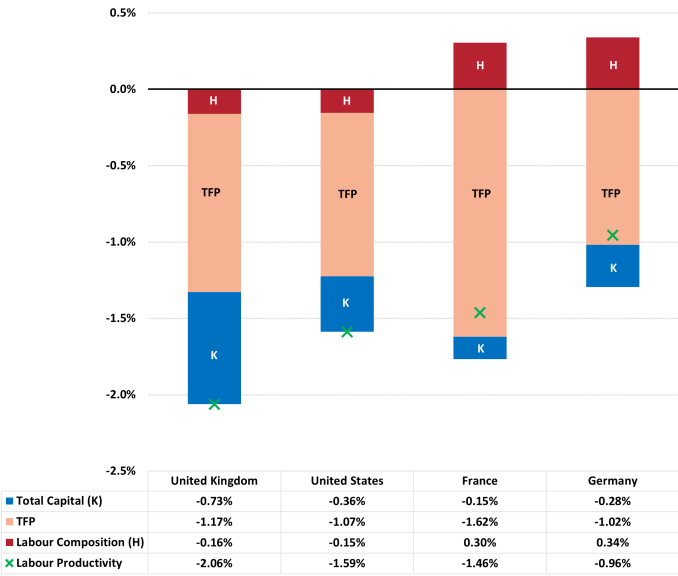
Basic Results

We now turn from productivity growth to level analysis. Chart 4 illustrates the UK labour productivity gap with its counterparts for 2019, adjusted for differences in capital intensity and labour composition. The first and darkest green bar shows that the United Kingdom lags behind all three countries. Specifically, US labour productivity is 30 per cent higher than that of the United Kingdom, while France and Germany lead by 14 per cent and 22 per cent respectively.

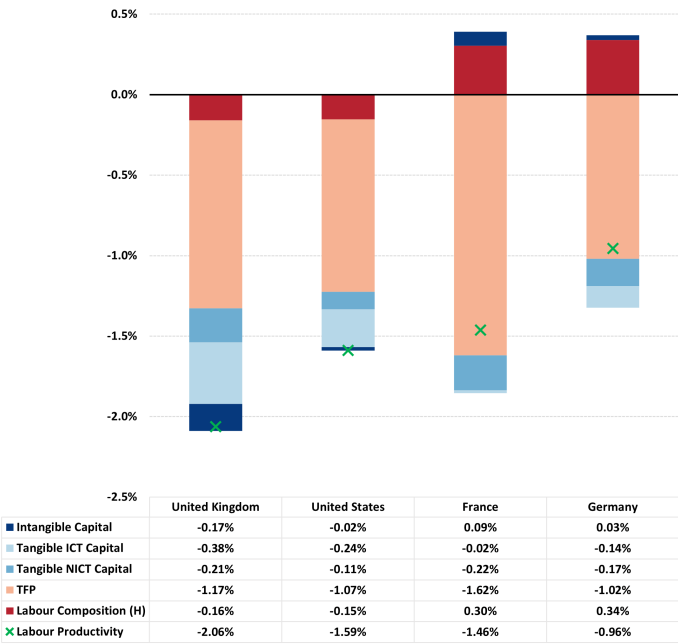
The next two bars in Chart 4 show the impact of adjusting for capital and labour quality. The middle green bar accounts for differences in capital intensity, considering both tangible and intangible capital in national accounts. This adjustment explains 6 percentage points of the gap with the United States, 5 percentage points with France and 8 percentage points with Germany. Hence, approximately one-fifth to over one-third of labour productivity gaps stem from lower investment in physical cap-

Chart 2: Productivity Growth Slowdown After the Global Financial Crisis, SNA Market Economy, Percentage point contribution per year

Panel A: Breakdown by Total Capital

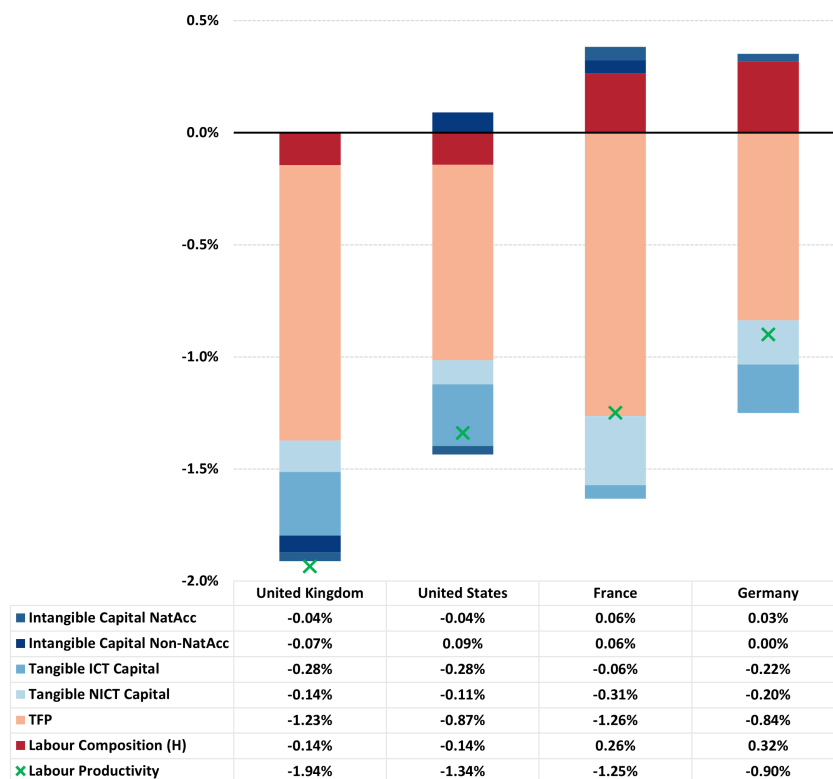


Panel B: Employment



Note: This shows the difference in labour productivity growth in the dozen years before (1995-2007) and after (2007-2019) the financial crisis. The green cross denotes the overall fall in labour productivity growth. Panel A has the overall decomposition and Panel B breaks down the capital contribution into tangible Information and Communication Technology (ICT), tangible non-ICT capital (NICT) and intangible capital (SNA boundaries). Source: See Chart 1 for data sources and Chart notes.

Chart 3: Productivity Growth Slowdown After the Global Financial Crisis, CHS Market Economy, Percentage Contribution per Year



Note: This shows the difference in labour productivity growth in the dozen years before (1995-2007) and after (2007-2019) the financial crisis in the CHS market economy. We decompose this into labour composition, TFP, and capital per hour growth (tangible ICT, tangible non-ICT, SNA intangible capital and non-SNA intangible capital). The green cross denotes the overall fall in labour productivity growth.

Source: See Chart 1 for data sources and Chart notes.

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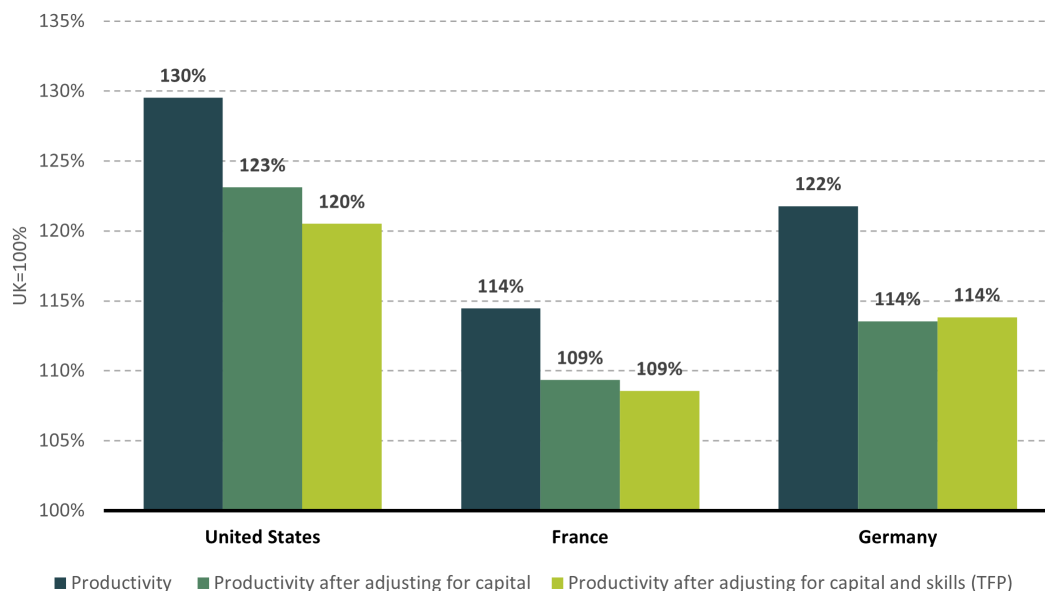
The last and lightest green bar in Chart 4 also takes into account labour quality differences and serves as our measure of TFP. Labour quality has little impact on the UK's productivity gap with Germany and France, but accounts for about 3 percentage points of its gap with the United States. After controlling for input differences, the UK TFP gap is 20 per cent with the United States, 9 per cent with France and 14 per cent with Germany. Hence, differences in observable capital and labour

inputs have accounted for 31 per cent, 41 per cent and 36 per cent of the productivity gap with the United States, France and Germany respectively.⁹

Such productivity-level accounting comes with many caveats, such as imperfect measurement of labour composition and the different choices of purchasing power parity (PPP). We employ an alternative labour composition measure and conducted more robustness checks in Appendix B, which show these qualitative findings to be robust.

⁹ The proportion of the productivity gap explained by differences in observable capital and labour inputs = 1 - (TFP gap/ total labour productivity gap). For example, this proportion in the United States is 67 per cent = 1 - (20.5/29.5)

Chart 4: Labour Productivity Level in the United States, France and Germany Relative to the United Kingdom, SNA Market Economy, 2019



Note: The chart shows labour productivity levels adjusted for different factor inputs, normalized to the United Kingdom in 2019=100 per cent. The labour productivity level is in 2015 PPP prices. Capital intensity and labour composition are estimated by level accounting based on Equation 2, which are weighted by capital and labour shares respectively. See Appendix Table C1 for level accounting results. Because of data availability in EUKLEMS, unweighted labour composition is assumed to be the same for market and non-market sectors in the United States. See Appendix A for further details.

Source: EUKLEMS & INTANProd 2023. (Bontadini *et al.*, 2023); OECD productivity statistics (OECD, 2014); PPP (OECD, 2023c); Average years of schooling (Barro and Lee, 2013)

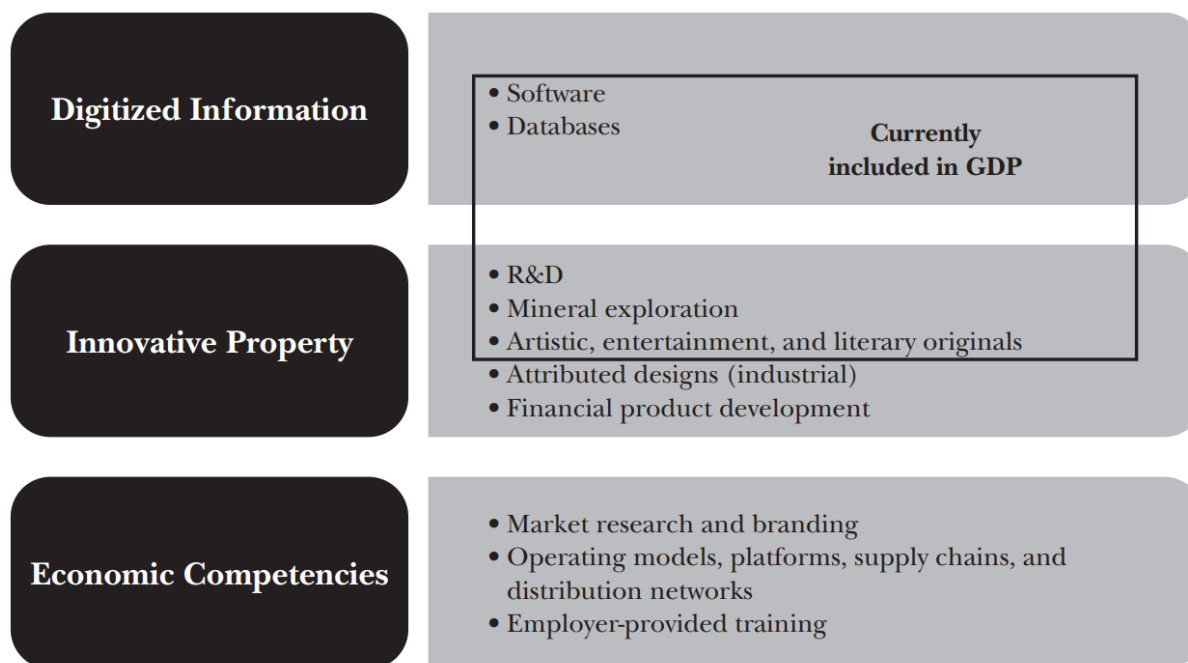
Extended Intangible Capital Measures

Intangible capital has become an increasingly important component of firm assets in the modern economy (Haskel and Westlake, 2017). However, the System of National Accounts (SNA) asset boundary only takes a rather narrow approach to incorporating intangibles, specifically digitized information (software and databases) and specific innovative property (R&D, mineral exploration, and arts originals). This fails to capture the more comprehensive value of intangibles such as marketing to enhance brand capital and company training to build human capital. For countries that in-

vest heavily in intangible assets beyond the SNA boundary, output and capital stocks in national accounts will not accurately reflect productivity and the contribution of capital. To address this concern, Corrado, Hulten and Sichel (2009) proposed an expanded asset boundary (the “CHS” boundary) that encompasses a broader concept as illustrated in Figure 1. We can use the analytical module in EUKLEMS & INTANProd 2023 (Bontadini *et al.*, 2023), which complements national accounts data with information on intangibles using the CHS framework.

The capitalization of intangible assets outside national accounts could impact labour productivity through three chan-

Figure 1: Intangible Capital: Broad Categories and Types of Investment



Source: Figure by Corrado *et al.* (2022).

nels. First, it increases the volume of the capital stock. Second, the capitalization of additional intangibles increases value-added, as these intangible assets are no longer considered intermediate inputs but rather part of final output. Third, it changes the capital and labour shares as capital compensation will be higher. How large these adjustments are is an empirical question.

We show the effect of incorporating broader intangibles on productivity gaps in Chart 5. The leftmost bar for each country represents the relative levels of labour productivity under the CHS boundary. Compared to Chart 4, the UK productivity gaps with the United States and France remain largely unchanged. However, the gap with Germany narrows considerably from 21.8 per cent to 14.5 per cent. This sug-

gests that German intangible capital stock is relatively lower, flattening its productivity performance.

The second bar of Chart 5 shows the impacts of adjusting for capital intensity in national accounts, as in Chart 4. The third bar reflects the adjustment for the wider notion of intangible capital. While this adjustment has minimal impact on France and Germany, it significantly reduces UK's productivity gap with the United States by 8 per cent, indicating that the United States is much more intangible capital-intensive. Lastly, the fourth and lightest bar gives the new relative TFP levels. The incorporation of broader intangibles has reduced the UK TFP gaps further to 11 per cent with the United States and approximately 6 per cent with France and Germany. Thus, the difference in physical

Chart 5: Labour productivity Level Relative to the UK, CHS Market Economy, 2019



See sources and notes in Chart 4. See Appendix Table C2 for decomposition estimates.

and human capital inputs explains 60 per cent of the UK’s productivity gap with the United States and over 50 per cent with France and Germany

In conclusion, the United Kingdom has lower value added per hour than France and Germany and much lower labour productivity than the United States. From two-fifths to one-third of these differences are accounted for by lower capital intensity, with the remaining gaps largely due to TFP. Using a broad measure of intangible capital, lower capital intensity emerges as the most important contributor to the productivity gap between the United Kingdom and its peers, with TFP playing a slightly smaller but still substantial role. Therefore, a key issue of the UK productivity problem lies in low investment both

for growth and levels.

Extensions

In this section, we present several extensions and robustness tests of our analysis.

Alternative Labour Composition Measures

In addition to our previous labour composition measure, another common approach in the literature to control for the quality of the workers in level accounting is to estimate a human capital index based on worker’s average years of schooling, assuming a rate of return to education (e.g. Caselli, 2005). In this section, we adopt this alternative following Hall and Jones (1999) in our level accounting:

$$h = e^{\phi(s)} \quad (4)$$

where s denotes the average years of schooling. The function $\phi(s)$ is piecewise linear with slope 0.13 for $s \leq 4$, 0.10 for $4 < s \leq 8$, and 0.07 for $8 < s$, following the specification in Caselli (2005).

One widely used data source for years of schooling s is the data on education attainment for the total population by Barro and Lee (BL, 2013) (e.g. the Penn World Table). However, directly using this data as a proxy for years of schooling in estimating the human capital index poses a challenge due to the differences in years of schooling between workers and the total population. To overcome this issue, we employ BL's average years of schooling for different education levels, weighted by the share of hours worked by each skill level in EUKLEMS data. As BL's data is available only every five years up to 2015, we extrapolate the average years of schooling to 2019 based on the growth rates observed between 2010 and 2015. Details are provided in the appendix.

The alternative labour composition measure results in a significantly higher skills level in the United States relative to the United Kingdom and a much lower relative skills level for France, while Germany's skills level remains largely unchanged. Chart 6 illustrates the level accounting results using these alternative measures, with the first two bars from the right remaining consistent with our previous analysis. However, the UK's TFP gap with the United States decreased significantly by 6 percentage points, while its gap

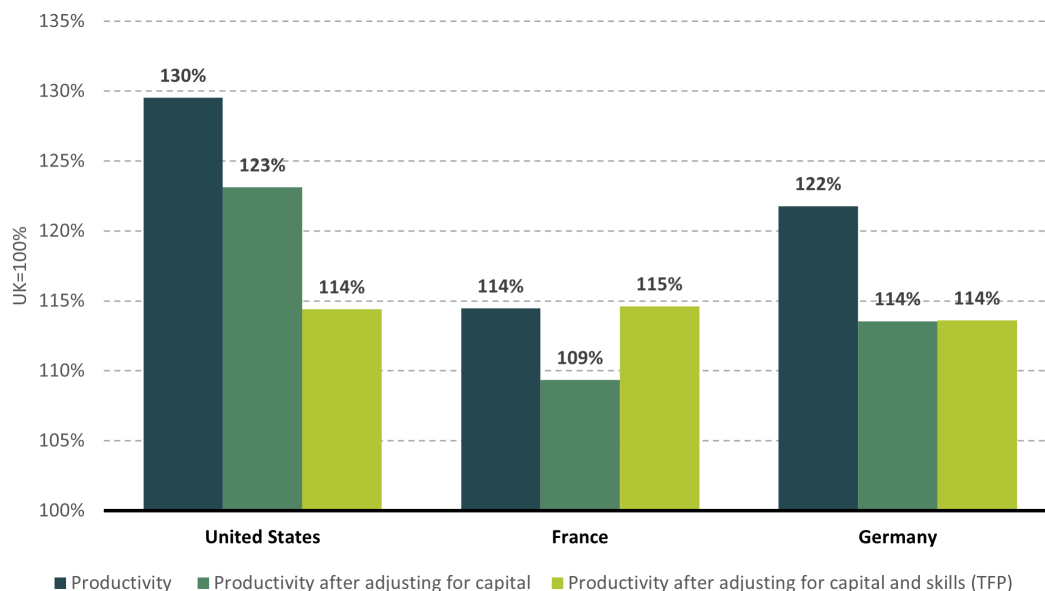
with France increased by the same margin when employing the alternative labor composition measures. Considering broader intangibles in Chart 7, the UK's productivity gap further decreased to 6 percentage points with the United States, 12 percentage points with France, and 7 percentage points with Germany.

Productivity Breakdowns Across Industries

Is poor UK labour productivity growth after 2007 economy-wide or sector-specific? Chart 8 shows the sectoral decomposition of the productivity slowdown, weighted by industry size in terms of nominal GVA. Four things stand out: First, there was a substantial slowdown in the manufacturing sector across all countries after 2007. In particular, the United Kingdom had a more severe slowdown in manufacturing (0.98 per cent) than the other European countries (0.60 per cent for France and 0.65 per cent for Germany). Second, the manufacturing sector alone does not fully explain why the United Kingdom experienced a worse slowdown than other countries. When excluding the manufacturing sector from the market economy, as shown in Appendix Chart B17, our previous conclusions remain unchanged. Third, the wholesale and retail sector also saw a notable slowdown across all countries, but the United Kingdom was doing relatively well compared to other countries. Fourth, the United Kingdom performed significantly worse than other countries in Information and Communication (IC), finance and professional/scientific/technical services.

Chart B16 in the online Appendix

Chart 6: Labour Productivity Level Relative to the United Kingdom Using Alternative Labour Composition Measures, SNA Market Economy, 2019



Note: The Chart illustrates labour productivity levels adjusted for different factor inputs, as depicted in Chart 4. ‘Skills’ refers to the relative human capital levels calculated using Equation 4, which are weighted by labour shares. For detailed accounting results at the level, please refer to Appendix Table C7.

Source: EUKLEMS & INTANProd 2023. (Bontadini *et al.*, 2023); OECD productivity statistics (OECD, 2014); PPP (OECD, 2023c); Average years of schooling (Barro and Lee, 2013).

presents the growth accounting results for the four sectors that contributed the most to the UK’s slowdown.¹⁰ In manufacturing and professional services, the decline in TFP growth accounts for over three-fifths of the slowdown. However, in the IC and finance sectors, the most critical contributor is the collapse of capital deepening.

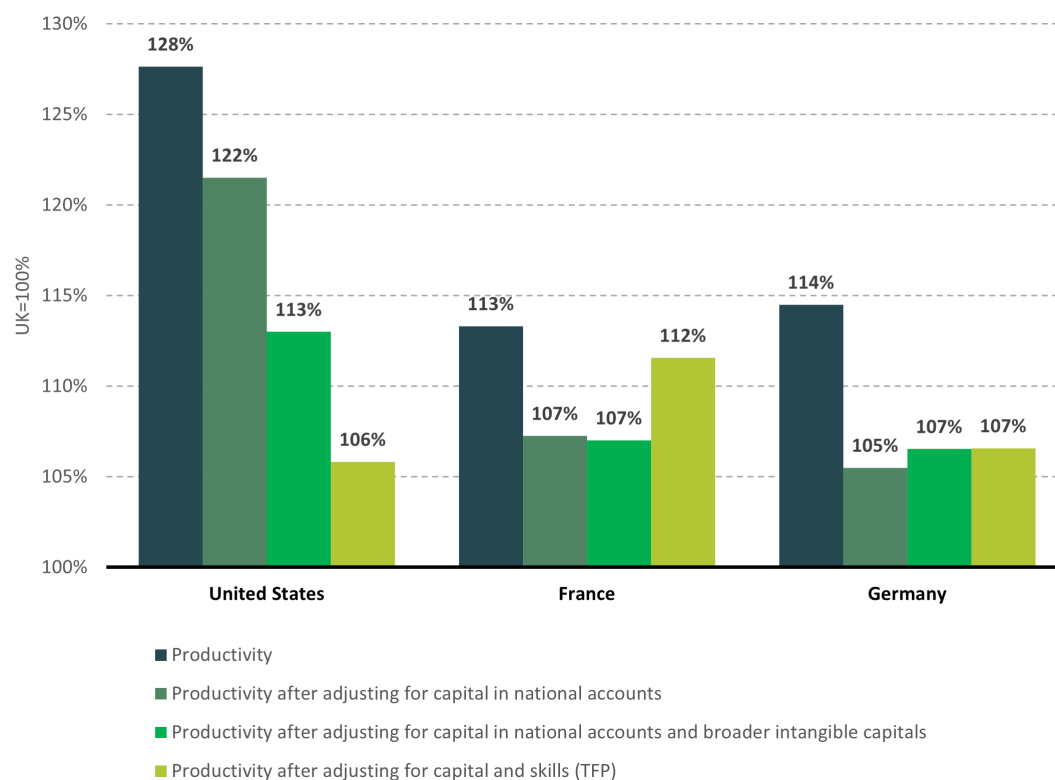
Performance after 2019

Our main analysis concludes in 2019 due to data availability and the onset of the COVID-19 pandemic. But we can use less comparable data to see whether the trajectory of labour productivity has substantially changed since then. Chart 9 plots

labour productivity through 2023Q1. Despite the large swings observed during the pandemic (highlighted by the shaded area) in Chart 9, the post-pandemic trajectory of labour productivity in the UK continued the slow growth observed in the 2007-2019 period. There was a “heartbeat shape” in the lock-down period, but after 2001 productivity looks – if anything – even slower than the pre-Covid period. Germany looks similar to the UK. The United States seemed to weather the storm relatively well and France rather poorly. These most recent years are likely to be subject to the most data revisions across all countries, so we should be cautious about reading too much into them.

¹⁰ Alternative starting years for the pre-GFC period (1995 versus 1997) result in different rankings of weighted sector slowdown. However, the top four contributors remain unchanged. See Appendix B for further analysis.

Chart 7: Labour Productivity Level Relative to the United Kingdom Using Alternative Labour Composition Measures, CHS Market Economy, 2019



See sources and notes in Chart 7. See Appendix Table C8 for decomposition estimates.

Chart 8: Weighted Slowdown of Labour Productivity Growth After GFC Across Industries, SNA Market Economy, Percentage Point Contribution Per Year

Industry	United Kingdom	United States	France	Germany
Manufacturing	-0.98%	-1.00%	-0.60%	-0.65%
Information and communication	-0.30%		0.03%	-0.20%
Finance and insurance	-0.22%	-0.18%		0.01%
Professional, scientific and technical activities	-0.21%		0.07%	-0.07%
Transportation	-0.16%	-0.08%	-0.15%	-0.23%
Energy and water supply, waste management	-0.14%		0.01%	-0.12%
Wholesale and retail	-0.10%	-0.56%	-0.14%	-0.28%
Agriculture	-0.09%	-0.07%	-0.05%	-0.03%
Arts, entertainment and recreation	-0.06%		0.01%	-0.01%
Mining	-0.05%		0.05%	0.00%
Construction	0.01%	0.06%	-0.10%	0.01%
Accommodation and food	0.01%	-0.06%	-0.01%	0.02%
Other service activities	0.04%	-0.03%	-0.06%	-0.01%
Administrative and support service	0.11%	-0.02%		0.05%

Note: The productivity slowdown is the change in average labour productivity growth rates in 1995-2007 vs. 2007-2019. The slowdown by industry is weighted by the output share of each sector in the market economy. Source: EUKLEMS & INTANProd 2023 (Bontadini *et al.*, 2023); OECD productivity statistics (OECD, 2014)

Overall, the impact of COVID-19 on labour productivity appears to be a one-time shock that has not fundamentally changed the long-term trends. Our sense is that nothing major has changed in the data to alter our analysis.

Output Growth Decomposition

Productivity is a ratio of output (value added) to labour input (hours). An alternative decomposition is to focus on explaining total value-added growth as a function of overall inputs including hours. The interpretation of this approach is less clear than our main decomposition as hours can grow for many reasons such as higher population (e.g. from immigration), demographic change, lower unemployment and less leisure (fewer holidays and longer working weeks).

Nevertheless, to investigate whether the UK's position is all due to more hours growth rather than lower output growth, we decompose value-added growth as:

$$\begin{aligned} \Delta \ln Y_{i,t} = & (1 - \bar{\alpha}_{i,t}) \Delta \ln K_{i,t} + \bar{\alpha}_{i,t} \Delta \ln LC_{i,t} \\ & + \bar{\alpha}_{i,t} \Delta \ln Hours_{i,t} + \ln A_{i,t} \end{aligned} \quad (5)$$

Chart 10 shows the decomposition results derived from Equation 5. The first bar on the left illustrates the slowdown in value-added growth. The magnitude of deceleration is similar for the United Kingdom, United States, and France, but notably smaller for Germany. Despite the slowdown in output growth, both the United Kingdom and Germany increased

hours growth compared to their pre-crisis trends (the second, red bar). In contrast, hours growth slowed in the United States and France.

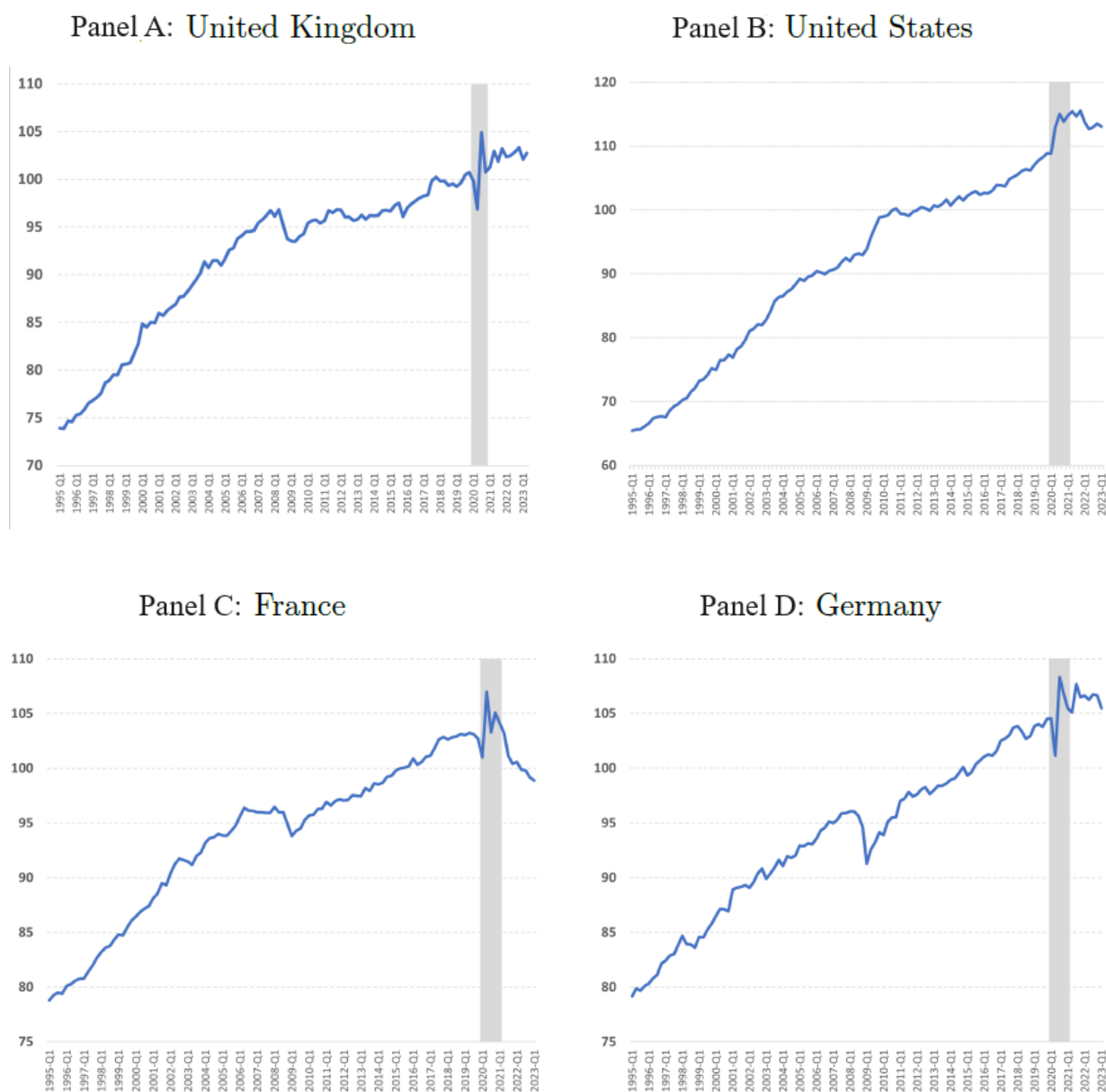
Regarding capital, it is still clear that Britain experienced the most severe slowdown in capital growth, being approximately three times as large as the EU countries and about one-sixth larger than the United States. TFP remains the most important contributor to the output growth slowdown across all countries.

Is the hours story more of a success for the UK? The problem is that the increase in hours worked post crisis does not seem to translate into better output growth. Given the extra hours, we would expect output growth to have been stronger than it was in the United States and France, not more or less the same. And Germany, which had a faster increase in hours growth than the United Kingdom, seems to have had a far superior productivity performance.

Labour Market Response after the Global Financial Crisis

The hours analysis of the previous subsection prompts a more in-depth look at labour markets. Chart 11 shows the employment rate of the working-age population by quarter between 1995 and 2023. Going into the financial crisis, the employment rate was highest in the United Kingdom (about 72 per cent), slightly lower in Germany and the United States (about 70 per cent) and much lower in France (about 66 per cent). All countries experienced falls in the employment rate during the financial crisis, with some recovery afterwards. Germany was particularly quick to recover,

Chart 9: Quarterly Labour Productivity Trend, 1995Q1-2023Q1

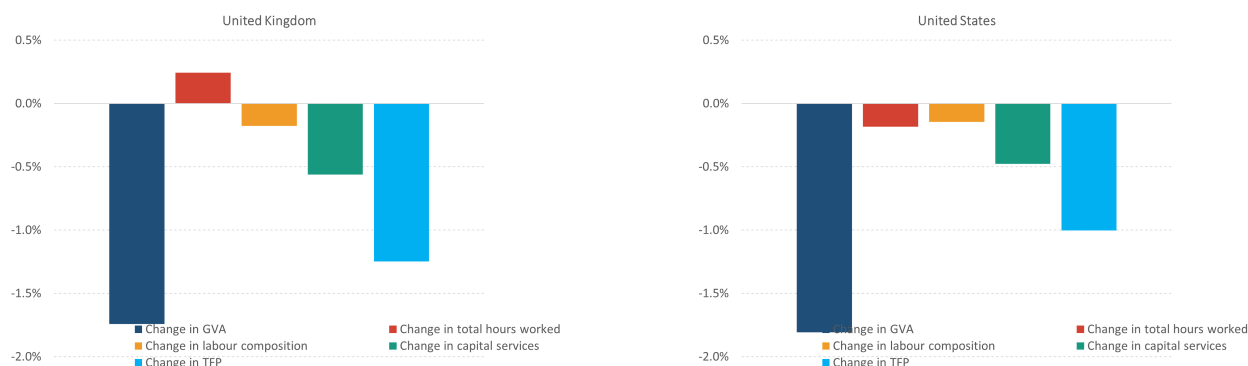


Note: Labour productivity indicator for the United Kingdom, France and Germany is calculated based on the whole economy. The labour productivity indicator for the United States is based on the business sector. Labour productivity is indexed with a base year of 2019=100 in the United Kingdom, 2012=100 in the United States, and 2015=100 in France and Germany.

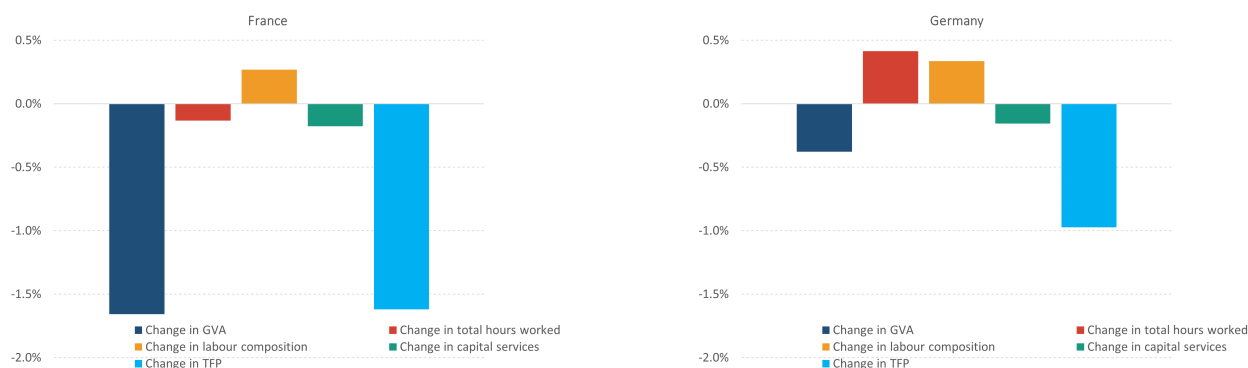
Source: Labour productivity indicator (ONS, 2023); Labour productivity for all workers (U.S. Bureau of Labor Statistics, 2023); Labour productivity indicator (Eurostat, 2023).

Chart 10: Decomposition of Output Growth Slowdown, SNA Market Economy

Panel A: United Kingdom and United States



Panel B: France and Germany



Note: The change in GVA or other factors of production is the difference in their average annual growth rates between 1995-2007 and 2007-2019. See Table C15 for detailed decomposition results.

Source: EUKLEMS & INTANProd 2023(Bontadini *et al.*, 2023); OECD productivity statistics (OECD, 2014).

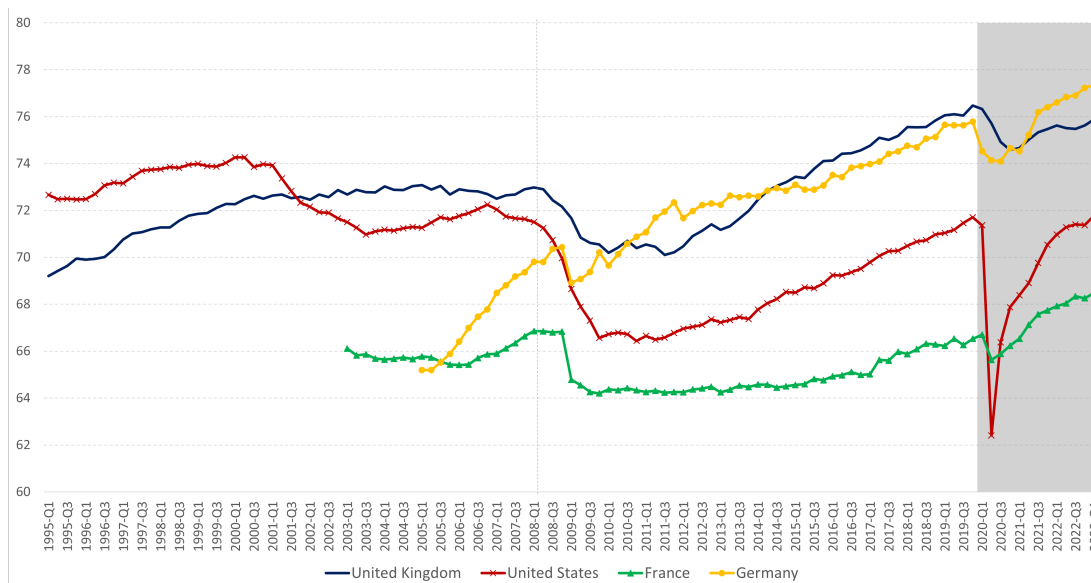
and by 2019 both the United Kingdom and Germany now had an employment rate of around 74 per cent. In 2023, the German employment rate was actually higher than the United Kingdom at around 76 per cent. The United States rate fell by more in the crisis and was very slow to recover, with levels that are still below those in 2007. France had the slowest recovery of all and has only just managed to reach its pre-crisis

levels.¹¹

Could the poorer productivity performance in the United Kingdom be due to successfully getting more low-skilled people into jobs than these other countries? Under this interpretation, low UK productivity growth is a sign of a successful labour market, rather than a weak business sector. The controls for labour composition are meant to deal with this issue. If more low-

¹¹ Table C16 and Table C17 in the online appendix, we compare the cumulative (beginning-to-end) change in the employment rate and employment/population ratio for pre-GFC and post-GFC periods across countries. From 2007 to 2019, the employment rate grew by 3.47 percentage points in the United Kingdom whereas it only grew by 1.65 and -0.42 percentage points in France and the United States respectively. Note that these are for the whole economy rather than the market economy as reported in earlier tables, as the market economy employment rate is not a well-defined concept (population is intrinsically a whole economy concept).

Chart 11: Quarterly Employment Rate of Working-age Population, SNA Total Economy



Note: The working-age population refers to people aged 15-64. The quarterly employment rates of the working-age population for France and Germany start in 2003Q1 and 2005Q1 respectively, due to data availability.

Source: Employment rate indicator (OECD, 2023a).

educated workers are now employed, this should be reflected in a fall in labour quality (skills) and picked up in the decomposition. But this control is only across age-education-gender-industry groups. Maybe the young and less educated unemployed individuals are particularly less productive and the standard labour quality controls fail to reflect this.

Two observations cause us to doubt this more hopeful reading of the United Kingdom position. First, Germany has been more successful than the United Kingdom in raising the employment rate - a full 6.68 percentage points (see Table C16). Despite its employment rate growth being twice as large as that in the United Kingdom, Germany's productivity growth was in fact better than Britain's. Second, there was a similar large increase in the employment rate in the United Kingdom in the 1995-2007 period as there was in the post-2007

period (indeed it was larger than any of the other three countries). But productivity growth did not seem held back by this at all in the pre-GFC period.

In summary, although our labour quality controls are imperfect, it is unclear how much in principle they bias the UK's relative position if at all. The analysis here suggests that poor productivity performance cannot be explained by a relatively resilient labour market.

Alternative Labour Productivity Growth Decomposition

One potential concern for interpreting the growth accounting results in section two is the endogeneity of capital deepening. Fernald *et al.* (2017) argues that the weak capital intensity growth is induced by a slowdown in the TFP growth, and proposed an alternative decomposition in

terms of the capital-output ratio. Specifically, labour productivity can be decomposed as:

$$\Delta \ln \left(\frac{Y_{i,t}}{H_{i,t}} \right) = \frac{1 - \overline{\alpha}_{i,t}}{\overline{\alpha}_{i,t}} \Delta \ln \left(\frac{K_{i,t}}{Y_{i,t}} \right) + \Delta \ln LC_{i,t} + \frac{\Delta \ln A}{\overline{\alpha}_{i,t}} \quad (6)$$

Chart 12 decomposes the labour productivity growth before and after the GFC using Equation 6. Both labour composition and TFP growth rates make up a larger share of the productivity slowdown. In contrast, the contribution of capital intensity decreases substantially. Capital over output growth was almost zero in Germany throughout the two periods, while the United States and France observed an increase in capital-output ratio growth after the GFC. The United Kingdom is the only one amongst all that experienced a decline in capital intensity, although the decline is quantitatively much smaller than our previous decomposition results. The capital story remains to be a key differentiating factor between the United Kingdom and other countries, which is qualitatively consistent with our findings in section two.¹²

Alternative Hours Calculations

As noted above, among our four countries, only the United Kingdom adopts the direct method (surveying employees) to calculate hours, which tends to overestimate the actual hours worked. Labour productivity estimated using the direct method is consistently lower than that estimated using component method (CM) hours.¹³ Since labour input data in EU-KLEMS is sourced from national accounts, using hours data in EUKLEMS underestimates the UK productivity level and overestimates the UK productivity gap with other countries. Although the method used by OECD (2014) to construct the harmonized working hours data that we use in this article is not perfect, it offers a consistent estimate across countries, mitigating biases in international comparisons.

Other Robustness Checks

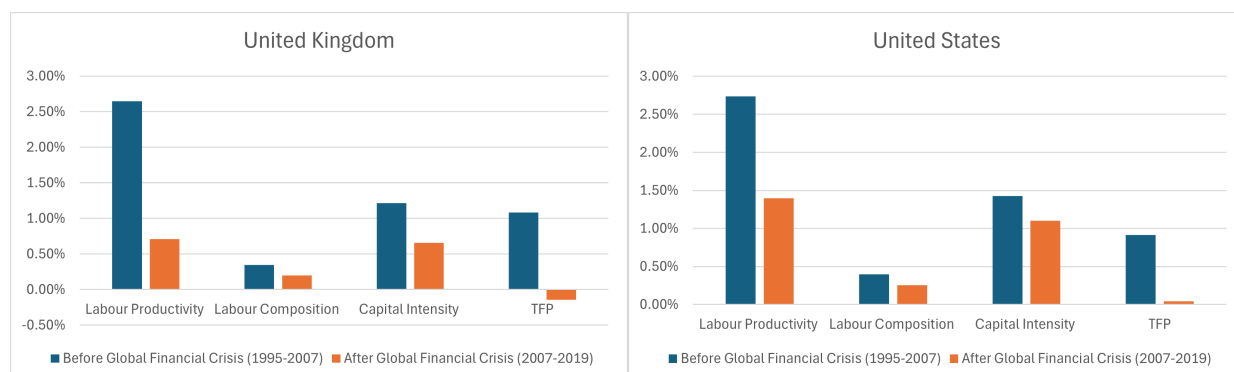
To ensure the robustness of our findings, we conducted many additional checks. First, we employ different PPP series in our productivity level analysis. In Appendix Table B2 and Chart B18 in the online appendix, we use both constant PPPs and current-year PPPs to convert productivity levels into international dollars. Both PPP series yield similar productivity level decomposition results, but

¹² The key question regarding the two different decomposition methods revolves around what is really captured by TFP. Fernald *et al.* (2017) assume that TFP reflects the actual exogenous state of technology. In this case, TFP determines the return on investment and thus capital intensity. On the other hand, an alternative interpretation of TFP considers it as the residual due to mismeasurement and other factors omitted from the growth accounting model. In the latter case, TFP growth reflects the productivity change due to investment that is not well-reflected in existing measurements.

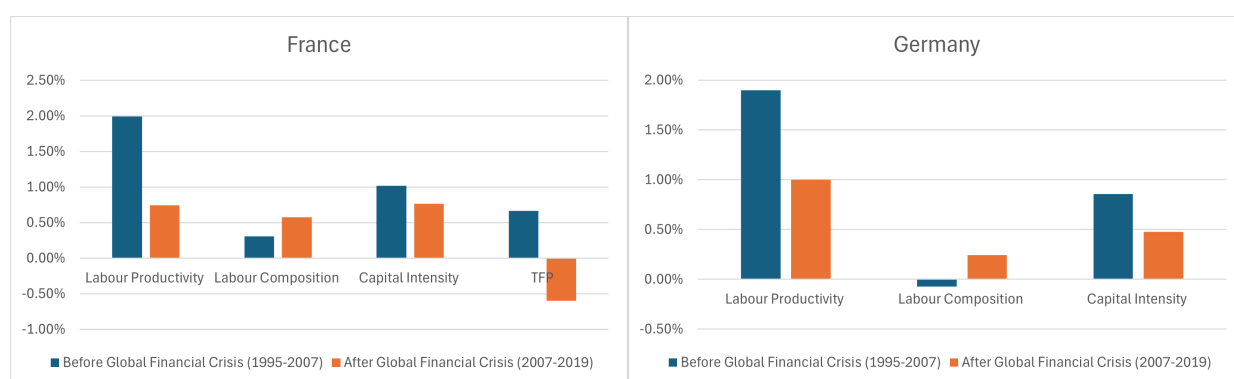
¹³ See Chart B2 in the online Appendix. We provide a more detailed comparison of different methods employed by each country for constructing labour input data in national accounts in Appendix A.

Chart 12: Growth Accounting Using an Alternative Decomposition Method

Panel A: United Kingdom and United States



Panel B: France and Germany



Source: EUKLEMS and INTANProd 2023 (Bontadini *et al.*, 2023). This implements the Fernald *et al.* (2017) approach.

lead to different rankings of relative labour productivity among countries in the earlier years. Second, we conduct growth accounting using alternative cut-off years for the pre-GFC and post-GFC periods in Appendix Table C13. Different choices of time frames have minimal impact on our main results. Third, we compare the double-deflated data from the Office for National Statistics (ONS) with the 2023 EUKLEMS data at the industry level. Although the United States and other European countries have long used double deflation for

the calculation of real GVA, the ONS in the United Kingdom only introduced this method in 2021. Double deflation has little impact on labour productivity growth at the aggregate level but leads to significant revisions in labour productivity growth at the industry level.¹⁴

Conclusion and Policy Implications

We have examined UK productivity compared to the United States, France and

¹⁴ Table A5 in the online Appendix presents a comparison of the industrial labour productivity growth rates using the ONS and EUKLEMS data, confirming their overall consistency.

Germany using the latest comparable data for the market economy (i.e. dropping the hard-to-measure, public sector-related industries). We focused on the dozen years before and after the financial crisis that began in 2007, ending just before the COVID pandemic (although our findings do not much change if we go forward to 2023 or back to 1979).

The United Kingdom has a productivity problem in terms of growth and levels. British productivity growth in the market economy fell by over two percentage points (from 2.5 per cent to 0.5 per cent a year) post-crisis compared to pre-crisis, and this slowdown was worse than in other countries. Although the slowdown in TFP growth was fairly similar across countries, the United Kingdom had a particularly large slowdown in capital intensity growth and (to a lesser extent) in skills growth. In 2019, the level of output per hour worked was much lower than United States and significantly lower than in Germany and France. Just about half of these gaps are due to lower tangible and intangible capital per hour worked.

The conclusions from both looking at UK productivity in a comparative perspective are clear. Apart from the common TFP issue across most countries, the United Kingdom has weak productivity because it has chosen to make fewer investments.

What are the policy options for raising productivity? Our finding that both low capital inputs and TFP explain the productivity, suggests that the main problem in the United Kingdom is not misallocation or inefficiency, but rather investments in the broadest sense (including intangible

investments). This is not to say that TFP-raising policies are unwelcome, but rather that attention may need to be focused on what is holding back investment.

We would point readers towards the Economy 2030 initiative (e.g. Brandily *et al.*, 2023) which builds on the work of the LSE Growth Commission (Aghion *et al.*, 2013). There are many practical recommendations, but we draw upon some broad themes.

First, the United Kingdom has indulged in a large number of policy mistakes, prevarications and reversals. The overly tough austerity of the early 2010s and the very hard Brexit in 2020 are two of the most obvious failures. Simply making fewer of these mistakes and having greater stability in policy would create a less uncertain environment for business investment. For example, keeping trade costs to Europe to a minimum through greater regulatory convergence.

Second, and related to the previous point, the United Kingdom lacks a credible Growth Plan and the institutions to deliver it. Having stronger institutions to promote growth in the heart of government to develop and deliver a long-term strategy based on Britain's comparative advantages (actual and latent) is vital (Valero and van Ark, 2023).

Third, create a better supply of finance for investment from Pension Funds. The United Kingdom stands out internationally by having low domestic investment from Pension Funds and a fragmented ownership base. Consolidating funds and changing regulations could increase business investment. Greater institutional involvement would also mean higher monitoring and en-

courage corporations to take a longer-term perspective (Aghion, Van Reenen and Zingales, 2013).

Fourth, higher education is a strong export industry in Britain (Costa *et al.*, 2023). But intermediate skills are weak for those who do not go to university. Reform of the system of Further Education, vocational and adult skills and apprenticeships could both raise skill levels and reduce inequality (Layard, McNally and Ventura, 2023).

Finally, it has long been recognized that the land-use planning system is not fit for purpose. It holds back development in some of our highest productivity clusters and industries, such a life sciences in the London-Cambridge-Oxford “golden triangle”.

Without a way of returning to productivity growth, there is little hope of sustainable increases in living standards or gaining political consent for a just transition to a green economy. Policies helped deliver better productivity growth in the past as we have shown from the pre-2007 period. We need to do this again in the future.

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DATA APPENDIX

Cracking the Productivity Code: An International Comparison of UK Productivity

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Xuji Yang (University of Cambridge and POID)

To main article in *International Productivity Monitor*

Vol. 46, pp. 63-86, Spring 2024

(https://csls.ca/ipm/46/IPM_46_Vanreenen.pdf)

DATA APPENDIX

A1. Hours Worked in National Accounts

In general, there are four common sources used to construct labour input data in national accounts: the labour force survey (LFS), the population census (PC), business statistics (BS), and administrative data sources. And there are two main approaches for estimating the total actual hours worked in national accounts:

- **Direct Method:** the direct method (DM) annualizes the average actual hours worked per week from continuous surveys in all weeks of the calendar year. The LFS is often used as the single source for this method, and the self-reported data in the LFS is assumed to capture absences and extra hours worked. Since there is a natural tendency to exaggerate how hard one works, the direct method overstates hours (see Ward, Zinni and Marianna (2018)).
- **Component Method:** the component method (CM) starts with estimating the contractual, paid, or usual hours per week from establishment surveys and administrative sources. It then adjusts for absences and overtime using various datasources such as the LFS.

Table A1—: National accounts labour input data sources and methods

Country	Method		Main Data Source		Secondary Data Source	
	Employee	Self-employed	Employee	Self-employed	Employee	Self-employed
UK	DM	DM	LFS	LFS	-	-
US	Ratio of worked to paid hours	DM	BS	LFS	LFS	-
France	CM	CM	BS	AS	LFS/AS	LFS
Germany	CM	CM	AS	LFS	LFS/BS	AS

Sources: Table 3.6 and Table 3.7 in Ward, Zinni and Marianna (2018)

Notes: AS—Administrative data sources, LFS — The labour force survey, BS - Business statistics.

Table A1 summarises the data sources and methods used in the national accounts across countries. Among all four, the UK is the only country that adopts DM and solely relies on the LFS as its data source. As a result, the working hours in the UK national accounts are likely to be overstated. Since working hours in the EUKLEMS data are sourced from national accounts, the EUKLEMS working hours in the UK are consistently overstated compared to other countries by around 7% as shown in Figure B2.

A2. Hours Worked from OECD

The OECD publishes average hours worked per person employed using a harmonised data construction method (e.g. OECD (2014)). In cases where countries do not utilize the component method to construct hours data in their national accounts, the OECD substitutes the hours data in national accounts with estimates derived from a simplified component method. To construct a time series of the harmonised hours data, the OECD uses the 2016 level of hours constructed by the component method as a benchmark, and extrapolates this level forwards and backwards using official hours series. As a result, the growth rates of hours worked remain largely unchanged when comparing hours data from the OECD and EUKLEMS.

The OECD hours data is only available for total economies. To obtain the hours data for market economies, we utilize the share of hours worked in the market economy relative to the total economy in EUKLEMS to project the OECD hours series for the market economy, as shown below:

$$(A1) \quad H_{OECD,Mkt} = H_{OECD,Tot} \times \frac{H_{KLEMS,Mkt}}{H_{KLEMS,Tot}}$$

Where *Tot* and *Mkt* refer to the total economy and market economy respectively. The total annual hours worked are denoted by *H*.

Since labour service is the weighted sum of hours worked adjusting for labour quality, the choice of hours series also affects labour service calculation, and thus labour composition. In this report, we assume that using either the direct method or the component method biases the estimates of hours worked across different types of workers in a broadly consistent way. That is labour composition at the national level is not affected by the choice of hours series.

A3. EU KLEMS 2012 and 2023 Releases

To analyse the performance of the UK and its peers (the US, France, and Germany) over a longer period, we merge the EUKLEMS releases of 2012 and 2023 using the method proposed by Fernald and Inklaar (2022). Specifically, we use the values in the earliest year available in KLEMS 2023 and extrapolate them using the 2012 time series. The extrapolation follows the equation provided below:

$$(A2) \quad \tilde{x}_{2023,t} = x_{2012,t} \times \frac{x_{2017,t}}{x_{2012,t}}$$

Where *t* represents the earliest year in which data are available in the 2023 EUKLEMS and *x* denotes the variable of interest. Equation A2 is generally used for extrapolation purposes, with a few exceptions in the German data. The labour

service and capital service volume indices in Germany are missing before 1991, and we rely on the growth rates of labour service and capital service in 2012 EUKLEMS for the extrapolation of the respective time series before 1991.

A4. Labour Composition

EUKLEMS 2023 estimates the share of hours worked and the share of labour compensation by worker type. In the labour accounts, the labour force is categorized along three dimensions—age, gender and educational attainment. For the UK, France and Germany, their labour force is divided into 18 types at the industry level, as illustrated in Table A2. However, for the US, labour types are classified differently based on Table A3. To ensure consistency with the labour accounts in the other three countries, we transform the US labour accounts data using Table A4. In situations where the age groups in the US labour accounts span across two standard age groups in Table A2, we assume a uniform distribution of the share of hours worked and labour compensation within each age group. Based on this assumption, the shares of hours worked and labour compensation of these US age groups can be split into sub-age groups for the transformation. Another caveat is that the US labour accounts data is available only for the total economy. Due to this data limitation, we assume that the labour composition is the same for both the market economy and the total economy in the US.

Labour service are defined as below:

$$(A3) \quad \log LabService_{j,t} = \sum_l v_{l,j,t} \log H_{l,j,t}$$

where $v_{l,j,t}$ denotes the nominal cost share of labour type l in industry j and year t , and $H_{l,j,t}$ are total hours worked by labour type l in industry j and year t .

Labour composition is then specified as

$$(A4) \quad \begin{aligned} \log LabComp_{j,t} &= \log LabService_{j,t} - \log H_{j,t} \\ &= \sum_l v_{l,j,t} \log H_{l,j,t} - \log H_{j,t} \end{aligned}$$

where $H_{j,t}$ is the total hours worked by all types of labour in the industry j and year t .

Table A2—: Standard EUKLEMS & INTANProd database labour types

Worker types					
Gender	Gender code	Age group	Age code	Educational Attainment	Education Code
Male	G1	15-29	A1	highly skilled	E1
Female	G2	30-49	A2	medium skilled	E2
		50+	A3	low-skilled	E3

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

Table A3—: EUKLEMS & INTANProd database labour types for the US

Worker types					
Gender	Gender code	Age group	Age code	Educational Attainment	Education Code
Male	G1	15 - 18	A11	Less than a high school diploma education group	E11
Female	G2	19 - 24	A12	A high school diploma (or GED) education group	E12
		25 - 34	A13	Some college education group	E13
		35 - 44	A14	A college degree education group	E14
		45 - 54	A15	More than a college degree education group	E15
		55 - 64	A16		
		65 +	A17		

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

Table A4—: Conversion of worker types in the US labour accounts

Standard age group	Standard age code	Corresponding US labour accounts age code
15-29	A1	$A_{11} + A_{12} + 0.5 \times A_{13}$
30-49	A2	$0.5 \times A_{13} + A_{14} + 0.5 \times A_{15}$
50+	A3	$0.5 \times A_{15} + A_{16} + A_{17}$
Standard educational attainment	Standard education code	Corresponding US labour accounts education code
highly skilled	E1	$E_{13} + E_{14} + E_{15}$
medium skilled	E2	E_{12}
low-skilled	E3	E_{11}

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

A5. *Alternative Labour Composition*

Barro and Lee (2013) only provide the average years of schooling for the total population between 15-64 every five years. However, the average education attainment varies between the total population and the workers. To overcome this issue, we transform BL's average years of schooling as below:

- For high skilled labour ($year_h$): Years of schooling of highly skilled workers = Total years of primary education + Total years of secondary education + Average years of education in the tertiary education reported by Barro and Lee (2013)
- For medium skill ($year_m$): Years of schooling of medium-skilled workers = Total years of primary education + Average years of schooling for secondary school by Barro and Lee (2013)
- For low skilled ($year_l$): Years of schooling of low skilled workers = Average years of schooling for primary education by Barro and Lee (2013)

And the average education years of all workers are calculated as below:

$$(A5) \quad year_{worker} = year_h \times share_h + year_m \times share_m + year_l \times share_l$$

Where $year_i$ denotes the transformed average years of schooling of workers with skill level i , and $share_i$ refers to the share of hours worked by skill level i over all types of workers from the EUKLEMS data.

Since BL's data is only available every five years, we take the most recent data in 2015 and extrapolate up to the year 2019 using the average growth rate of years of education between 2015 and 2010 from Barro and Lee (2013) as below:

$$(A6) \quad year_{2019} = year_{2015} * (1 + growth_{2010/2015} \times 4)$$

where $year_t$ is the average years of education in year t . $growth_{2010/2015}$ is the average growth rate of average years of education between 2010 and 2015 from Barro and Lee (2013) as below:

$$(A7) \quad growth_{2010/2015} = \left(\frac{year_{2015} - year_{2010}}{year_{2010}} - 1 \right) / 5$$

A6. Industrial Breakdown

In 2021, the ONS implemented double deflation in the calculation of GVA volume for the first time. Double deflation has a modest impact on aggregate GVA volume, but a much more significant impact at the sub-sector level. The output price deflator for telecommunications services, for instance, decreased substantially, which led to much higher productivity and output in the IC sector.

Table A5 compares the sector performance using EUKLEMS data (Panel A) and ONS data (Panel B). The ONS data shows the UK has a less significant decline (-0.9%) in the total economy than the EUKLEMS data (-1.44%). This is due to both slower productivity growth before the crisis and higher productivity growth after the crisis in the ONS data.

At the sector level, both panels (A and B) have the same top four contributors to the post-GFC productivity slowdown: manufacturing, information, finance, and professional services. Using either data source has a relatively small impact on the performance of the manufacturing, finance, and professional services sectors. However, the slowdown of the information sector in the ONS data (-3.1%) is about half of the slowdown in EUKLEMS data (-6.2%). This is mainly due to a much higher growth rate before 2007 in the ONS data (10.0%) than the EUKLEMS data (12.5%). This could be related to the introduction of a new price index for telecommunications by the ONS.

Table A5—: Breakdown of labour productivity growth by industry EUKLEMS vs. ONS data

PANEL A: EUKLEMS LABOUR GROWTH BY SECTOR 1997-2019														PANEL B: ONS LABOUR GROWTH BY SECTOR 1997-2019																	
Industry	Overall (1997-2019)				Pre-GFC (1997-2007)				Post-GFC (2007-2019)				Change		SIC07 code	Overall (1997-2019)				Pre-GFC (1997-2007)				Post-GFC (2007-2019)				Change			
	Within Growth	Weight	Weighted Growth	Share	Within Growth	Weight	Weighted Growth	Share	Within Growth	Weight	Weighted Growth	Share	Within Growth	Weight		Within Growth	Weight	Weighted Growth	Share	Within Growth	Weight	Weighted Growth	Share	Within Growth	Weight	Weighted Growth	Share	Within Growth	Weight	Weighted Growth	
Total Economy	1.12%	100.00%	1.12%	100.00%	1.94%	100.00%	1.94%	100.00%	0.51%	100.00%	0.51%	100.00%	-1.44%	0.00%		0.9%	100.0%	0.9%	100.0%	1.5%	100.0%	1.5%	100.0%	0.6%	100.0%	0.6%	100.0%	-0.9%	0.0%	-0.9%	
Agriculture	3.53%	0.78%	0.04%	3.38%	7.16%	0.85%	0.06%	3.14%	-0.25%	0.70%	0.00%	-0.34%	-7.41%	-0.15%		2.9%	0.8%	0.0%	3.4%	5.1%	0.8%	0.1%	3.6%	1.2%	0.0%	1.2%	-5.0%	-0.1%	0.0%	0.0%	
Mining	-5.65%	1.55%	-0.12%	-10.92%	-5.50%	1.78%	-0.10%	-5.03%	-5.83%	1.37%	-0.08%	-15.77%	-0.34%	-0.41%	0.02%		-5.1%	1.5%	-0.1%	-12.4%	-6.2%	1.8%	-0.1%	-8.2%	-5.3%	-0.1%	-22.3%	0.9%	-0.4%	0.0%	
Manufacturing	3.91%	11.80%	0.50%	44.52%	6.90%	13.47%	0.93%	47.81%	1.48%	10.30%	0.15%	29.99%	-5.42%	-3.17%	-0.78%		4.0%	11.6%	0.5%	54.5%	7.1%	13.2%	0.9%	63.3%	1.6%	10.3%	0.2%	30.6%	-5.5%	-2.9%	-0.8%
Energy supply	0.04%	1.44%	0.00%	-0.07%	1.86%	1.29%	0.02%	1.24%	-2.42%	1.57%	-0.04%	-7.48%	-4.29%	0.27%	-0.06%		-0.7%	1.4%	0.0%	-2.0%	2.0%	1.3%	0.0%	1.6%	-3.3%	1.6%	-0.1%	-10.4%	-5.3%	0.3%	-0.1%
Water supply and waste management	-2.34%	1.32%	-0.03%	-2.83%	-1.88%	1.31%	-0.02%	-1.27%	-2.87%	1.32%	-0.04%	-7.49%	-1.00%	0.01%	-0.01%		-2.4%	1.3%	0.0%	-3.6%	-1.3%	1.3%	0.0%	1.3%	-2.9%	1.3%	0.0%	-7.2%	-1.6%	0.0%	0.0%
Construction	-0.37%	5.90%	-0.03%	-2.67%	-0.96%	5.92%	-0.06%	-2.91%	-0.28%	5.94%	-0.02%	-3.22%	0.68%	0.02%	0.04%		-0.7%	6.0%	-0.1%	-5.7%	-2.0%	6.0%	-0.1%	5.9%	0.0%	5.9%	0.0%	-1.3%	2.0%	-0.1%	0.1%
Wholesale & retail	0.54%	11.02%	0.06%	5.04%	0.93%	11.64%	0.11%	5.55%	0.16%	10.50%	0.02%	3.39%	-0.76%	-1.14%	-0.09%		0.8%	11.0%	0.1%	9.4%	1.2%	11.6%	0.1%	9.1%	0.4%	10.5%	0.0%	7.4%	-0.8%	-1.1%	-0.1%
Transport	0.06%	4.17%	0.00%	0.43%	1.53%	4.33%	0.07%	3.41%	-0.76%	4.02%	-0.03%	-6.01%	-2.29%	-0.31%	-0.10%		1.3%	4.2%	0.0%	-2.0%	2.0%	1.3%	0.0%	1.6%	-3.3%	1.6%	-0.1%	-10.4%	-5.3%	0.3%	-0.1%
Food & accommodation	-0.43%	2.72%	-0.01%	-1.08%	-0.29%	2.67%	-0.01%	-0.40%	-0.81%	2.77%	-0.02%	-4.41%	-0.52%	0.09%	-0.01%		-0.4%	2.7%	0.0%	-1.1%	1.1%	2.7%	0.0%	2.8%	0.0%	2.8%	0.0%	-1.8%	-0.1%	0.1%	0.0%
Information & communication	8.89%	6.13%	0.54%	48.59%	12.47%	5.99%	0.75%	38.44%	6.23%	6.25%	0.39%	76.72%	-6.25%	0.26%	-0.36%		8.1%	6.2%	0.5%	55.2%	10.0%	6.1%	0.6%	41.8%	6.9%	0.4%	78.3%	-3.1%	0.2%	-0.2%	0.0%
Finance & insurance	1.53%	8.04%	0.12%	10.38%	4.23%	7.29%	0.31%	15.88%	0.68%	8.74%	0.06%	11.76%	-3.55%	1.45%	-0.25%		1.5%	8.0%	0.1%	10.3%	3.9%	7.2%	0.3%	12.9%	0.0%	12.9%	0.0%	-6.7%	3.2%	-0.7%	0.4%
Real estate	-1.76%	13.28%	-0.24%	-21.31%	-4.44%	13.69%	-0.61%	-31.25%	-0.66%	12.90%	0.00%	-0.35%	-4.42%	-0.79%	0.61%		-1.4%	13.2%	-0.2%	-21.0%	-3.5%	13.6%	-0.5%	-31.5%	-0.2%	12.9%	0.0%	-6.7%	3.2%	-0.7%	0.4%
Professional & scientific services	0.21%	6.63%	0.01%	0.93%	1.16%	6.08%	0.07%	3.61%	-0.66%	7.10%	-0.05%	-9.28%	-1.82%	1.03%	-0.12%		0.2%	6.6%	0.0%	0.9%	1.1%	6.0%	0.0%	7.1%	0.0%	7.1%	0.0%	-1.9%	2.2%	0.9%	-0.1%
Administrative and support service	0.13%	4.27%	0.01%	0.93%	-1.23%	3.92%	-0.05%	-2.48%	1.22%	4.56%	0.06%	10.99%	2.45%	0.64%	0.10%		0.1%	4.2%	0.0%	-0.9%	0.9%	4.2%	-0.07%	-0.07%	-0.07%	-0.07%	-13.15%	-1.45%	1.21%	-0.10%	
Public administration	1.60%	5.15%	0.08%	7.35%	0.57%	5.16%	0.03%	1.50%	2.29%	5.15%	0.12%	23.27%	1.73%	-0.01%	0.09%		1.6%	5.1%	0.0%	-7.63%	-2.88%	5.45%	-0.16%	-8.08%	-0.32%	6.14%	-0.02%	-3.82%	2.57%	0.68%	0.14%
Education	-1.47%	5.82%	-0.09%	-7.63%	-2.88%	5.45%	-0.16%	-8.08%	-0.32%	6.14%	-0.02%	-3.82%	-2.57%	0.68%	0.14%		-1.4%	5.8%	-0.0%	-0.09%	0.0%	5.8%	0.0%	6.1%	0.0%	6.1%	0.0%	-3.1%	2.4%	0.1%	0.0%
Health	-0.31%	1.37%	0.00%	-0.34%	1.56%	1.29%	0.02%	1.03%	-2.08%	1.43%	-0.03%	-5.86%	-3.63%	0.14%	-0.05%		-0.3%	1.3%	0.0%	-0.34%	1.5%	1.2%	0.0%	1.4%	-0.0%	1.4%	-0.0%	-1.8%	-0.1%	0.1%	0.0%
Art and entertainment	-1.02%	1.59%	-0.01%	-1.30%	-2.39%	1.49%	-0.04%	-1.84%	0.00%	1.67%	0.00%	-0.01%	2.39%	0.17%	0.04%		-1.0%	1.5%	-0.0%	-1.30%	-2.3%	1.4%	-0.0%	1.4%	0.0%	1.4%	0.0%	-1.8%	-0.1%	0.1%	0.0%
Other service	2.11%	0.16%	0.01%	0.46%	-3.45%	0.16%	-0.01%	-0.28%	5.03%	0.15%	0.01%	1.52%	8.49%	0.00%	0.01%		2.1%	0.1%	0.0%	0.4%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	2.39%	0.2%	0.0%	0.0%
Household activities																															

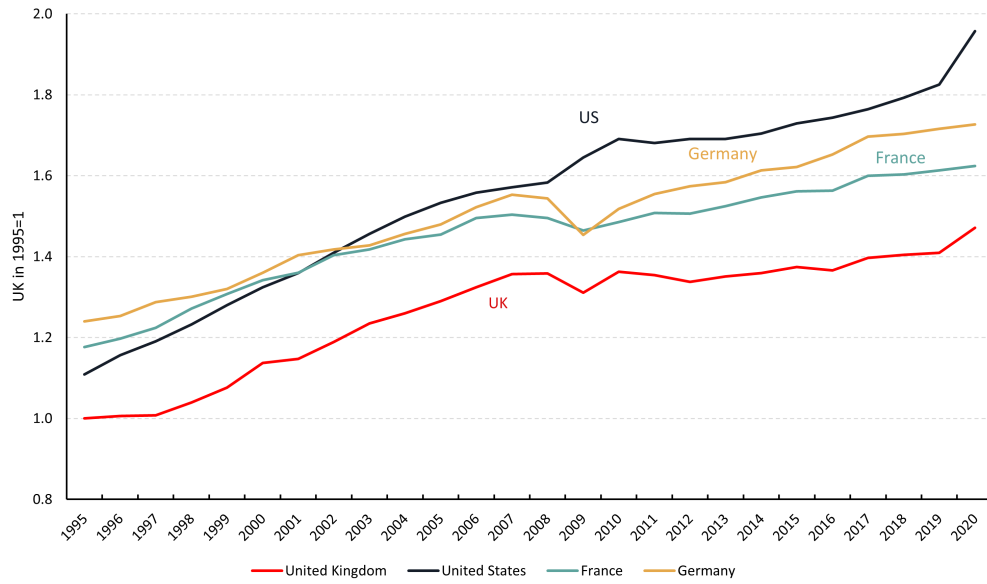
Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023), Blue Books (ONS, 2022).

FURTHER RESULTS

B1. Productivity Level Decomposition

In section IV, we decompose the productivity gap into weighted level differences in factor inputs and TFP. The share contributed by each factor input to the overall productivity gap is contingent upon both its cost share (weight) and its absolute level. In this section, we present the unweighted factor input level differences and conduct further decomposition of the capital intensity gap based on distinct capital asset classes. Figure B3 illustrates the unweighted relative levels of factor inputs. Notably, the UK's capital intensity gap is the largest when compared to Germany, while its skill gap is most pronounced when compared to the US. However, when we take into account broader intangibles in Figure B5, both the capital and labour composition gaps between the UK and the US stand out as the largest across all countries. This is mainly due to that the US is more intangible intensive than the EU countries. Figure B4 offers a detailed decomposition of the total capital intensity, distinguishing tangible from intangible capital. The UK marginally outperformed the US in terms of tangible capital intensity, yet significantly lagged behind the US in terms of intangible capital. Furthermore, the UK's performance in both tangible and intangible capital was worse than the other EU countries. Similar results are observed in Figure B6, which include broader intangibles.

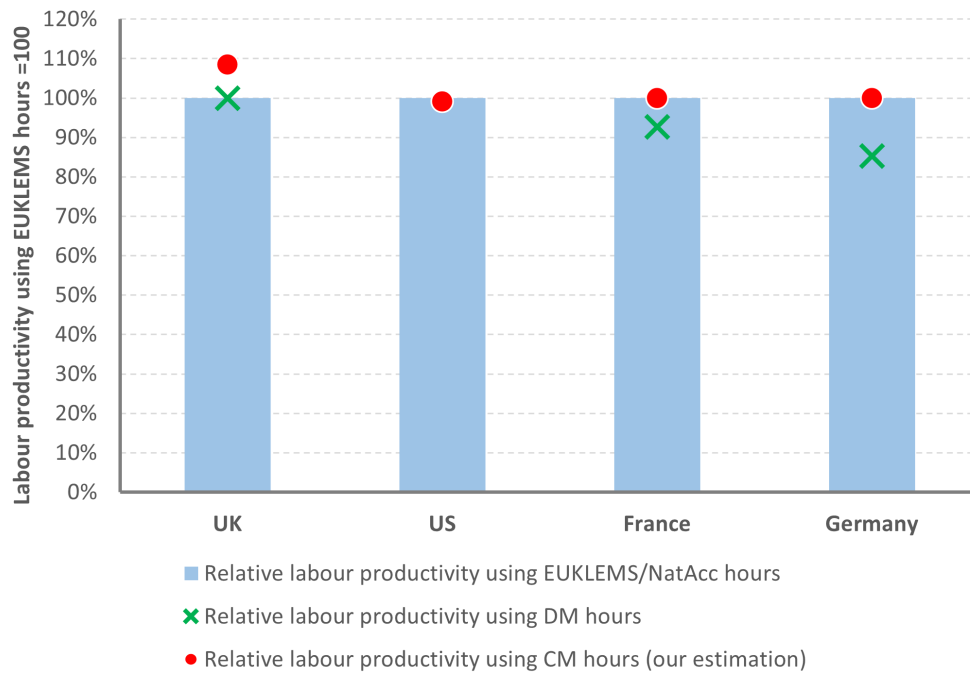
Figure B1. : Labour productivity, 1995-2019, SNA market economy



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); OECD productivity statistics (OECD, 2014); PPP (OECD, 2023c).

Note: Capital intensity and labour composition gaps are the absolute level differences. See Table C5 for level accounting results. Because of data availability in EUKLEMS, unweighted labour composition is assumed to be the same for market and non-market sectors in the US. See the data appendix for further details.

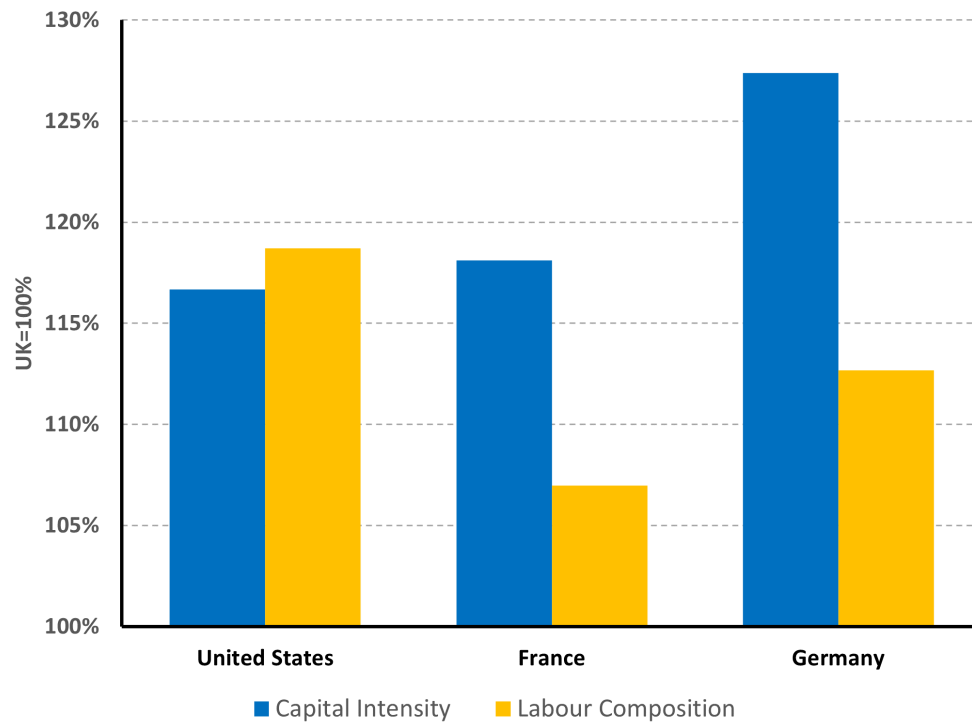
Figure B2. : Comparison of labour productivity constructed by different working hours data, SNA market economy



Sources: Euklems & INTANProd 2023 (Bontadini et al., 2023); OECD productivity statistics (OECD, 2014).

Notes: Relative labour productivity is averaged from 1997 to 2019. Working hours data in Euklems are sourced from national accounts. DM working hours are missing in the US. CM hours data in the UK and US are estimated using the simplified component method by OECD, as they are not available through NSIs.

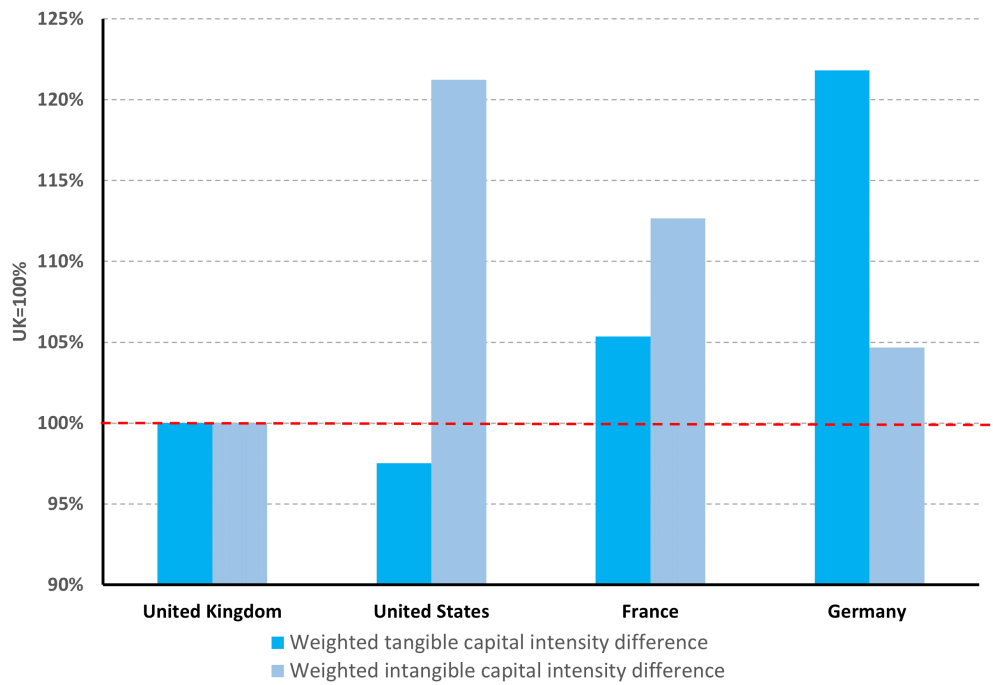
Figure B3. : Unweighted level of factor inputs relative to the UK, SNA market economy, 2019



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); OECD productivity statistics (OECD, 2014); PPP (OECD, 2023c).

Notes: Capital intensity and labour composition gaps are the absolute level differences. See Table C5 for level accounting results. Because of data availability in EUKLEMS, unweighted labour composition is assumed to be the same for market and non-market sectors in the US. See the data appendix for further details.

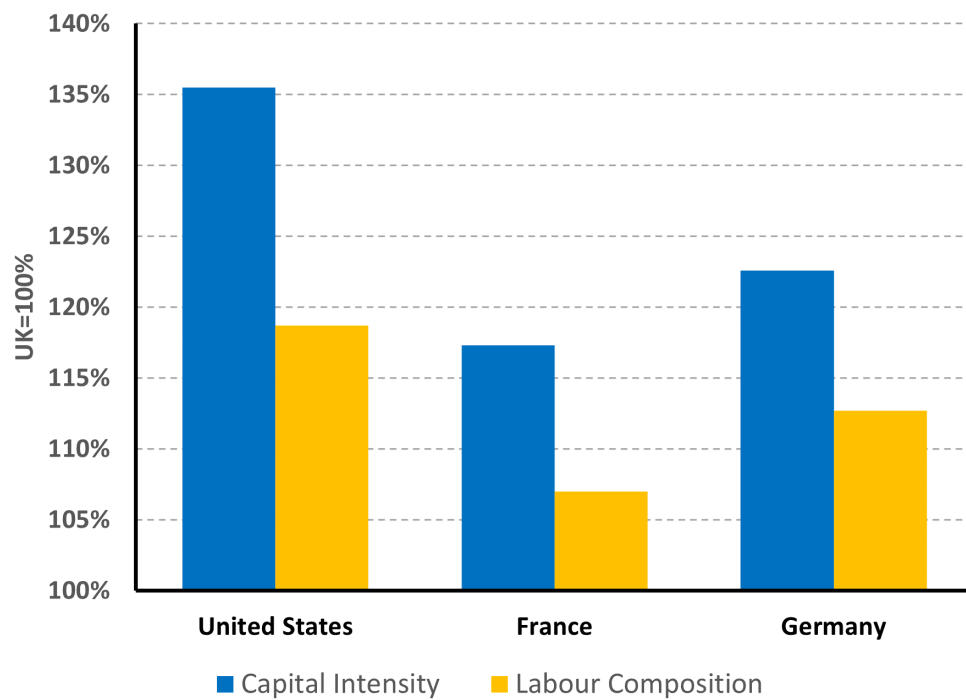
Figure B4. : Weighted breakdown of differences in capital intensity level, SNA market economy, 2019



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); OECD productivity statistics (OECD, 2014); PPP (OECD, 2023c)

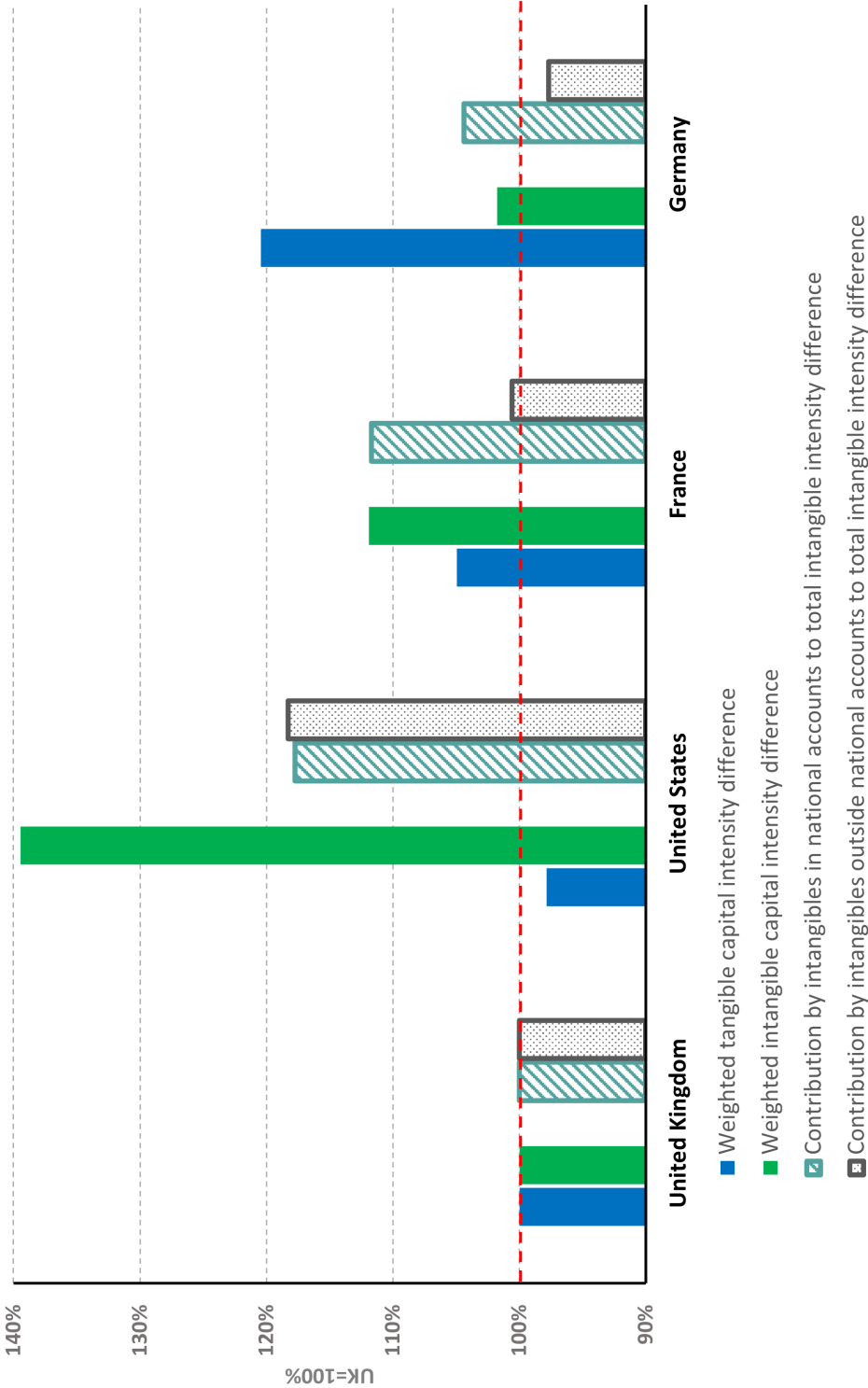
Notes: Tangible and intangible capital intensities are weighted by their shares over total capital assets. The product of weighted tangible and intangible capital intensity differences is the total capital intensity difference in Figure B3.

Figure B5. : Unweighted level of factor inputs relative to the UK, CHS market economy, 2019



Sources & notes: See sources and notes in Figure B3. See Table C5 for decomposition estimates

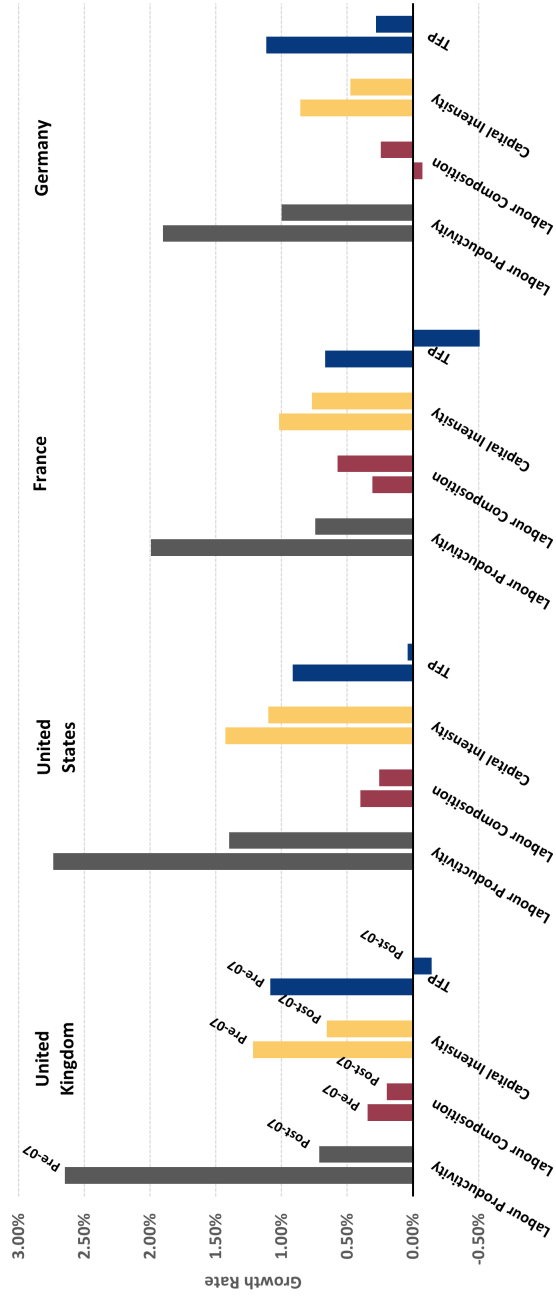
Figure B6. : Weighted breakdown of differences in capital intensity level, CHS market economy, 2019



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); OECD productivity statistics (OECD, 2014); PPP (OECD, 2023c)

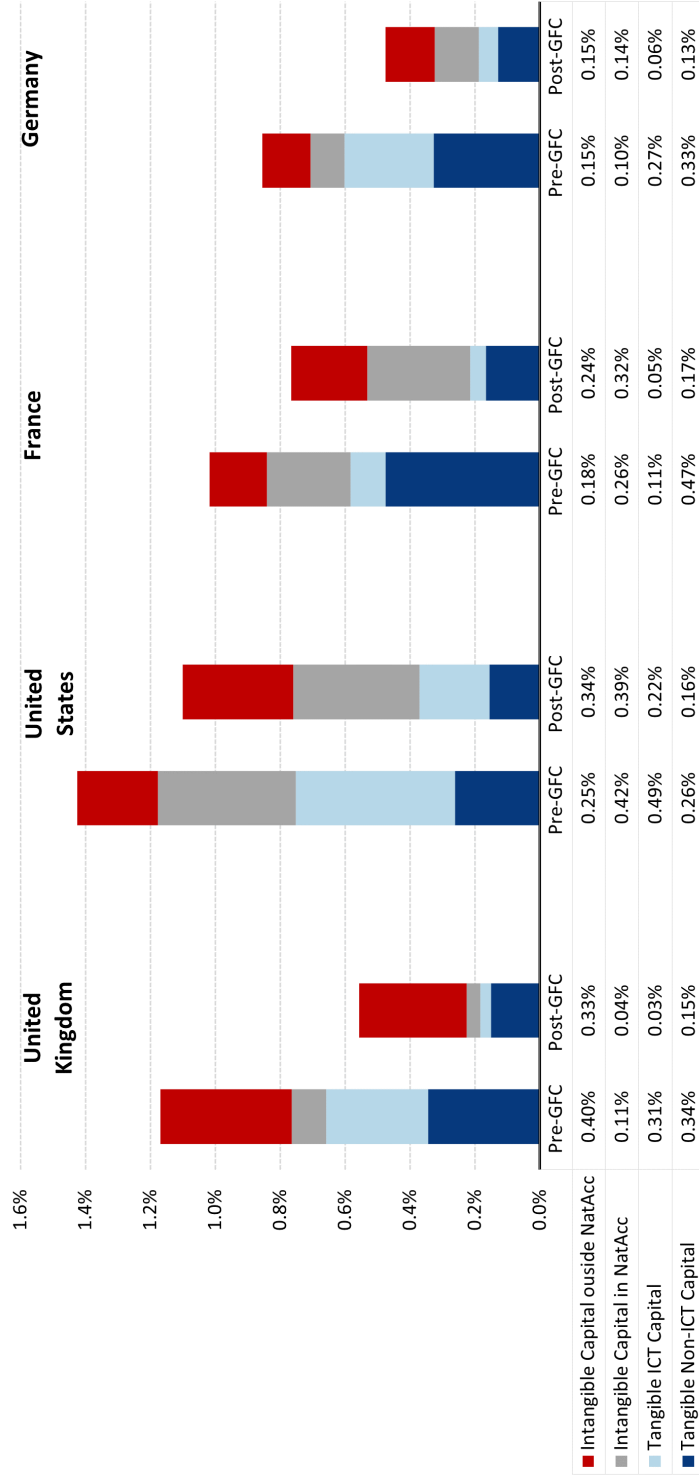
Notes: Tangible capital intensity and intangible capital intensity are weighted by their shares over total capital stock. The product of weighted tangible and intangible capital intensity differences is the total capital intensity difference in Figure B5. Contributions by intangibles in and outside national accounts are weighted by their shares over total intangible capital stock. The product of the contribution by intangibles in and outside national accounts is the weighted intangible capital differences.

Figure B7. : Growth accounting before and after the GFC, CHS market economy



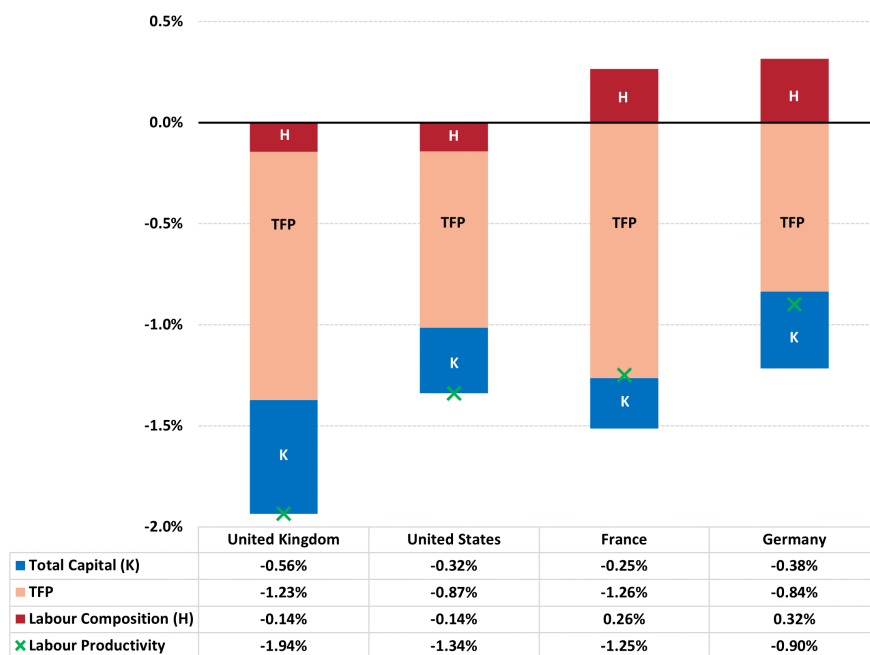
Sources & notes: See Figure 1 for data sources and table notes. See Table C12 for growth accounting results.

Figure B8. : Contribution of capital deepening to labour productivity growth before and after the GFC, CHS market economy



Source & note: See Figure 1 for data sources and table notes.

Figure B9. : Decomposition of the slowdown in labour productivity growth after the GFC, CHS market economy



Sources & notes: See Figure 1 for data sources and table notes.

B2. Looking Back Further in Time

We have focused on productivity performance since the mid-1990s. Bergeaud et al. (2016) look at trends across our four countries since 1870 (see Figure B10). Germany and the US first overtook the UK before WW1, and by the mid-1970s a clear gap of around 20% emerged. However, in the decade leading up to the financial crisis, the UK was closing its gap with other European countries and keeping pace with the US.

As noted in the data section, we can splice earlier versions of EUKLEMS in order to obtain a consistent series since 1979 as in Fernald and Inklaar (2022).¹³ Table B1 shows our growth accounting exercise from Equation 3 over the four decades between 1979 and 2019, dividing it into the Conservative years (1979-1997 under Prime Ministers Thatcher and Major) and (as before), pre-GFC years (1997-2007) and post-GFC years (2007-2019).

During the 1979-97 years, UK productivity growth outstripped that of the US and Germany, but was lower than France. The Anglo-Saxon countries both had the fastest rates of productivity growth in the 1997-2007 period, and this was an acceleration compared to 1979-1997.

Table B1—: Labour productivity growth accounting, 1979-2019

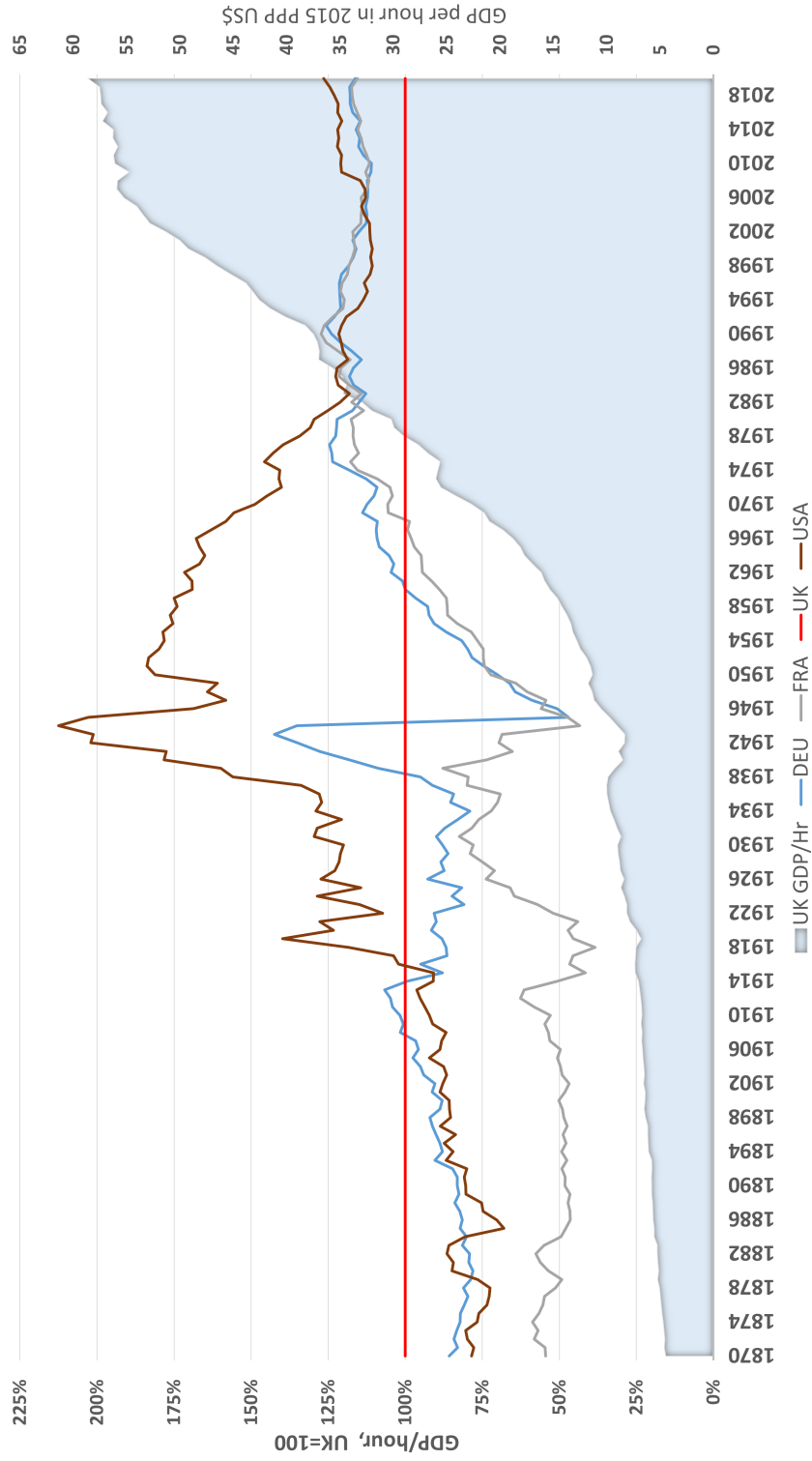
Market Economy Growth Rates	UK	US	France	Germany
2007-2019				
Labour Productivity	0.48%	1.21%	0.58%	0.92%
Labour Composition	0.23%	0.29%	0.65%	0.26%
Capital Intensity	0.20%	0.73%	0.27%	0.23%
TFP	0.06%	0.20%	-0.33%	0.43%
1997-2007				
Labour Productivity	2.72%	2.80%	2.07%	1.95%
Labour Composition	0.41%	0.44%	0.27%	-0.05%
Capital Intensity	0.87%	1.09%	0.42%	0.48%
TFP	1.43%	1.27%	1.38%	1.53%
1979-1997				
Labour Productivity	2.20%	1.67%	2.87%	1.69%
Labour Composition	0.18%	0.05%	0.75%	-0.09%
Capital Intensity	1.39%	1.04%	0.71%	1.26%
TFP	0.64%	0.58%	1.40%	0.52%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); EUKLEMS & INTANProd 2012 (O'Mahony and Timmer, 2009); OECD productivity statistics (OECD, 2014).

Notes: EUKLEMS & INTANProd 2023 is merged with EUKLEMS 2012. See Appendix A for further details. Growth accounting starts in 1991 for Germany and 1980 for France due to data availability issues.

¹³Additional details regarding the data merging process are provided in Appendix A.

Figure B10. : Long-term labour productivity level relative to the UK, total economy, 1870-2018



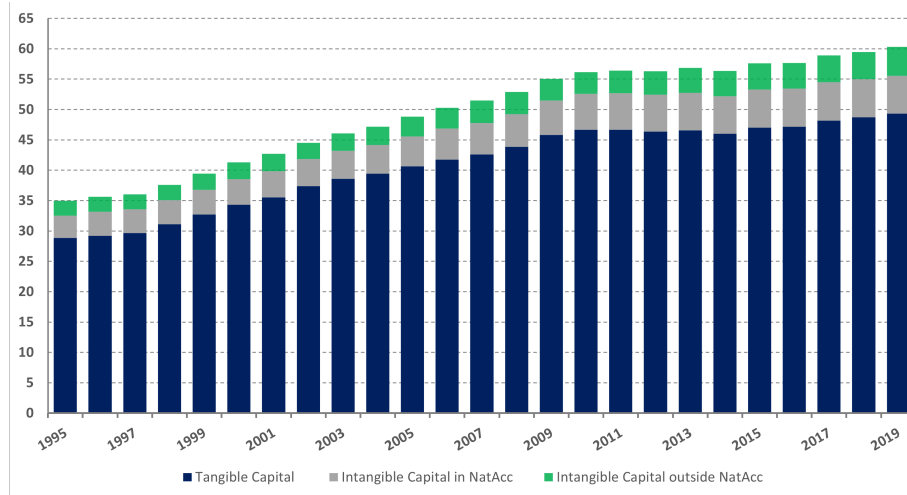
Sources: Long-Term Productivity Database (Bergeaud, Cetto and Lecat, 2016)

Notes: GDP per hour (represented by each line) is relative to the UK level, and the UK's relative GDP per hour is 100%. The shaded area is the UK's real GDP level in 2015 PPP US\$.

B3. Capital Intensity Growth in the UK

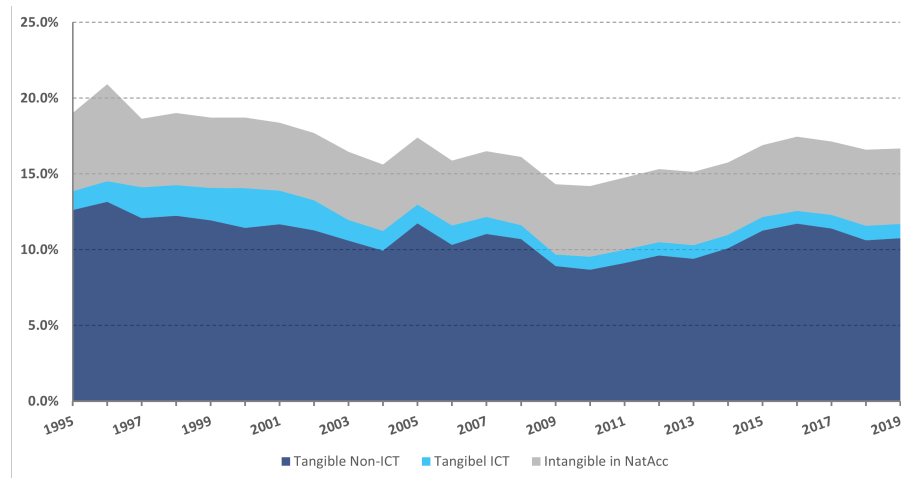
As noted above, besides TFP, the slowdown in capital deepening is a key contributor to the UK's declining productivity growth after the GFC. In Figure B11, we observe that the tangible capital stock per hour was rising before 2007, and has become stagnant since then. Intangible capital stock per hour, however, has been rising steadily throughout both periods. This pattern of capital stock per hour worked aligns with the investment trend shown in Figure B13. Over time, the share of GVA invested in tangible capital has declined, but the share invested in intangibles has remained robust. An interesting feature of the graph is that the size of investment in intangibles outside national accounts is twice as large as the investment in intangibles reported in national accounts.

Figure B11. : UK's real capital intensity level, CHS market economy



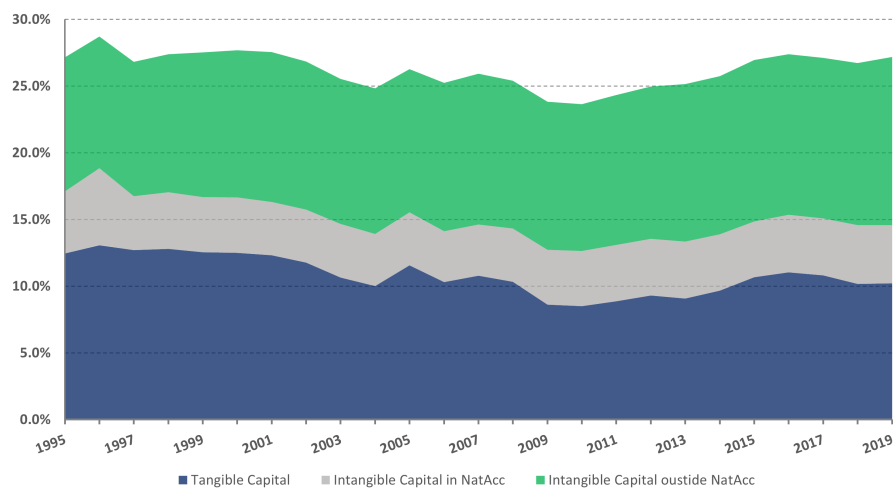
Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

Figure B12. : Investment as a share of UK's GDP, SNA market economy



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

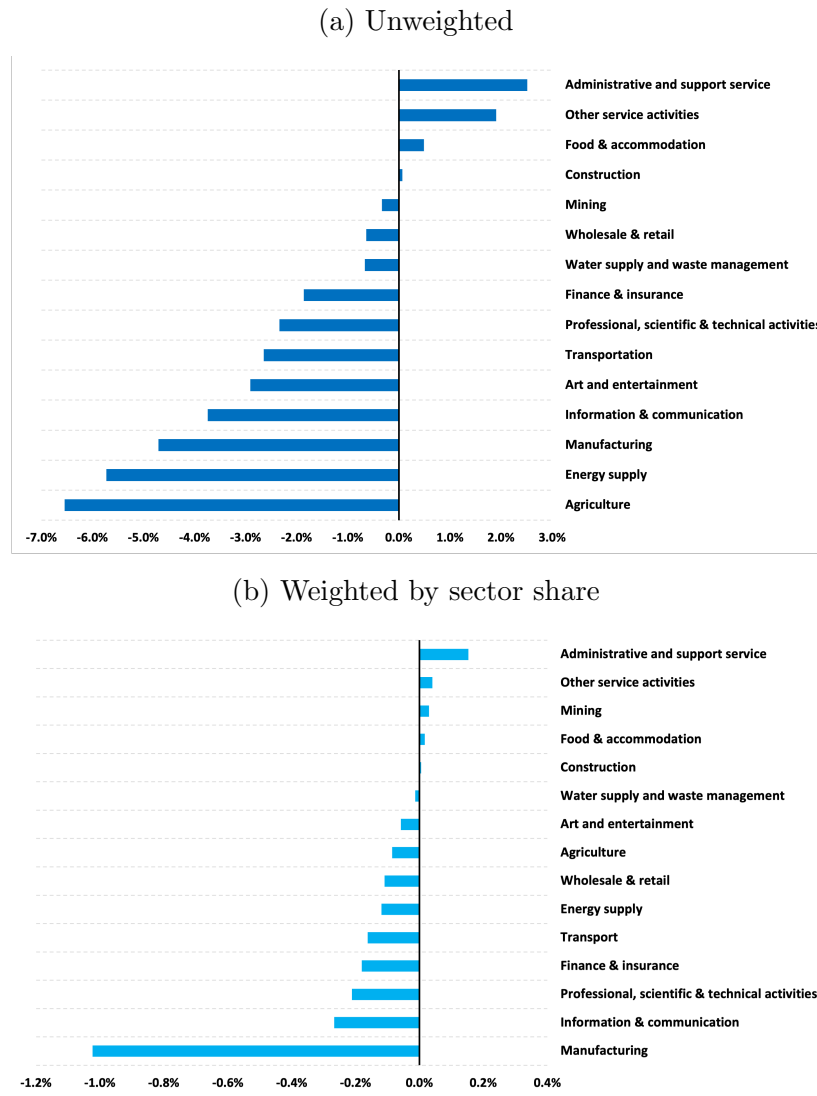
Figure B13. : Investment as a share of UK's GDP, CHS market economy



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

B4. UK Labour Productivity Performance by Sector

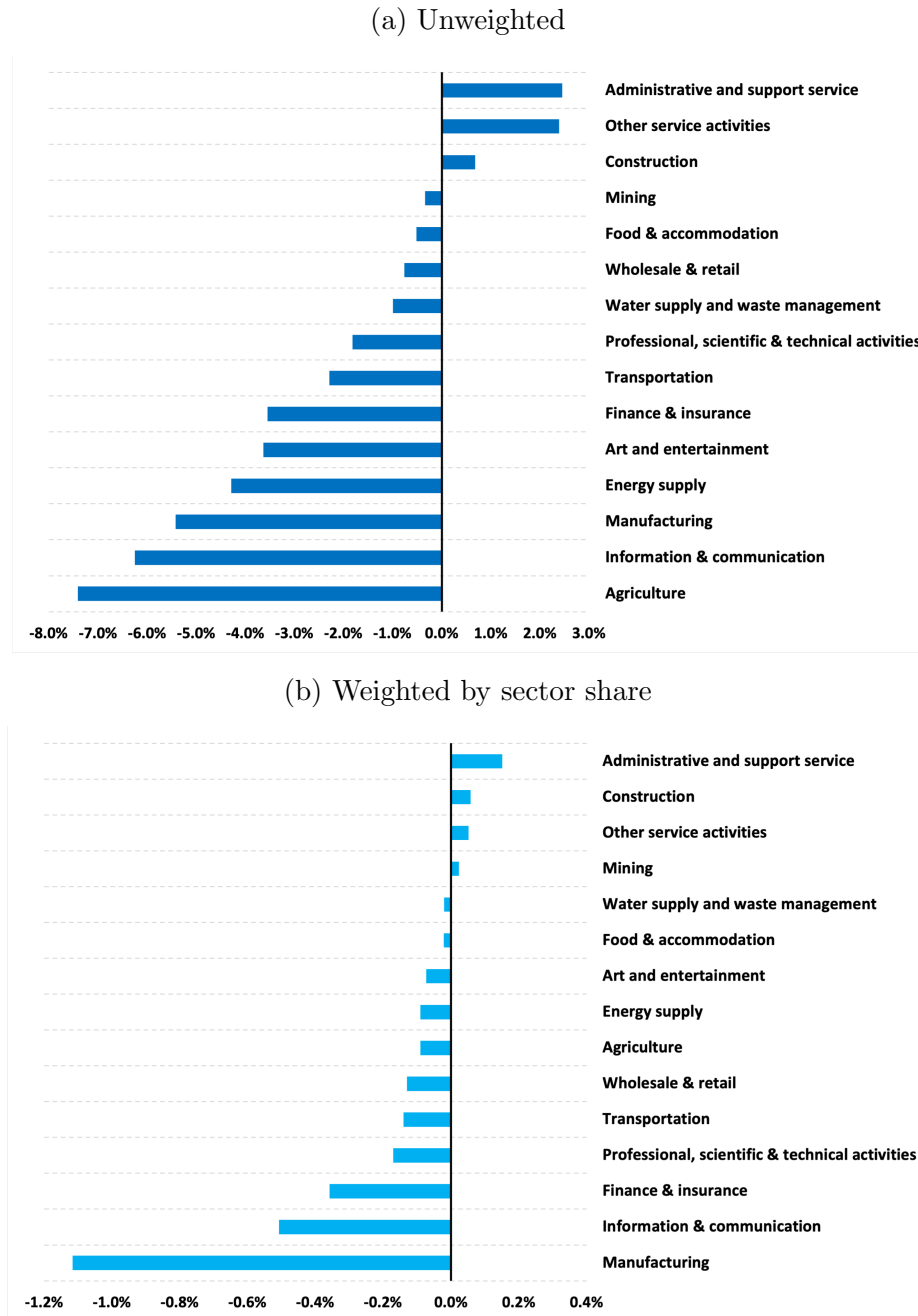
Figure B14. : Productivity slowdown after the GFC across sectors, SNA market economy



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

Notes: The productivity slowdown is the change in average labour productivity growth rates between 1995-2007 and 2007-2019. Panel (a) is the unweighted productivity slowdown by sector in the market economy. Panel (b) is the sectoral slowdown in productivity growth weighted by the output share of each sector.

Figure B15. : Productivity slowdown across sectors, 1997-2007 vs 2007-2019, SNA market economy

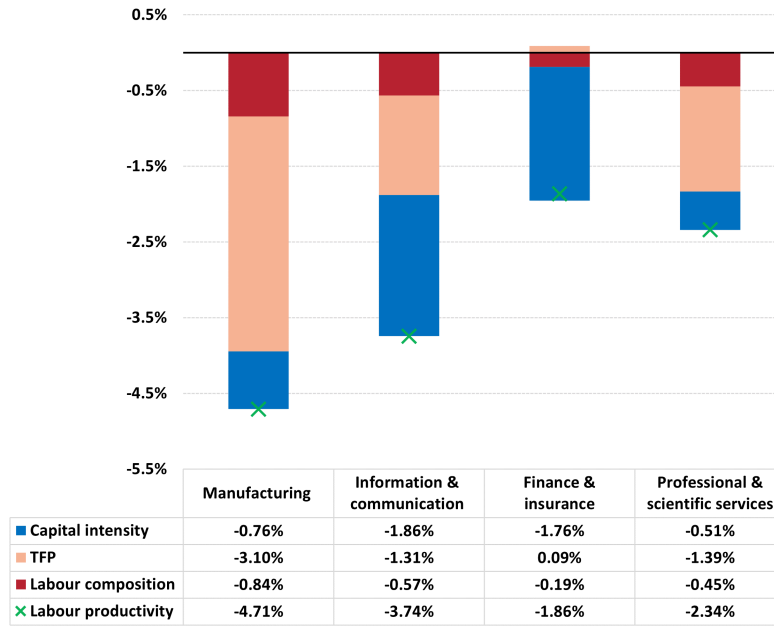


Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

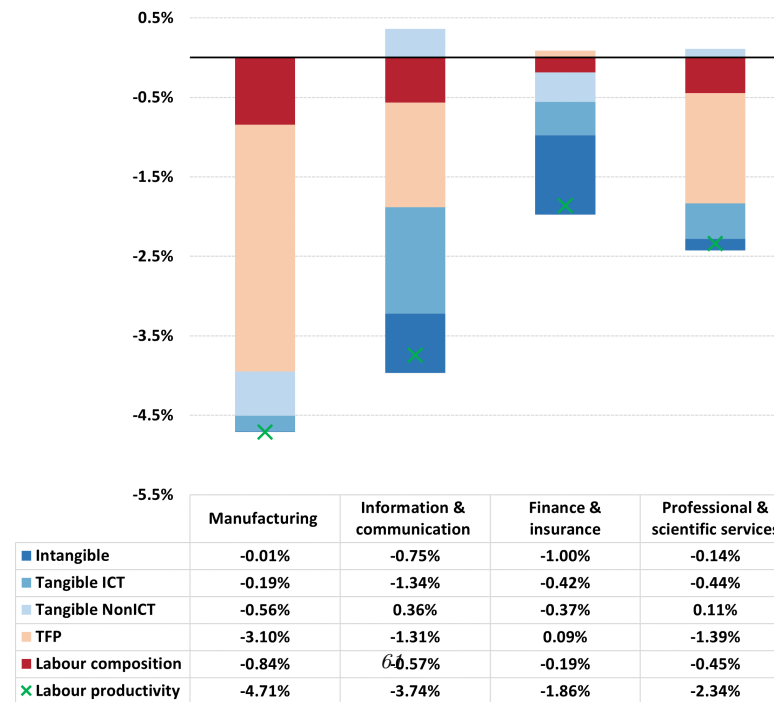
Notes: The productivity slowdown is the change in average labour productivity growth rates between 1997-2007 and 2007-2019. Panel (a) is the unweighted productivity slowdown by sector in the market economy. Panel (b) is the sectoral slowdown in productivity growth weighted by the output share of each sector.

Figure B16. : Decomposition of slowdown by sector after the GFC, SNA market economy

(a) Decomposition by factor inputs and TFP

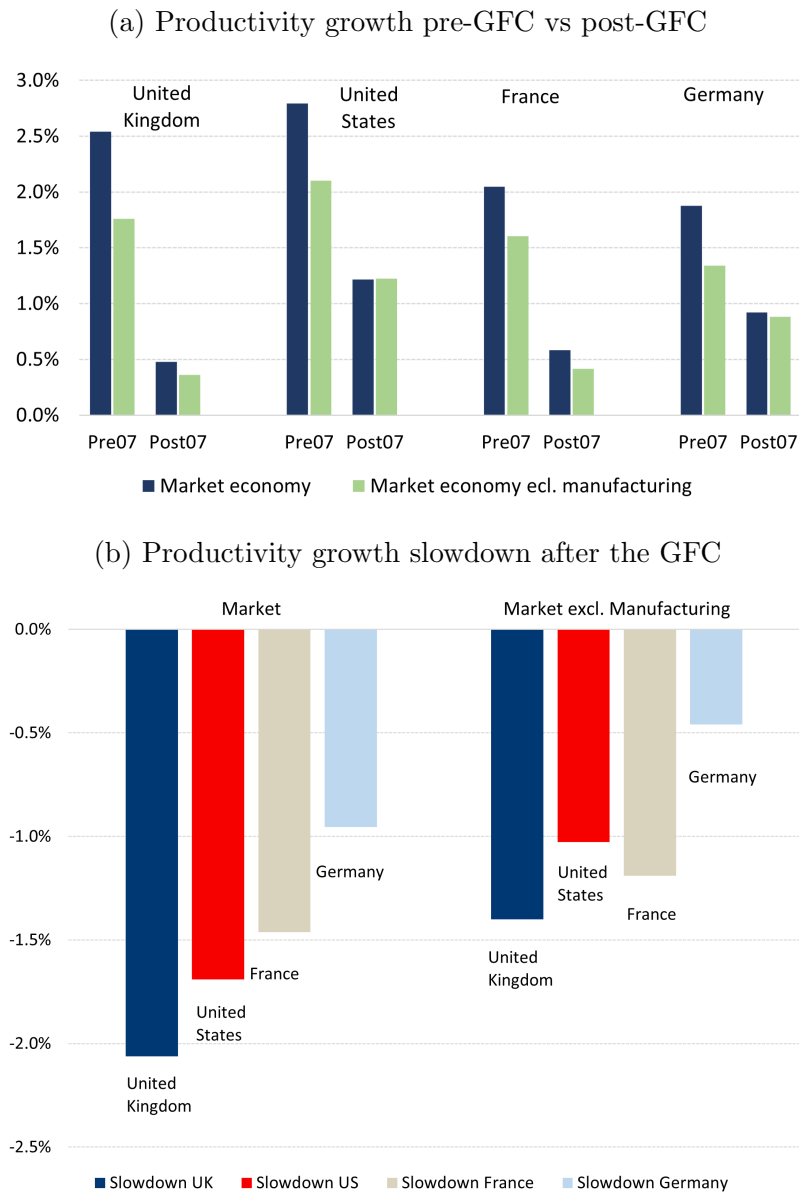


(b) Decomposition by different capital assets



Sources & notes: See Figure 2 for data sources and figure notes.

Figure B17. : Labour productivity growth, SNA market economy vs. market economy excluding manufacturing



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023).

Notes: Pre-GFC period is from 1995 to 2007, and the post-GFC period is from 2007-2019. The productivity slowdown is the change in average labour productivity growth rates from the pre-GFC to the post-GFC period.

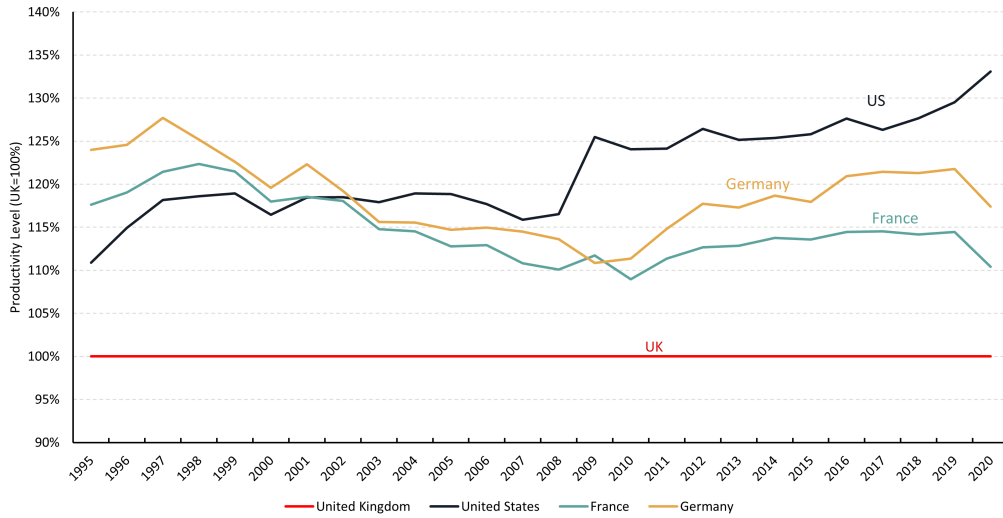
B5. Purchasing Power Parity Series

In section IV, our estimates of productivity gaps are based on input and output volume measures in 2015 price index and subsequently converted into international dollars using the 2015 PPP series. In essence, a single year, namely 2015 in our study, needs to be selected for the comparison of productivity levels. All subsequent productivity levels are derived by applying relative rates of productivity growth, consistent with those derived in national currencies. This method is commonly referred to as the ‘constant purchasing power parities (PPPs)’ approach. One key advantage of this approach is that it allows for both cross-country and over-time comparison. However, PPPs and price indexes may exhibit inconsistency over time due to changes in weighting and product sampling (Fernald, Inklaar and Ruzic, 2023). Moreover, estimations derived through this approach are contingent upon the relative productivity levels in the base year. An alternative method uses the current PPPs, i.e. a new set of PPPs for each period, which allows for variation in prices and price structure across time periods. While cross-country comparison in a given year is straightforward, the current PPPs approach presents more challenges when interpreting changes over time (OECD, 2019).

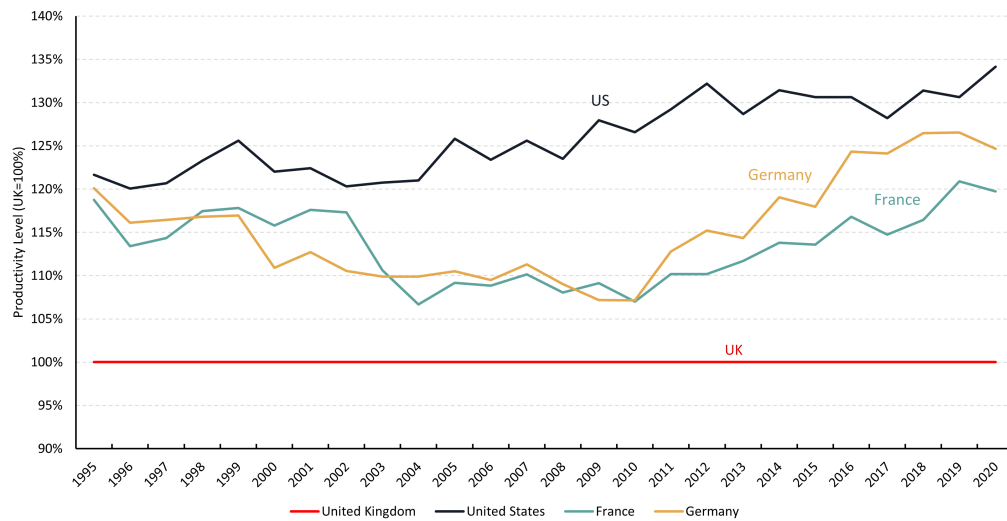
To illustrate the implications of these two approaches on our levels analysis, we conduct productivity level decomposition in section IV, employing both the current PPPs approach and the constant PPPs approach, as outlined in Table B2. For productivity and TFP levels, the use of the current PPPs approach results in a 5pp larger gap for France and Germany, but has a negligible impact on the gap for the US. For relative capital intensity levels, both approaches lead to very similar estimates across all three countries. In general, our main conclusions remain robust to both approaches.

Figure B18. : Labour productivity gap UK=100%, constant PPP vs. current-year PPP, SNA market economy

(a) Constant PPP (2015 PPP)



(b) Current-year PPP



Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c).

Table B2—: Productivity level decomposition by constant PPPs approach vs. current PPPs approach, SNA market economy, 2019

(a) 2015 constant PPPs and prices

2015 constant PPPs and prices	United Kingdom	United States	France	Germany
Productivity	100.00%	129.52%	114.46%	121.77%
Labour composition	100.00%	112.23%	105.03%	108.88%
Capital intensity	100.00%	105.18%	104.66%	107.21%
TFP	100.00%	109.72%	104.13%	104.31%

(b) Current PPPs and prices

Current PPPs and prices	United Kingdom	United States	France	Germany
Productivity	100.00%	130.63%	120.90%	126.54%
Labour composition	100.00%	112.23%	105.03%	108.88%
Capital intensity	100.00%	103.49%	105.18%	107.86%
TFP	100.00%	112.47%	109.44%	107.75%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); EUKLEMS & INTANProd 2012 (O'Mahony and Timmer, 2009); OECD productivity statistics (OECD, 2014).

Notes: Levels in (a) are in 2015 constant prices and converted to international dollars using 2015 PPP series, which is identical to results in Table C4. Levels in (b) are in current prices and converted to international dollars using the current PPP series (i.e. 2019 PPP series).

B6. Comparison with Other Productivity Estimates

The Groningen Growth and Development Centre (GGDC) Productivity Level database (Inklaar and Timmer, 2008) offers estimates of comparative labour productivity, factor inputs and TFP levels across countries. We compare our level decomposition results in Table B3 with Inklaar and Timmer (2008)'s decomposition results in Table B4. Both sets of estimates show similar productivity and TFP gaps between the UK and France. However, the UK's labour productivity gaps with the US and Germany (120.6% and 116.5%) are significantly lower compared to the GGDC productivity estimates (147.4% and 132.3%). Similarly, the UK's TFP gaps with the US and Germany are almost 20pp and 30pp lower in our estimates. The divergence between our estimates and GGDC estimates stems from five differences in data sources and methodologies.

To understand the impact of each source on the estimate of productivity gaps, we systematically adjust for the differences in data and methodology one by one in Table B5. First, our analysis employs harmonised working hours data from the OECD to ensure consistency in measurement across countries, while Inklaar and Timmer (2008) relied on the working hours in national accounts for their estimates. Therefore, we start the adjustment by replacing the OECD hours data in our analysis with hours data in national accounts in Table B5 (a). The use of national accounts hours increases UK's productivity gaps by around 10pp and TFP gaps by around 5pp with all countries.

Second, Inklaar and Timmer (2008) constructed their own PPP series for the year 1997, whereas we rely on the PPP series by OECD (2023b). In panel (b), we

adjust our analysis from (a) by using the same PPP series as the GGDC database. Inklaar and Timmer (2008)’s PPP series leads to a 7pp larger productivity gap with the US. However, the UK’s gap with EU countries decreases by about 7pp.

Third, national accounts data and methodology undergo revisions over time. Since Inklaar and Timmer published the GGDC estimates 15 years ago, the raw data in national accounts have undergone significant changes. To account for this difference, we use the raw levels of GVA and working hours in the GGDC database in panel (c). The change in raw data accounts for about 10pp of the differences in productivity gap compared to panel (b).

Fourth, Inklaar and Timmer (2008) and our study independently construct labour composition measures. To address discrepancies in the measurement of labour composition, we replace our measures with those provided by Inklaar and Timmer (2008) in panel (d). This substitution results in marginally larger productivity gaps between the UK and the US and France. Notably, the skills gap with Germany undergoes a substantial reduction of 13pp, consequently contributing to a proportional increase in the TFP gap.

Lastly, the capital intensity measures in the GGDC database encompass only tangible capital, whereas our original analysis incorporates both tangible and intangible capital as outlined in national accounts. In Panel (e), we only include tangible capital to align with the definition of capital in the GGDC database. The exclusion of intangible capital slightly increases the UK’s TFP gap with its peers. Following the adjustments for these methodological and data source disparities, our analysis ultimately produces a TFP gap similar to the estimates presented by Inklaar and Timmer (2008).

In conclusion, among all sources of divergence, three stand out—incorporation of harmonised working hours data, revision of national accounts data, and inclusion of intangible— as clear improvements in data measurement, highlighting the robustness of our analysis. Yet, it remains challenging to determine which of the PPP series and labour composition measures are better choices. The findings in Table B5 affirm the overall consistency of our approach with Inklaar and Timmer (2008)’s estimates, and underscore the sensitivity of productivity gaps to data choices.

Table B3—: 1997 Relative labour productivity level by our analysis

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	120.7%	114.4%	116.4%
Labour composition	100.0%	107.5%	102.2%	116.3%
Capital intensity	100.0%	108.2%	102.0%	115.9%
TFP	100.0%	103.8%	109.7%	86.4%

Sources: EUKLEMS & INTANProd (Bontadini et al., 2023); PPP (OECD, 2023b).

Notes: Results in this table are based on our analysis using Equation 2. Labour productivity is measured at the SNA market economy level, with values in each cell benchmarked against the UK's level. GVA and factor input levels in each cell are in current prices (i.e. 1997 prices) and then converted to international dollars using the current PPP series (i.e. 1997 OECD PPP series).

Table B4—: 1997 Relative labour productivity level by Inklaar and Timmer (2008)

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	147.4%	115.8%	132.3%
Labour composition	100.0%	113.5%	108.4%	105.5%
Capital intensity	100.0%	133.6%	120.7%	141.1%
TFP	100.0%	123.2%	103.1%	114.4%

Sources & notes: : Results in this table are recalculations based on the appendix tables by Inklaar and Timmer (2008). Labour productivity is measured at the SNA market economy level, with values in each cell benchmarked against the UK's level. Labour productivity is defined as the double-deflated gross value added per hour worked (LP_VADD as per Inklaar and Timmer (2008)'s appendix tables), labour composition represents labour input per hour worked (LAB_QPH), capital intensity represents capital input per hour worked (CAP_QPH), and TFP represents double-deflated multifactor productivity (MFP_VADD).

Table B5—: Analysis on the differences in data sources

(a) Adjusting for the difference in working hours data

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	129.6%	122.9%	125.2%
Labour composition	100.0%	107.5%	102.2%	116.3%
Capital intensity	100.0%	110.8%	104.3%	118.5%
TFP	100.0%	108.8%	115.3%	90.8%

(b) Adjusting for the difference in PPP series

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	136.7%	106.6%	118.6%
Labour composition	100.0%	107.5%	102.2%	116.3%
Capital intensity	100.0%	116.1%	99.3%	117.0%
TFP	100.0%	109.6%	105.0%	87.2%

(c) Adjusting for changes in national accounts data

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	147.4%	115.8%	132.3%
Labour composition	100.0%	107.9%	102.3%	117.5%
Capital intensity	100.0%	115.6%	99.7%	119.7%
TFP	100.0%	118.2%	113.5%	94.1%

(d) Adjusting for difference in labour composition measures

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	147.4%	115.8%	132.3%
Labour composition	100.0%	109.3%	106.2%	104.1%
Capital intensity	100.0%	115.6%	99.7%	119.7%
TFP	100.0%	116.6%	109.4%	106.2%

(e) Adjusting for difference in capital definition

	United Kingdom	United States	France	Germany
Labour productivity	100.0%	147.4%	115.8%	132.3%
Labour composition	100.0%	109.3%	106.2%	104.1%
Capital intensity	100.0%	111.5%	97.9%	118.6%
TFP	100.0%	120.9%	111.3%	107.2%

Sources: EUKLEMS & INTANProd,(Bontadini et al., 2023); The appendix tables by Inklaar and Timmer (2008)

Notes: Results in this table are based on our analysis using Equation 2. Labour productivity is measured at the SNA market economy level, with values in each cell benchmarked against the UK's level.

APPENDIX: TABLES

Table C1—: Relative labour productivity level after adjusting for factor inputs, SNA market economy

	United Kingdom	United States	France	Germany
1997 level				
Productivity	100.0%	118.2%	121.4%	127.7%
Productivity after adjusting for capital	100.0%	112.0%	118.7%	111.4%
Productivity after adjusting for capital and skills (TFP)	100.0%	109.6%	122.1%	106.3%
2007 level				
Productivity	100.0%	115.9%	110.8%	114.5%
Productivity after adjusting for capital	100.0%	111.9%	108.9%	104.2%
Productivity after adjusting for capital and skills (TFP)	100.0%	108.4%	112.7%	103.5%
2017 level				
Productivity	100.0%	126.3%	114.5%	121.4%
Productivity after adjusting for capital	100.0%	120.4%	109.6%	113.2%
Productivity after adjusting for capital and skills (TFP)	100.0%	117.2%	109.6%	112.5%
2018 level				
Productivity	100.0%	127.6%	114.2%	121.3%
Productivity after adjusting for capital	100.0%	121.6%	109.3%	113.3%
Productivity after adjusting for capital and skills (TFP)	100.0%	118.5%	108.6%	112.9%
2019 level				
Productivity	100.0%	129.5%	114.5%	121.8%
Productivity after adjusting for capital	100.0%	123.1%	109.3%	113.5%
Productivity after adjusting for capital and skills (TFP)	100.0%	120.5%	108.6%	113.8%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c).

Notes: Levels in each cell are relative to the UK's level. Productivity level is measured in 2015 constant prices and converted to international dollars using the constant 2015 PPP series. The adjusted productivity in the second and third rows of each panel accounts for the relative level differences in factor inputs. "Capital" refers to capital intensity (i.e. capital stock per hour). Capital intensity and labour composition levels are estimated by level accounting based on Equation 2. See Table C3 for level accounting results.

Table C2—: Labour productivity level decomposition, CHS market economy

	United Kingdom	United States	France	Germany
1997 level				
Productivity	100.0%	119.1%	122.6%	123.1%
Productivity after adjusting for capital in NatAcc	100.0%	111.3%	122.0%	123.1%
Productivity after adjusting for capital in NatAcc and broader intangibles	100.0%	105.1%	118.6%	105.8%
Productivity after adjusting for skills and capital	100.0%	103.1%	121.6%	101.3%
2007 level				
Productivity	100.0%	114.5%	109.9%	109.1%
Productivity after adjusting for capital in NatAcc	100.0%	108.5%	110.2%	109.8%
Productivity after adjusting for capital in NatAcc and broader intangibles	100.0%	103.9%	107.6%	99.0%
Productivity after adjusting for skills and capital	100.0%	101.0%	110.9%	98.4%
2017 level				
Productivity	100.0%	125.0%	114.4%	115.1%
Productivity after adjusting for capital in NatAcc	100.0%	118.3%	114.6%	115.9%
Productivity after adjusting for capital in NatAcc and broader intangibles	100.0%	111.3%	108.1%	107.0%
Productivity after adjusting for skills and capital	100.0%	108.7%	108.1%	106.4%
2018 level				
Productivity	100.0%	126.3%	114.0%	114.7%
Productivity after adjusting for capital in NatAcc	100.0%	119.3%	114.2%	115.6%
Productivity after adjusting for capital in NatAcc and broader intangibles	100.0%	112.2%	107.7%	106.8%
Productivity after adjusting for skills and capital	100.0%	109.7%	107.1%	106.6%
2019 level				
Productivity	100.0%	127.6%	113.3%	114.5%
Productivity after adjusting for capital in NatAcc	100.0%	120.5%	113.7%	115.5%
Productivity after adjusting for capital in NatAcc and broader intangibles	100.0%	113.0%	107.0%	106.5%
Productivity after adjusting for skills and capital	100.0%	110.9%	106.3%	106.8%

Sources & notes: “Capital in NatAcc” refers to the tangible and intangible capital within the SNA boundary. “Broader intangibles” refer to intangible capital not included in national accounts but included in the CHS assets boundary. See ?? for data sources and additional notes. See Table C4 for level accounting results using CHS framework.

Table C3—: Labour productivity level decomposition, SNA market economy

	United Kingdom	United States	France	Germany
1997 level				
Productivity	100.0%	118.2%	121.4%	127.7%
Labour composition	100.0%	102.1%	97.3%	104.9%
TFP	100.0%	109.6%	122.1%	106.3%
Capital intensity	100.0%	105.5%	102.3%	114.6%
<i>Tangible capital intensity</i>	100.0%	102.5%	100.9%	113.4%
<i>Intangible capital intensity</i>	100.0%	103.1%	101.5%	101.0%
2007 level				
Productivity	100.0%	115.9%	110.8%	114.5%
Labour composition	100.0%	103.2%	96.7%	100.7%
TFP	100.0%	108.4%	112.7%	103.5%
Capital intensity	100.0%	103.5%	101.7%	109.9%
<i>Tangible capital intensity</i>	100.0%	99.3%	99.9%	108.7%
<i>Intangible capital intensity</i>	100.0%	105.0%	102.1%	101.0%
2017 level				
Productivity	100.0%	126.3%	114.5%	121.4%
Labour composition	100.0%	102.8%	100.0%	100.7%
TFP	100.0%	117.2%	109.6%	112.5%
Capital intensity	100.0%	104.9%	104.4%	107.3%
<i>Tangible capital intensity</i>	100.0%	99.4%	101.6%	106.0%
<i>Intangible capital intensity</i>	100.0%	106.7%	103.2%	101.2%
2018 level				
Productivity	100.0%	127.6%	114.2%	121.3%
Labour composition	100.0%	102.6%	100.7%	100.3%
TFP	100.0%	118.5%	108.6%	112.9%
Capital intensity	100.0%	105.0%	104.4%	107.1%
<i>Tangible capital intensity</i>	100.0%	99.2%	101.4%	105.7%
<i>Intangible capital intensity</i>	100.0%	107.1%	103.5%	101.4%
2019 level				
Productivity	100.0%	129.5%	114.5%	121.8%
Labour composition	100.0%	102.2%	100.7%	99.7%
TFP	100.0%	120.5%	108.6%	113.8%
Capital intensity	100.0%	105.2%	104.7%	107.2%
<i>Tangible capital intensity</i>	100.0%	99.2%	101.4%	105.7%
<i>Intangible capital intensity</i>	100.0%	107.5%	103.9%	101.6%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c).

Notes: Decomposition follows Equation 2, and the relative levels of labour and capital inputs are weighted by their respective cost shares.

AN INTERNATIONAL COMPARISON OF UK PRODUCTIVITY

Table C4—: Labour productivity level decomposition, CHS market economy

	United Kingdom	United States	France	Germany
1997 level				
Productivity	100.0%	119.1%	122.6%	123.1%
Labour composition	100.0%	101.9%	97.5%	104.5%
TFP	100.0%	103.1%	121.6%	101.3%
Capital intensity	100.0%	113.3%	103.4%	116.3%
<i>Tangible capital intensity</i>	100.0%	102.6%	101.0%	115.0%
<i>Intangible capital intensity</i>	100.0%	111.2%	102.8%	100.8%
<i>Intangible capital intensity in national accounts</i>	100.0%	103.2%	101.9%	101.2%
<i>Intangible capital intensity outside national accounts</i>	100.0%	108.0%	100.9%	99.5%
2007 level				
Productivity	100.0%	114.5%	109.9%	109.1%
Labour composition	100.0%	102.9%	97.0%	100.7%
TFP	100.0%	101.0%	110.9%	98.4%
Capital intensity	100.0%	110.2%	102.2%	110.2%
<i>Tangible capital intensity</i>	100.0%	99.3%	99.9%	109.6%
<i>Intangible capital intensity</i>	100.0%	112.8%	102.7%	100.2%
<i>Intangible capital intensity in national accounts</i>	100.0%	105.1%	102.5%	101.1%
<i>Intangible capital intensity outside national accounts</i>	100.0%	107.3%	100.2%	99.0%
2017 level				
Productivity	100.0%	125.0%	114.4%	115.1%
Labour composition	100.0%	102.5%	100.0%	100.6%
TFP	100.0%	108.7%	108.1%	106.4%
Capital intensity	100.0%	112.3%	105.8%	107.5%
<i>Tangible capital intensity</i>	100.0%	99.4%	102.0%	106.8%
<i>Intangible capital intensity</i>	100.0%	115.0%	104.3%	100.5%
<i>Intangible capital intensity in national accounts</i>	100.0%	106.9%	103.9%	101.4%
<i>Intangible capital intensity outside national accounts</i>	100.0%	107.5%	100.4%	99.1%
2018 level				
Productivity	100.0%	126.3%	114.0%	114.7%
Labour composition	100.0%	102.3%	100.6%	100.3%
TFP	100.0%	109.7%	107.1%	106.6%
Capital intensity	100.0%	112.6%	105.8%	107.4%
<i>Tangible capital intensity</i>	100.0%	99.2%	101.8%	106.5%
<i>Intangible capital intensity</i>	100.0%	115.4%	104.5%	100.6%
<i>Intangible capital intensity in national accounts</i>	100.0%	107.2%	104.2%	101.5%
<i>Intangible capital intensity outside national accounts</i>	100.0%	107.7%	100.4%	99.1%
2019 level				
Productivity	100.0%	127.6%	113.3%	114.5%
Labour composition	100.0%	101.9%	100.6%	99.8%
TFP	100.0%	110.9%	106.3%	106.8%
Capital intensity	100.0%	113.0%	105.9%	107.5%
<i>Tangible capital intensity</i>	100.0%	99.2%	101.7%	106.6%
<i>Intangible capital intensity</i>	100.0%	115.7%	104.6%	100.7%
<i>Intangible capital intensity in national accounts</i>	100.0%	107.5%	104.5%	101.8%
<i>Intangible capital intensity outside national accounts</i>	100.0%	107.5%	100.2%	99.0%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c).

Notes: Intangible capital in national accounts refers to intangible assets within the SNA boundary. Intangible capital outside national accounts refers to intangible assets that are not included in national accounts but are covered within the CHS asset boundary.

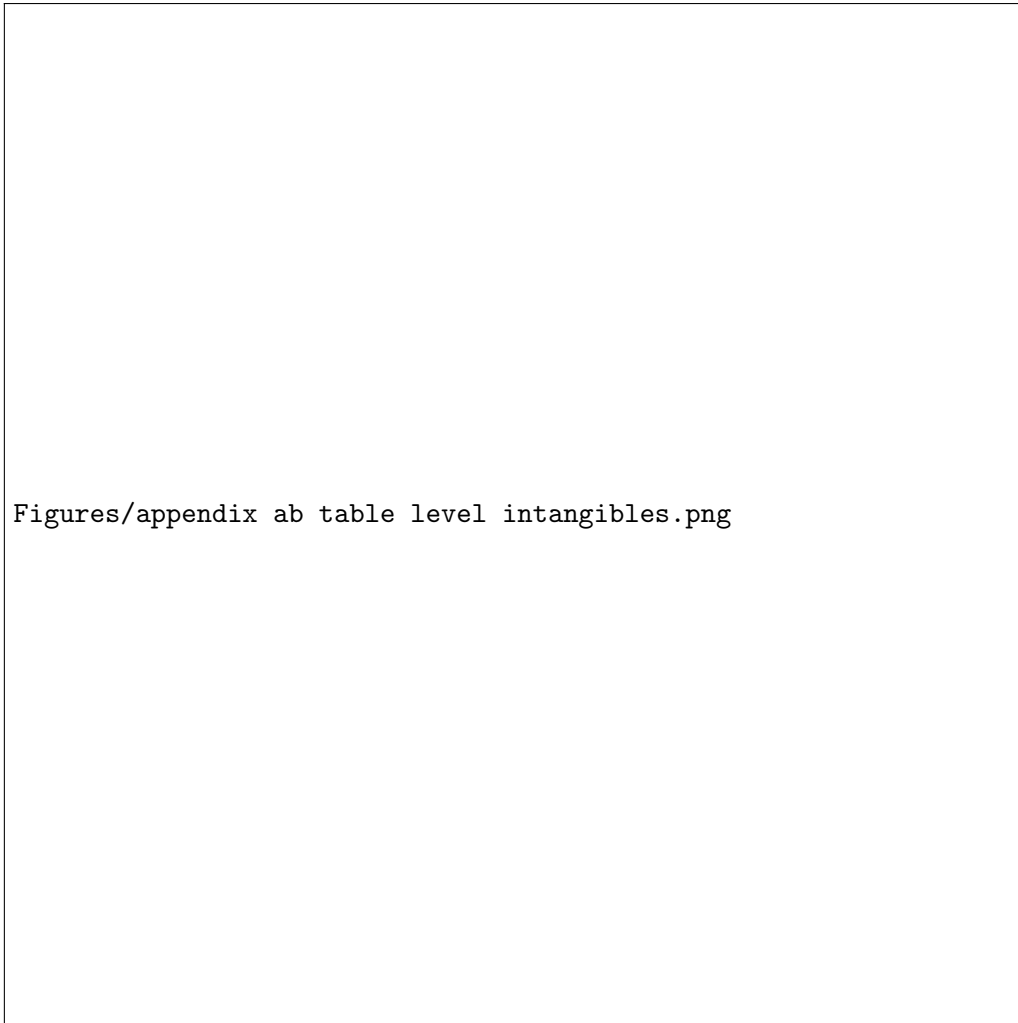
Table C5—: Unweighted relative level of factor inputs, SNA market economy

	United Kingdom	United States	France	Germany
1997 Level				
Labour composition	100.0%	111.4%	103.1%	124.3%
Capital intensity	100.0%	119.1%	108.4%	162.6%
<i>Tangible capital intensity</i>	100.0%	108.5%	103.2%	156.6%
<i>Intangible capital intensity</i>	100.0%	110.1%	105.9%	103.6%
2007 Level				
Labour composition	100.0%	114.6%	102.2%	117.5%
Capital intensity	100.0%	111.4%	106.1%	135.0%
<i>Tangible capital intensity</i>	100.0%	97.9%	99.7%	131.2%
<i>Intangible capital intensity</i>	100.0%	114.6%	106.9%	102.9%
2017 Level				
Labour composition	100.0%	119.3%	106.2%	115.1%
Capital intensity	100.0%	115.7%	118.0%	126.8%
<i>Tangible capital intensity</i>	100.0%	98.2%	106.5%	122.2%
<i>Intangible capital intensity</i>	100.0%	120.0%	111.7%	103.8%
2018 Level				
Labour composition	100.0%	119.1%	105.9%	114.0%
Capital intensity	100.0%	115.9%	117.9%	126.5%
<i>Tangible capital intensity</i>	100.0%	97.7%	105.7%	121.6%
<i>Intangible capital intensity</i>	100.0%	120.5%	112.2%	104.2%
2019 Level				
Labour composition	100.0%	118.7%	107.0%	112.7%
Capital intensity	100.0%	116.7%	118.1%	127.4%
<i>Tangible capital intensity</i>	100.0%	97.5%	105.4%	121.8%
<i>Intangible capital intensity</i>	100.0%	121.2%	112.7%	104.7%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c).

Notes: Labour composition and capital intensity are the absolute levels relative to the UK, which are not weighted by labour or capital shares. The relative levels of tangible and intangible capital intensity are weighted by the share of each type of capital over the total capital stock.

Table C6—: Unweighted relative level of factor inputs, CHS market economy



Sources & notes: Intangible capital in NatAcc refers to intangible assets within the SNA boundary. Intangible capital outside NatAcc refers to intangible assets that are not included in national accounts but are covered within the CHS asset boundary. For more data sources and table notes, see Table C5.

Table C7—: Relative labour productivity level using alternative labour composition measure, SNA market economy

	United Kingdom	United States	France	Germany
Productivity	100.0%	129.5%	121.8%	114.5%
Productivity after adjusting for capital	100.0%	123.1%	113.5%	109.3%
Productivity after adjusting for capital and skills (TFP)	100.0%	114.4%	113.6%	114.6%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c); Average years of schooling (Barro and Lee, 2013).

Notes: Levels in each cell are relative to the UK's level. Productivity level is measured in 2015 constant prices and converted to international dollars using the constant 2015 PPP series. The adjusted productivity in the second and third rows of each panel accounts for the relative level differences in factor inputs. "Capital" refers to capital intensity (i.e. capital stock per hour). Labour composition levels are estimated using the alternative human capital measure based on Equation 4. See Table C9 for level accounting results.

Table C8—: Relative labour productivity level using alternative labour composition measure, CHS market economy

	United Kingdom	United States	France	Germany
Productivity	100.0%	127.6%	113.3%	114.5%
Productivity after adjusting for capital in NatAcc	100.0%	121.5%	107.3%	105.5%
Productivity after adjusting for capital in NatAcc and broader intangibles	100.0%	113.0%	107.0%	106.5%
Productivity after adjusting for skills and capital	100.0%	105.8%	111.6%	106.6%

Sources & notes: Labour composition levels are estimated using the alternative human capital measure based on Equation 4. "Capital in NatAcc" refers to the tangible and intangible capital within the SNA boundary. "Broader intangibles" refer to intangible capital not included in national accounts but included in the CHS assets boundary. See Table C7 for data sources and additional notes. See Table C10 for level accounting results using CHS framework.

Table C9—: Labour productivity level decomposition using alternative labour composition measures, SNA market economy

	United Kingdom	United States	France	Germany
Productivity	100.0%	129.5%	114.5%	121.8%
Labour composition	100.0%	107.6%	95.4%	100.0%
TFP	100.0%	114.4%	114.6%	113.6%
Capital intensity	100.0%	105.2%	104.7%	107.2%
<i>Tangible capital intensity</i>	100.0%	99.2%	101.4%	105.7%
<i>Intangible capital intensity</i>	100.0%	107.5%	103.9%	101.6%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c); Average years of schooling (Barro and Lee, 2013).

Notes: Labour composition is estimated using the alternative human capital measure in Equation 4. The relative levels of labour and capital inputs are weighted by their respective cost shares.

Table C10—: Labour productivity level decomposition using alternative labour composition measures, CHS market economy

	United Kingdom	United States	France	Germany
Productivity	100.0%	127.6%	113.3%	114.5%
Labour composition	100.0%	106.8%	95.9%	100.0%
TFP	100.0%	105.8%	111.6%	106.6%
Capital intensity	100.0%	113.0%	105.9%	107.5%
<i>Tangible capital intensity</i>	100.0%	99.2%	101.7%	106.6%
<i>Intangible capital intensity</i>	100.0%	115.7%	104.6%	100.7%
<i>Intangible capital intensity in national accounts</i>	100.0%	107.5%	104.5%	101.8%
<i>Intangible capital intensity outside national accounts</i>	100.0%	107.5%	100.2%	99.0%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); Productivity Statistics (OECD, 2014); PPP (OECD, 2023c); Average years of schooling (Barro and Lee, 2013).

Notes: Labour composition is estimated using the alternative human capital measure in Equation 4. Intangible capital in national accounts refers to intangible assets within the SNA boundary. Intangible capital outside national accounts refers to intangible assets that are not included in national accounts but are covered within the CHS asset boundary.

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Table C11—: Decomposition of labour productivity growth, SNA market economy, 1995-2019

	Overall (1995-2019)	Pre-GFC (1995-2007)	Post-GFC (2007-2019)
United Kingdom			
Productivity	1.43%	2.54%	0.48%
Labour composition	0.31%	0.39%	0.23%
TFP	0.57%	1.22%	0.06%
Capital intensity	0.55%	0.93%	0.20%
<i>Non-ICT tangible capital intensity</i>	0.15%	0.26%	0.05%
<i>ICT tangible capital intensity</i>	0.20%	0.40%	0.01%
<i>Intangible capital intensity</i>	0.23%	0.32%	0.15%
United States			
Productivity	1.99%	2.79%	1.22%
Labour composition	0.36%	0.44%	0.29%
TFP	0.74%	1.27%	0.20%
Capital intensity	0.88%	1.09%	0.73%
<i>Non-ICT tangible capital intensity</i>	0.27%	0.33%	0.22%
<i>ICT tangible capital intensity</i>	0.31%	0.44%	0.21%
<i>Intangible capital intensity</i>	0.32%	0.33%	0.31%
France			
Productivity	1.32%	2.05%	0.58%
Labour composition	0.52%	0.34%	0.65%
TFP	0.44%	1.29%	-0.33%
Capital intensity	0.36%	0.42%	0.27%
<i>Non-ICT tangible capital intensity</i>	0.14%	0.24%	0.03%
<i>ICT tangible capital intensity</i>	0.04%	0.05%	0.03%
<i>Intangible capital intensity</i>	0.18%	0.12%	0.21%
Germany			
Productivity	1.35%	1.88%	0.92%
Labour composition	0.12%	-0.08%	0.26%
TFP	0.86%	1.45%	0.43%
Capital intensity	0.37%	0.51%	0.23%
<i>Non-ICT tangible capital intensity</i>	0.13%	0.22%	0.05%
<i>ICT tangible capital intensity</i>	0.08%	0.16%	0.02%
<i>Intangible capital intensity</i>	0.15%	0.13%	0.16%

Sources & notes: See Figure 1 for data sources and notes.

Table C12—: Decomposition of labour productivity growth, CHS market economy, 1995-2019

	Overall (1995-2019)	Pre-GFC (1995-2007)	Post-GFC (2007-2019)
United Kingdom			
Productivity	1.58%	2.65%	0.71%
Labour composition	0.27%	0.34%	0.20%
TFP	0.46%	1.14%	-0.07%
Capital intensity	0.85%	1.17%	0.58%
Tangible capital intensity	0.41%	0.66%	0.18%
<i>Non-ICT tangible capital intensity</i>	0.24%	0.34%	0.15%
<i>ICT tangible capital intensity</i>	0.17%	0.31%	0.03%
Intangible capital intensity	0.43%	0.51%	0.37%
<i>Intangible capital intensity in national accounts</i>	0.08%	0.11%	0.04%
<i>Intangible capital intensity outside national accounts</i>	0.35%	0.40%	0.33%
United States			
Productivity	2.05%	2.73%	1.40%
Labour composition	0.33%	0.40%	0.26%
TFP	0.48%	0.91%	0.04%
Capital intensity	1.24%	1.42%	1.10%
Tangible capital intensity	0.54%	0.75%	0.37%
<i>Non-ICT tangible capital intensity</i>	0.20%	0.26%	0.16%
<i>ICT tangible capital intensity</i>	0.34%	0.49%	0.22%
Intangible capital intensity	0.70%	0.67%	0.73%
<i>Intangible capital intensity in national accounts</i>	0.40%	0.42%	0.39%
<i>Intangible capital intensity outside national accounts</i>	0.29%	0.25%	0.34%
France			
Productivity	1.38%	1.99%	0.74%
Labour composition	0.46%	0.31%	0.57%
TFP	0.01%	0.67%	-0.60%
Capital intensity	0.91%	1.02%	0.77%
Tangible capital intensity	0.40%	0.58%	0.21%
<i>Non-ICT tangible capital intensity</i>	0.32%	0.47%	0.17%
<i>ICT tangible capital intensity</i>	0.08%	0.11%	0.05%
Intangible capital intensity	0.51%	0.43%	0.55%
<i>Intangible capital intensity in national accounts</i>	0.29%	0.26%	0.32%
<i>Intangible capital intensity outside national accounts</i>	0.22%	0.18%	0.24%
Germany			
Productivity	1.41%	1.90%	1.00%
Labour composition	0.11%	-0.07%	0.25%
TFP	0.62%	1.12%	0.28%
Capital intensity	0.67%	0.85%	0.48%
Tangible capital intensity	0.39%	0.60%	0.19%
<i>Non-ICT tangible capital intensity</i>	0.23%	0.33%	0.13%
<i>ICT tangible capital intensity</i>	0.16%	0.27%	0.06%
Intangible capital intensity	0.28%	0.25%	0.29%
<i>Intangible capital intensity in national accounts</i>	0.13%	0.10%	0.14%
<i>Intangible capital intensity outside national accounts</i>	0.15%	0.15%	0.15%

Sources & notes: Intangible capital in NatAcc refers to intangible assets within the SNA boundary. Intangible capital outside NatAcc refers to intangible assets that are not included in national accounts but are covered within the CHS asset boundary. For more data sources and table notes, see Figure 1.

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Table C13—: Decomposition of labour productivity growth with alternative cut-off years, SNA market economy, 1995-2019

	1995-2008	2008-2019	1995-2007	2008-2019
United Kingdom				
Productivity	2.36%	0.32%	2.54%	0.32%
Labour composition	0.32%	0.23%	0.39%	0.23%
TFP	1.13%	-0.08%	1.22%	-0.08%
Capital intensity	0.91%	0.17%	0.93%	0.17%
<i>Non-ICT tangible capital intensity</i>	0.27%	0.03%	0.26%	0.03%
<i>ICT tangible capital intensity</i>	0.38%	0.00%	0.40%	0.00%
<i>Intangible capital intensity</i>	0.31%	0.15%	0.32%	0.15%
United States				
Productivity	2.62%	1.25%	2.79%	1.25%
Labour composition	0.48%	0.29%	0.44%	0.29%
TFP	0.99%	0.26%	1.27%	0.26%
Capital intensity	1.14%	0.70%	1.09%	0.70%
<i>Non-ICT tangible capital intensity</i>	0.37%	0.21%	0.33%	0.21%
<i>ICT tangible capital intensity</i>	0.43%	0.19%	0.44%	0.19%
<i>Intangible capital intensity</i>	0.35%	0.30%	0.33%	0.30%
France				
Productivity	1.85%	0.59%	2.05%	0.59%
Labour composition	0.34%	0.70%	0.34%	0.70%
TFP	1.08%	-0.41%	1.29%	-0.41%
Capital intensity	0.42%	0.30%	0.42%	0.30%
<i>Non-ICT tangible capital intensity</i>	0.24%	0.04%	0.24%	0.04%
<i>ICT tangible capital intensity</i>	0.05%	0.03%	0.05%	0.03%
<i>Intangible capital intensity</i>	0.13%	0.23%	0.12%	0.23%
Germany				
Productivity	1.69%	0.83%	1.88%	0.83%
Labour composition	-0.05%	0.32%	-0.08%	0.32%
TFP	1.24%	0.28%	1.45%	0.28%
Capital intensity	0.49%	0.24%	0.51%	0.24%
<i>Non-ICT tangible capital intensity</i>	0.21%	0.05%	0.22%	0.05%
<i>ICT tangible capital intensity</i>	0.15%	0.01%	0.16%	0.01%
<i>Intangible capital intensity</i>	0.13%	0.17%	0.13%	0.17%

Sources & notes: See Table C11 for data sources and table notes.

Table C14—: Growth accounting using alternative input shares, SNA market economy, 1995-2019

Alpha	United Kingdom			United States			France			Germany		
	Bilateral	Multilateral	Standard	Bilateral	Multilateral	Standard	Bilateral	Multilateral	Standard	Bilateral	Multilateral	Standard
Productivity	1.43%	1.43%	1.43%	1.99%	1.99%	1.99%	1.32%	1.32%	1.32%	1.35%	1.35%	1.35%
Labour composition	0.31%	0.32%	0.32%	0.36%	0.38%	0.38%	0.52%	0.49%	0.49%	0.12%	0.12%	0.12%
Capital intensity	0.55%	0.52%	0.51%	0.88%	0.81%	0.80%	0.36%	0.42%	0.41%	0.37%	0.41%	0.40%
TFP	0.57%	0.60%	0.60%	0.74%	0.80%	0.81%	0.44%	0.41%	0.42%	0.86%	0.83%	0.84%

Sources & notes: See ?? for data sources and table notes.

Table C15—: Output growth decomposition, SNA market economy, 1995-2019

Market Economy	UK			US			France			Germany		
	Pre-GFC	Post-GFC	Change	Pre-GFC	Post-GFC	Change	Pre-GFC	Post-GFC	Change	Pre-GFC	Post-GFC	Change
GVA	3.12%	1.38%	-1.74%	3.45%	1.64%	-1.81%	2.81%	1.16%	-1.66%	1.75%	1.37%	-0.38%
LC	0.40%	0.23%	-0.18%	0.46%	0.31%	-0.14%	0.33%	0.60%	0.27%	-0.08%	0.26%	0.34%
Hour	0.39%	0.63%	0.24%	0.44%	0.25%	-0.18%	0.56%	0.43%	-0.13%	-0.11%	0.30%	0.41%
TFP	1.30%	0.05%	-1.25%	1.33%	0.33%	-1.00%	1.25%	-0.37%	-1.62%	1.41%	0.44%	-0.97%
CAP	1.03%	0.46%	-0.56%	1.22%	0.75%	-0.48%	0.68%	0.50%	-0.18%	0.53%	0.37%	-0.16%
TangNICT	0.44%	0.21%	-0.23%	0.24%	0.39%	0.16%	0.55%	0.14%	-0.41%	0.11%	0.11%	0.00%
TangICT	0.42%	-0.02%	-0.44%	0.46%	0.21%	-0.25%	0.06%	0.04%	-0.02%	0.15%	0.03%	-0.13%
Intang	0.36%	0.21%	-0.15%	0.38%	0.37%	-0.01%	0.19%	0.26%	0.07%	0.13%	0.19%	0.06%

Sources & notes: LC — labour composition, Hour —total hours worked, CAP — total capital service volume, TangNICT — tangible non-ICT capital service volume, TangICT — tangible ICT capital service volume, and Intang — intangible capital service volume in national accounts. See Figure 11 for data sources.

Table C16—: Cumulative change in employment rate (working-age) for the pre-GFC vs. post-GFC, total economy

	Data Availability					Cumulative Change	
	1995	2003	2005	2007	2019	Δ 95-07	Δ 07-19
UK	✓	✓	✓	✓	✓	3.15	3.47
US	✓	✓	✓	✓	✓	-0.75	-0.42
France	✗	✓	✓	✓	✓	-	1.65
Germany	✗	✗	✓	✓	✓	-	6.68

Sources: Employment rate indicator (OECD, 2023*a*).

Notes: “X” indicates that data is unavailable for this year, and “✓” indicates that data is available. The employment rate is calculated as the ratio of the employed to the working-age population aged 15-64. Cumulative change is the annual employment rate in the last year minus the rate in the first year for each period.

Table C17—: Cumulative change in employment-to-population ratio pre-GFC vs. post-GFC, total economy

	Data Availability					Cumulative Change	
	1995	2003	2005	2007	2019	Δ 95-07	Δ 07-19
UK	✓	✓	✓	✓	✓	3.10	1.20
US	✓	✓	✓	✓	✓	0.10	-2.20
France	✓	✓	✓	✓	✓	1.60	-0.90
Germany	✓	✓	✓	✓	✓	1.40	5.90

Sources: Employment/population ratio (OECD, 2023*b*).

Notes: “X” indicates that data is unavailable for this year, and “✓” indicates that data is available. The employment-to-population ratio is calculated as the ratio of the employed to the total population. Cumulative change is the employment-to-population ratio in the last year minus the ratio in the first year for each period.

Table C18—: Cumulative change in employment rate and labour productivity for the pre-GFC vs. post-GFC period, SNA market economy

Market Economy	1995-2007				2007-2019			
	UK	Germany	US	France	UK	Germany	US	France
Employment Rate	3.01%	1.02%	0.04%	2.62%	3.47%	6.68%	-0.42%	1.65%
Labour Productivity	30.50%	22.53%	34.89%	24.56%	3.82%	9.98%	7.04%	14.96%
Labour Composition	4.72%	-0.97%	4.53%	4.14%	2.79%	3.72%	8.12%	3.56%
Capital Intensity	10.84%	6.57%	15.00%	4.84%	1.99%	2.97%	3.94%	8.31%
TFP	14.94%	16.94%	15.36%	15.58%	-0.97%	3.30%	-5.02%	3.10%

Sources: EUKLEMS & INTANProd 2023 (Bontadini et al., 2023); OECD productivity statistics (OECD, 2014).

Notes: Growth accounting is estimated based on Equation 3. Labour composition and capital intensity changes are weighted by their respective cost shares. Cumulative change is the value of each variable in the last year minus its value in the first year for each period.

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Accounting for the Decline of Canada's Real GDP Per Capita since Mid-2022

Philip Smith¹

Abstract

Real GDP per capita has been falling in Canada since mid-2022, while the number of non-permanent residents has been rising sharply. This article discusses how these two developments are linked. The paper identifies six factors currently influencing real GDP per capita: (1) labour productivity; (2) average hours worked per job; (3) the employment rate of the working-age population; (4) the ratio of the working-age population to the permanent resident population (where working-age includes NPRs in that age class); (5) the share of permanent residents in the total population; and (6) the relative rate of growth of the government and non-profit sectors compared to that of the business sector. The relative importance of each of these factors is assessed via a multiplicative decomposition and the analysis indicates the share of permanent residents in the total population is currently the single most important factor.

Real gross domestic product (GDP) per capita (or real domestic income per capita), defined as GDP with inflation removed and divided by the total population, is an important indicator of changes in Canadians' well-being through time.²

The track of GDP per capita over the last 77 years reveals a strong upward trend, with the index more than tripling over the entire period (Chart 1). The upward trend is interrupted occasionally and these disruptions are closely related to the business

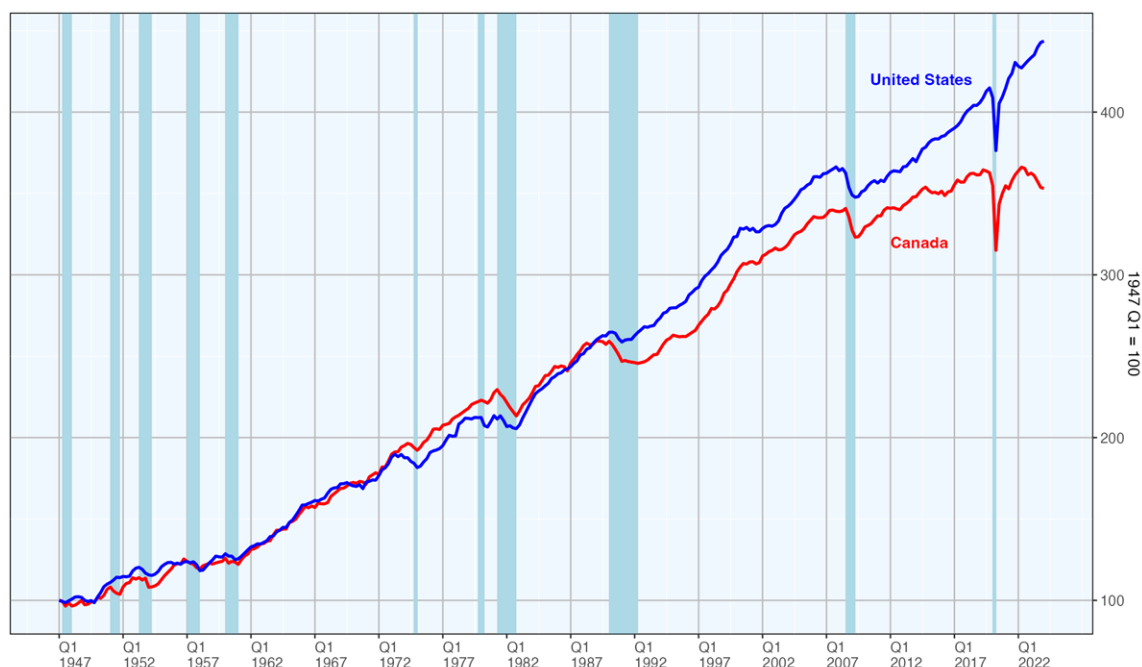
cycle (the C.D. Howe Institute's dates for Canadian recessions are shaded).

As shown in Chart 1, Canada's GDP per capita followed the path of its U.S. counterpart fairly closely until the recession of 1990-1992, when it fell behind. It has not closed the resulting gap, but did continue along a path parallel to the United States until around 2015 when Canada experienced a mini-recession related to falling world energy prices (evident but not shaded in Chart 1). From that

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2 GDP is not the whole story, of course. Well-being is also affected by other factors, notably externalities such as pollution, the availability of leisure time, income distribution, life expectancy and the degree of social harmony. But these additional factors are not the subject addressed here.

Chart 1: Real GDP per capita in Canada and United States, Quarterly Index, 1947 Q1 to 2024 Q1, Seasonally Adjusted



Note: Statistics Canada's official GDP time series covers the period from the first quarter of 1961 to date and is calculated based on the 2008 international standard System of National Accounts. To extend this time series back to 1947 Q1, Statistics Canada's historical estimates based on the 1968 international standard System of National Accounts were linked. The estimates from 1961 to date are therefore a quarterly chained Fisher volume index while those for the period prior to 1961 are an infrequently chained Laspeyres index. Source: Statistics Canada vectors v87224024, v62305752 and v1 and author's calculations. U.S. Bureau of Economic Analysis NIPA table 7.1. Shaded areas are recessions.

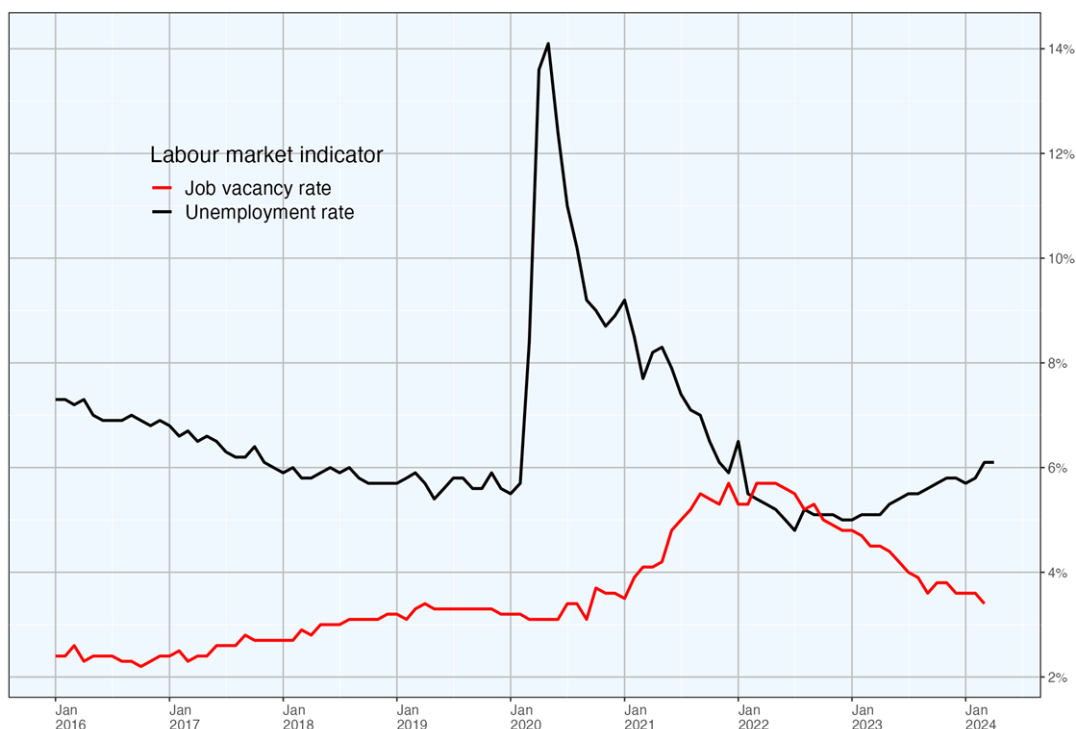
point on, the gap began to widen further and quite considerably as Canada's productivity growth slowed while U.S. productivity grew more quickly.

The focus of this article is on the most recent four years shown in the chart, which were impacted by the COVID-19 pandemic and its aftermath. GDP per capita plunged in early 2020 when the economy was put on lockdown, affecting both production and spending as everyone sought to minimize the spread of infection. But the economy rebounded quickly as people and businesses found adjustments that allowed for an opening up of activities while still countering the virus' spread.

By 2022, real GDP and inflation were surging. Real GDP grew at a 3.9 per cent

average annual rate in the first two quarters of that year while the CPI rose at a 9.0 per cent rate on the same basis. Many other countries faced a similar situation. Central banks around the world, including the Bank of Canada, raised interest rates to slow their economies down. Canada's GDP growth did indeed slow, growing on average at an annual rate of just 0.9 per cent in the following seven quarters to 2024 Q1. The labour market, which had attained record low unemployment rates and high job vacancy rates in 2022, loosened considerably (Chart 2). Unemployment rates edged up slightly in the United States as well, but American GDP growth, after also slowing in mid-2022, resumed its extraordinary strength with 2.2 per cent average

Chart 2: Canadian Unemployment and Job Vacancy Rates, Monthly, October 2015 to April 2024, Seasonally Adjusted



Source: Statistics Canada vectors v2062815 and v1446283289. Job vacancy statistics begin in October 2015.

quarterly growth at an annual rate between 2022 Q2 and 2024 Q1.

So why has GDP per capita been falling in Canada for several quarters? Unlike in previous episodes where Canada's GDP per capita has decreased substantially, this time modest economic growth continues. There is no apparent recession. What explains the difference and what policy action can be taken to turn this declining trend around without at the same time allowing a resurgence of inflation? These are the questions addressed in this article.

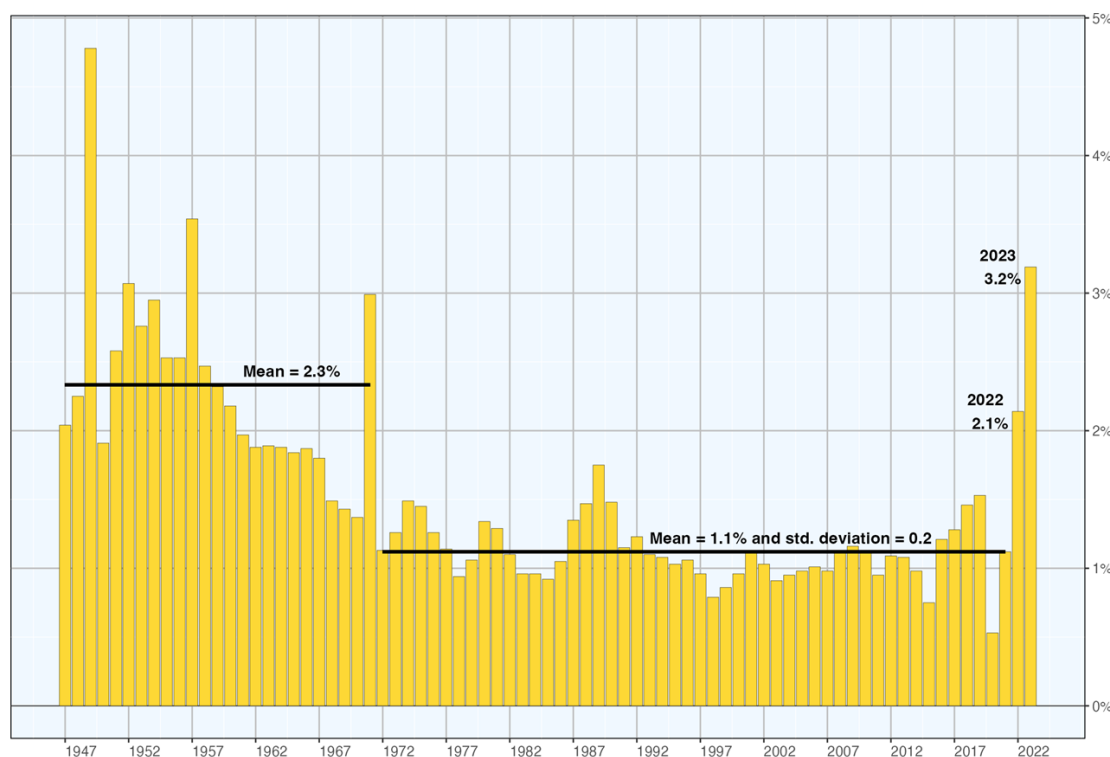
Population Growth and Non-permanent Residents

An unusual aspect of Canada's economy today, relative to the last 50 years, is the high rate of population growth (Chart 3).

Population normally grows at a slow and fairly predictable rate. It increased 1.1 per cent a year on average in the half-century from 1972 to 2021 with a standard deviation of 0.2 per cent. Since mid-2022, however, it has risen much more rapidly: 2.1 per cent in 2022 and 3.2 per cent in 2023. This indicates that unlike in the previous postwar episodes where weak or falling GDP explained most of the drop in GDP per capita, this time unusually rapid population growth is a major factor as well. The denominator is as much a factor as the numerator in explaining developments this time around.

Why has the population risen so rapidly since mid-2022? It is not because of more rapid birth rates or falling death rates. Nor is it because of substantially higher rates of immigration which, following a pandemic-

Chart 3: Canadian Population Growth, Annual Percentage Change, 1947 to 2023



Note: Annual population is measured as the value on October 1 of each year. Source: Statistics Canada Vector v1.

related decrease to 185 thousand in 2020, were 406 thousand in 2021, 438 thousand in 2022 and 472 thousand in 2023. It is, rather, because of a huge inflow of non-permanent residents (NPRs).

The percentage of NPRs in the Canadian population crept up gradually between 1971 and 2016, rising from under 1 per cent to a little over 2 per cent (Chart 4). It then rose more quickly from 2016 to 2023, in particular in 2022 and 2023. It climbed to around 3.5 per cent of the total population where it plateaued during pandemic-related restrictions on cross-border travel. In 2022, however, the share of NPRs resumed its upward climb at an even faster pace, bringing the number of non-permanent residents in Canada to 6.5 per cent of the population by January 2024, some 2.7 million people. That is a

large number, equivalent to more than double the total population in each of five of Canada's ten provinces

The composition of Canada's NPR population has shifted over the last two and a half years (Chart 5). Study permit holders accounted for a substantial share of the increase but the largest share was attributable to temporary work permit holders.

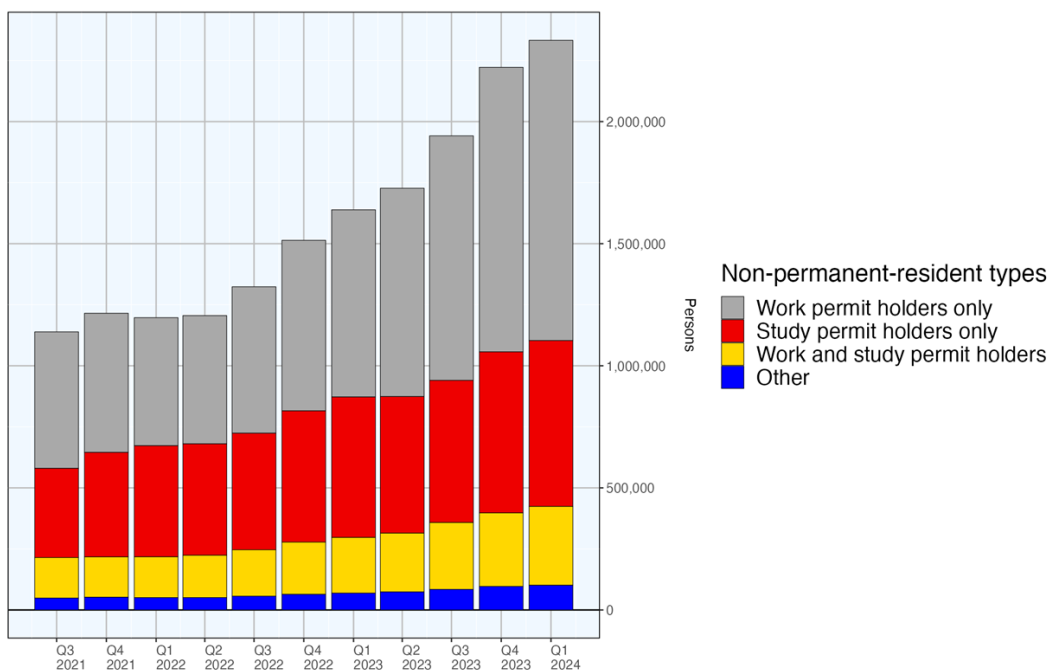
Asylum claimants were 12 per cent of NPRs in the most recent quarter and 60 per cent of them had work permits. Aside from asylum claimants, students accounted for 38 per cent of all NPRs and about a third of them had work permits (as well as study permits). People with work permits only (who were neither asylum claimants nor students) accounted for 46 per cent of NPRs and the remainder were family mem-

Chart 4: Non-permanent Residents as a Percentage of the Population, Quarterly, 1971 Q3 to 2023 Q4, not seasonally adjusted



Note: Calculated by decumulating net non-permanent-resident inflows starting from Statistics Canada's published value for the stock of non-permanent residents at the end of 2023 Q4. Source: Statistics Canada tables 17-10-0121-01 and 17-10-0040-01.

Chart 5: Types of Non-Permanent Residents, Quarterly, 2021 to 2024 Q1



Note: The non-permanent resident types are mutually exclusive. The estimates here are for the first day of the quarter.

Numbers of asylum claimants with study permits only and asylum claimants with work and study permits are very small.

Source: Statistics Canada Table 17-10-0121-01. The data in this Statistics Canada table begin in 2021 Q3.

bers and special cases, mostly without work permits. All told, about 65 per cent of NPRs had some kind of work permit, although based on census data for 2021, their labour force participation rate was substantially lower than 100 per cent (Tuey and Bastien, 2023).

The key question then is: What contribution to GDP is being made by the NPRs? If the recent influx of NPRs is causing the population to grow by 3.2 per cent a year instead of the 1.1 per cent or so seen in prior years, why is GDP growth not keeping up with this jump in population?

This is a question that cannot be answered with precision. We simply do not, at present, have the detailed statistical information about NPRs and their role in the economy that would permit a definitive analysis. But we have sufficient information to surmise their relative contribution to GDP is substantially less than that of the rest of the population (Canadian-born residents and immigrants).

Last year Statistics Canada released a study of the socio-economic characteristics of the NPR population using data for 2020 drawn from the 2021 Census of Population (Tuey and Bastien 2023). NPRs were found to be younger on average than the PR population. Of those who had jobs, more worked part-time and those who worked full-time in many cases worked less than a full year since some work permits have hours-per-week limitations and are for fixed-length work periods. According to

the study, 92 per cent resided in census metropolitan areas and 60 per cent lived in Ontario or British Columbia.³

Unfortunately, the Statistics Canada study contains no information about the earnings of NPRs.⁴ However, it does reveal the top ten occupations for NPRs were low-wage occupations. They are:

- Nurse aides, orderlies and patient service associates;
- Light duty cleaners;
- Material handlers;
- Labourers in food and beverage processing;
- Transport truck drivers;
- Food counter attendants, kitchen helpers and related support occupations;
- Delivery service drivers and door-to-door distributors;
- Retail salespersons and visual merchandisers;
- Security guards and related security service occupations; and
- Other customer and information services representatives.

The information in the Statistics Canada study implies the overall impact of NPRs on GDP per capita is quite different from that of Canada's PRs. Their average productivity level is likely significantly lower because NPRs tend to work primarily in occupations paying relatively low wages per hour worked. In addition, it seems they tend to work fewer hours per annum than PRs. The per capita GDP contribution of NPRs looks to be substantially smaller

³ Of Canada's total population, 38.9 per cent lived in Ontario and 13.8 per cent lived in British Columbia as of July 1, 2023. The percentage of the total population who lived in census metropolitan areas was 74.4.

⁴ The census requested earnings information from respondents, but the Tuey and Bastien study did not report any earnings information for non-permanent residents.

than that of PRs.

The relevance of the findings from the Statistics Canada study for what occurred in 2022 and 2023 must be qualified though, because it was based on census data for the pandemic year 2020. The results may be less applicable to the post-pandemic years 2022 and 2023 when the number of NPRs was so much bigger and when some important government policies vis-a-vis NPRs had changed.

Within the Temporary Foreign Worker Program, the federal government, in April 2022, increased the cap on the proportion of low-wage temporary foreign workers businesses could hire from 10 per cent to 20 per cent for all low-wage employers. Moreover, for low-wage employers in certain specific sectors it raised the cap to 30 per cent. These measures were in response to calls from businesses saying they were experiencing unskilled labour shortages (Employment and Social Development Canada, 2022 and 2023).

The government also adjusted its policies within the International Student Program. In 2022, it announced a number of measures intended to address the perceived shortage of unskilled labour, including extensions of the time period during which foreign students could remain in Canada after graduation and the temporary lifting of the 20-hour-per-week cap on the number of hours that eligible post-secondary students are allowed to work off-campus while class is in session (Immigration, Refugees and Citizenship Canada, 2022 a, b & c).

The unskilled labour shortage proved short-lived as the job vacancy rate began to drop in mid-2022 and the unemployment rate started moving up (Chart 2). In late

2023 and early 2024, the government took steps to unwind the policy changes relating to foreign student visas. In March 2024 it announced it would also cut back on the number of temporary foreign workers allowed in Canada and would do so gradually, over a three year period, aiming for an NPR-to-population ratio of 5 per cent by the end of 2026 (Immigration, Refugees and Citizenship Canada, 2024 a & b).

How NPRs Affect GDP and GDP per Capita

Working-age population growth can be expected to increase real GDP, though by how much will depend on the education and skill mix of the additional labour supply, and on how those people are employed. If the added labour supply is highly qualified but is employed in jobs requiring only low-level skills, the impact on GDP and productivity will clearly be lower. The 2021 census study stated that in 2020, NPRs were generally employed in jobs demanding education and skills below those they actually possessed (Tuey and Bastien, 2023).

We cannot know what real GDP growth would have looked like in 2022 and 2023 if there had been no NPR surge in those years, but it would probably have been weaker, especially in 2023. A rough ‘back of the envelope’ calculation, assuming a constant NPR employment rate of 65 per cent and average earnings of \$25,000 per NPR, indicates total NPR earnings rose from about \$21 billion in 2021 to \$24 billion

in 2022 and \$35 billion in 2023.⁵ An \$11 billion differential impact on GDP growth in 2023 would have been equivalent to just under 0.4 per cent of GDP. Statistics Canada reports an actual real GDP growth rate in that year of 1.5 per cent, so a rough estimate implies it would have been closer to 1 per cent without the NPR surge.

However, during the same period, real GDP per capita declined almost 2 per cent. This is because the relative increase in population greatly exceeded its relative impact on real GDP.

GDP per capita can be regarded as the population-weighted average of per capita production attributable to PRs and NPRs. As just mentioned, there are reasons to believe the latter is smaller than the former. As the weight of NPRs in the total population rose from around 3.5 per cent in 2020-2021 to 6.5 per cent by the end of 2023, this exerted a downward pull on the overall GDP-to-population ratio. There are, of course, other factors affecting GDP per capita in addition to the size and composition of the population. We explore these next.

Accounting for Changes in Real GDP per Capita

This article uses a multiplicative decomposition method to investigate the impact of factors affecting GDP per capita, in which real GDP per capita is defined to be the product of six important drivers, as follows:

$$\frac{GDP}{N} = \frac{GDP_b}{H_b} \cdot \frac{H_b}{J_b} \cdot \frac{J_b}{N_w} \cdot \frac{N_w}{N_p} \cdot \frac{N_p}{N} \cdot \frac{GDP}{GDP_b} \quad (1)$$

where:

- GDP = real total gross domestic product;
- N = total population;
- GDP_b = real business sector gross domestic product;
- H_b = total hours worked in the business sector;
- J_b = number of jobs in the business sector;
- N_w = working-age population;⁶
- N_p = permanent-resident population.

This decomposition framework is used below to analyze recent developments, us-

⁵ The minimum hourly wage in Canada varies by province and territory and the population-weighted average was \$15.88 in 2023. However, the considerable majority of NPRs appear to work in Ontario and British Columbia where the minimum wages are \$16.55 and \$16.75 respectively. In addition, some NPRs might receive more than the minimum wage. Assuming NPRs earn \$17 an hour on average, work 32.5 hours a week (30 per cent of permit-holders have study permits only and work part-time) and are employed for 50 weeks in the year would imply earnings of \$27,625. However, many NPRs are unlikely to work 50 weeks in the year and indeed some remain in Canada less than a year, so this crude estimate was reduced to \$25,000. In contrast, Statistics Canada's Survey of Employment, Payrolls and Hours indicated that average earnings of all employees were \$63,013 in December 2023. The crude estimate of \$25,000 a year for NPRs may be too low, but the point is simply that NPRs, on average, must surely have earned much less than PRs.

⁶ In this article the working-age population is defined as the portion of the Labour Force Survey target population consisting of persons between 15 and 64 years of age. The Labour Force Survey target population, in turn, consists of all persons 15 years of age or older, not living in the territories, First Nations people living on reserves, not in the military and not living in prisons or other live-in institutions. Accordingly the working-age population as defined here excludes persons over 65 years of age and older, most of whom are either fully retired or work part-time.

⁷ Lest there be any confusion, there is no hypothesis testing here. The six factors in the GDP per capita decomposition are chosen simply because they are believed to be important influencers. The decomposition reveals

ing quarterly statistics.⁷

The factors in equation (1) are measured using indexes scaled so the calendar average in 2017 = 100. This is also the practice followed by Statistics Canada in its table 36-10-0206-01, from which some of these time series are drawn.

The analysis is focused on the first difference of the logarithm of real GDP per capita, which implies an additive rather than a multiplicative relationship as in equation (2):

$$\begin{aligned} \Delta \ln \left(\frac{GDP}{N} \right) &= \Delta \ln \left(\frac{GDP_b}{H_b} \right) + \Delta \ln \left(\frac{H_b}{J_b} \right) \\ &+ \Delta \ln \left(\frac{J_b}{N_w} \right) + \Delta \ln \left(\frac{N_w}{N_p} \right) \\ &+ \Delta \ln \left(\frac{N_p}{N} \right) \\ &+ \Delta \ln \left(\frac{GDP}{GDP_b} \right) \end{aligned} \quad (2)$$

To a close approximation, the first difference of the logarithm, when multiplied by 100, is equal to the percentage change when the relative changes are small.

The decomposition starts from the fact that GDP per capita is a ratio, with GDP in the numerator and population in the denominator. This ratio can be expressed as a product of other ratios that are thought to be important in explaining changes in GDP per capita, with the proviso that the numerators of the additional ratios must be the same as the denominators in other ratios, so they cancel out.

Empirically, as will be discussed further

below, the most important driver is business sector labour productivity which dominates the others over the long run.⁸ The other five macroeconomic drivers considered in this article, while they have been important over relatively short periods of time, in specific circumstances, have not changed greatly over longer stretches of time. Productivity, however, has trended up strongly over the long run, increasing more than three-fold since the Second World War. The pace and composition of non-human capital formation, human capital upgrading, knowledge accumulation and technical change all help explain growth in labour productivity over time and have an outsized effect on GDP per capita.

Why the emphasis on labour productivity in the business sector rather than for the total economy? Simply because we have no good way to measure the productivity of the non-business sector. Its output is not sold in the market and, therefore, does not have a well-defined value. We know what it costs, but not what it is worth. Statistics Canada's measure of labour productivity change in the non-business sector is the deflated value of inputs - because there is no measure of the market value of outputs - divided by the number of hours worked in the sector. But if the total deflated value of inputs rises more rapidly than the value of hours worked in the non-business sector this does not imply that productivity is rising in any meaningful sense. Statistics

their relative importance over time.

⁸ Statistics Canada, in its labour productivity statistics Tables 36-10-0206 and 36-10-0207, works with the concept of jobs rather than persons employed and that is also the approach adopted here. One person employed can of course have more than one job.

Canada and most other national statistical agencies adopt the convention of measuring the numerator, conceptually the real value of its output, as the value of its inputs simply because they have no better way to do it. No doubt there is true productivity change in the non-business sector, but in the absence of market-based output values it cannot really be measured.

One of the other factors that can have an influence, though typically over shorter periods of time, is average hours worked per business sector job. If the working population works longer or shorter hours, this will have a corresponding impact on real GDP per capita. But unlike labour productivity, which has proven over a long period of time to trend upward indefinitely, there are limits on the average number of hours a person employed can work in a given time period. Short-term fluctuations in average hours worked per job can sometimes affect GDP per capita significantly as they did, for example, in the early months of the COVID-19 pandemic, but they are unlikely to be a consistent driving force over an extended period.

Another factor is the number of business sector jobs expressed as a ratio to the working-age population.⁹ This driver is similar to the previous factor, but rather than focusing on the amount of work done in the average job it focuses on the number of jobs themselves, as a ratio to all available people of working age. Occasionally

this ratio can trend up or down over an extended period, as it did gradually during the second half of the twentieth century as more and more women entered the labour force. But as with average hours worked per business sector job, there are limits to the percentage of the working-age population that can work. In the twenty-first century this driver is characterized mostly by short-term fluctuations, notably those associated with the business cycle.

Another component of the decomposition is the ratio of the working-age population to the permanent-resident population. The working-age population is defined here as the number of Canadian residents between 15 and 64 years of age as estimated in the Labour Force Survey. Until recently this large cohort had been declining significantly relative to the total permanent resident population due to the aging of the baby boom cohorts into the 65 and over age category which has much higher retirement rates than younger age groups. However, the huge increase in the NPR population in the last two years, consisting mostly of people of working age, has raised the numerator and reversed that trend for the time being.

The next factor influencing GDP per capita is the ratio of the permanent resident population (citizens and immigrants) to the total population. This ratio had been very high and trending down only mildly for many years, but starting around

⁹ It could be argued that a better formulation would be the number of business sector jobs expressed as a ratio to the total population, since some of those 65 and over are also employed. However relatively few seniors are employed — just 14.5 per cent in May 2024 using seasonally adjusted Labour Force Survey statistics — and of those who are employed, 45 per cent worked in part-time jobs. Identifying the impact of aging of the baby boom cohorts into retirement age, which has the effect of reducing the working-age population (15-64 years of age as conventionally defined) is an important objective here so this alternative approach is not taken.

2016 and especially after 2021 it has been decreasing more rapidly. (This, of course, is the counterpart to the rise in the NPR share seen in Chart 4). The drop in this ratio has an important impact on GDP per capita because as noted previously there are strong reasons to believe the average real GDP associated with a typical PR is considerably greater than that of a typical NPR.¹⁰

Finally, the remaining driver of GDP per capita in this decomposition is the ratio of all-economy GDP to business-sector GDP. The gap between the two consists of three parts: government sector value added, non-profit sector value added and imputed rents on owner-occupied dwellings.¹¹ While, as alluded to earlier, these are excluded from the productivity concept considered in this analysis, they nevertheless are included in total GDP which, after dividing by the total population, is the variable that is in focus in this article.

To the extent these non-business-sector elements are growing more or less rapidly than business sector GDP, total GDP per capita will also tend to grow at a higher or lower rate compared to the business sector than would otherwise be the case. For example, all of these non-business-sector components except for non-profit institutions kept growing during the recession of 2008-2009 while business sector output de-

creased and was slow to recover in 2009 and 2010. Thus, the ratio of total to business-sector GDP increased in late 2008 and early 2009. It remained fairly stable around this higher level until the pandemic struck in 2020. After the extreme volatility in the first half of 2020, the ratio moved again to a higher level. In the four years period between March 2020 and March 2024, total real GDP rose 13.2 per cent, business sector GDP 12.6 per cent, public administration GDP 14.5 per cent, health and social welfare GDP 18.5 per cent, education GDP 16.8 per cent, non-profit institutions GDP 15.7 per cent and imputed rent 10.3 per cent. In other words, one might say that the growth of total real GDP per capita has been somewhat ‘propped up’ since the pandemic began with disproportionately strong growth in the non-business sector.

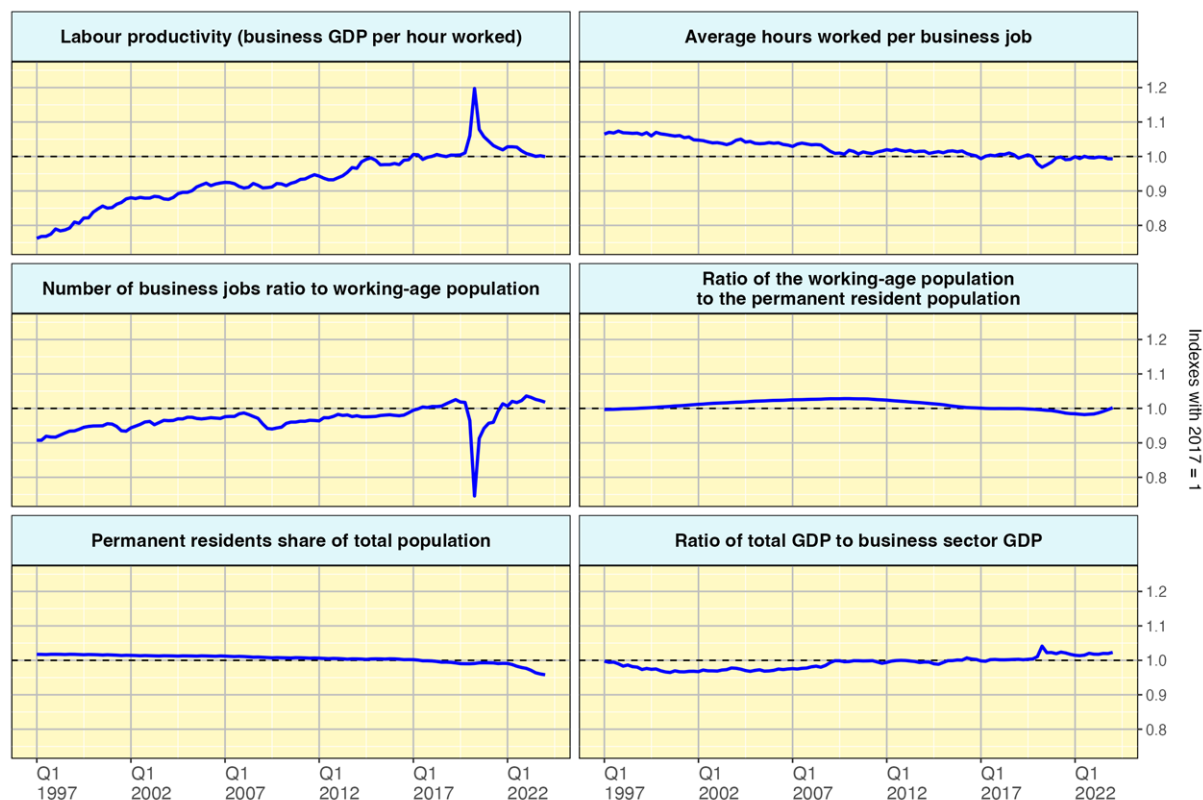
Statistical Results

The decomposition analysis described above shows that the six investigated variables have followed different paths over time (Chart 6). The vertical axis scale is the same on all six charts and it is the slope of each line that indicates how large its effect is on GDP per capita, in both the short and the longer-term. Labour productivity’s relative change (Percentage change)

10 A full general equilibrium analysis would be very useful here, with a well-specified model, estimated parameters and a good statistical portrait of the types of work done by NPRs and their remuneration. This is however beyond the scope of this article and in any case would probably not be feasible given the limited available data.

11 Imputed rents on owner-occupied dwellings are included in the GDP concept, by all countries, mainly so there will not be swings in GDP due simply to shifts in household preference with regard to housing ownership/rental. If I rent my house to you while you rent yours to me there will be no change in GDP compared to the case where we just live in our own houses.

Chart 6: GDP per Capita Decomposition Components, Quarterly Indexes with 2017 = 1, 1997 Q1 to 2024 Q1, Seasonally Adjusted



Source: Statistics Canada vectors v1, v29850346, v65201210, v1409154, v21580997, v1409155, v1409156

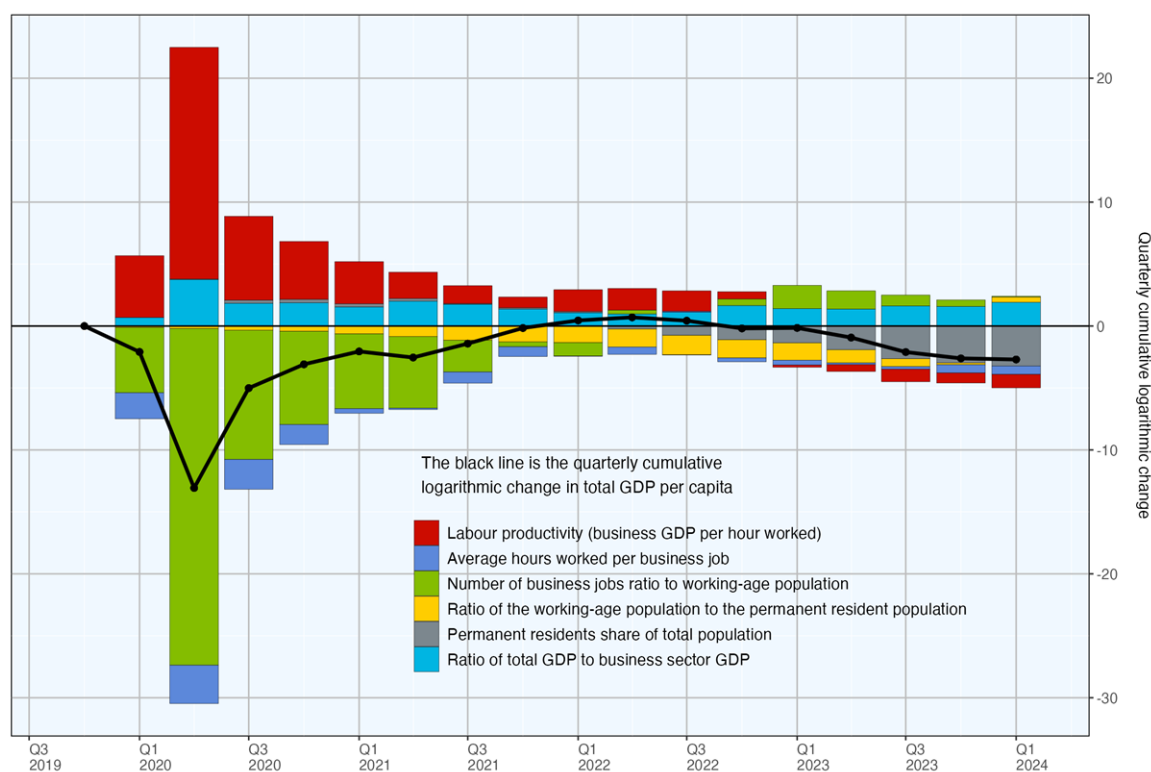
over the 26-year period has been much greater than the others and it is clearly the main driver of GDP per capita in the long run. It has been on a decline for the last few years though, and has hardly changed at all, on a net basis, since 2017.¹²

Average hours worked per job have been on a gradual trend decline over the full period, though they have been fairly stable in the years following the pandemic. The number of business sector jobs relative

to the total working-age population (15-64) (the employment rate) plunged when the pandemic began but recovered quite quickly thereafter and is now past its previous peak. The ratio of the working-age population to the permanent resident population started trending down around 2010 and continued doing so until 2022 when the surge of NPRs, the majority of whom are of working age, began. The number of permanent residents expressed as a ratio to the

¹² When this article was written, statistics were available for all the required variables up to and including the first quarter of 2024, but with two exceptions. The exceptions are connected to the fact that for purposes of this article population is measured at the end of the quarter. Statistics Canada's most recent estimate of Canada's population at time of writing was for the end of the fourth quarter of 2023. Accordingly an assumption was made about the first quarter population: that it was 41,000,000. This implies the same 0.6 per cent quarterly increase during the first quarter as in the previous quarter. For similar reasons, it was assumed that the net inflow of NPRs during the first quarter was 108,400 which is about the same as in the first quarter of 2023 (since NPR net inflows are seasonal). By making these assumptions we extend the entire analysis into the first quarter of 2024, but the reader should keep in mind that the results for the last quarter depend on these assumptions.

Chart 7: GDP per Capita and Its Determinants, Quarterly Cumulative Logarithmic Change, 2019 Q1 to 2024 Q1, Seasonally Adjusted



Source: Statistics Canada vectors v1, v29850346, v65201210, v1409154, v21580997, v1409155, v1409156

total population had been trending down gradually until recently. The numbers for 2022 and 2023 show a much sharper drop, due to the recent jump in the number of NPRs. Finally, since non-business sector economic activity has been growing more rapidly than business activity in the years since the pandemic, the ratio of total to business sector real GDP has increased.

Tracking the Drivers of Real GDP per Capita

The cumulative change in the real-GDP-to-population ratio since the fourth quarter of 2019 followed a down, up and then down again path over the last four years. Chart 7 decomposes these changes into our factors of interest and the statistics shown in the figure are reported in the appendix.¹³

GDP per capita (the black line) plummeted in the first half of 2020 when the economy was ‘locked down’ to limit the virus spread. Thereafter it began a gradual rebound as various steps were taken to limit that spread. The early 2020 drop and the

¹³ In Chart 7, starting from the 4th quarter of 2019, some of the following quarters show increases and others decreases. This chart does not show those increases and decreases directly (although it could be drawn that way as an alternative). Rather, for each quarter the chart shows the cumulative sum of all the changes, positive and negative, up to that particular quarter. It shows, for example, that in 2021 Q4 GDP per capita was finally back to the point where it was in 2019 Q4, and it shows this was due to the fact that increases in labour productivity and the ratio of total GDP to business GDP (relative to 2019 Q4) fully offset the continued cumulative decline in the other four components (again, relative to 2019 Q4).

next few recovery quarters were almost entirely accounted for by changes in the employment rate (the green bars - the number of business sector jobs ratio to working-age population) and average hours worked per business sector job (dark blue). Labour productivity (red) jumped initially and this change was almost all due to temporary compositional changes rather than innovations in the production process. Businesses laid off or reduced the working hours of their less-skilled, lower-wage employees while ‘hoarding’ their more highly-qualified and difficult-to-replace staff in anticipation that the pandemic disruption would be temporary.

In addition, the pandemic affected disproportionately the public-facing industries such as food services and accommodation where lower-skilled jobs tend to be predominant. Since the denominator of the labour productivity ratio does not distinguish how skilled and experienced the employed people are, on average, measured productivity increases simply by having a lower number of low-skilled workers. In effect, the productivity boost can be attributed to the temporary rise in average labour quality. In the subsequent quarters the cumulative change in labour productivity fell back down as economic activity recovered and businesses re-employed lower-skilled employees. During these pandemic quarters the ratio of total to business-sector GDP increased and the remaining identified drivers had little impact.

By mid-2022 the economy was boom-

ing and GDP per capita had risen slightly above its pre-pandemic level. The main reasons were that by this time, the cumulative change in the employment rate had turned positive and that of labour productivity remained positive. However, by then the baby-boomer retirement phase-in was well under way,¹⁴ serving to reduce the working-age share of the PR workforce (yellow bars) and offsetting some of the impact of the higher employment rate and productivity improvement (Statistics Canada, 2022).

The most recent few quarters, however, reveal the current weaker picture. The pandemic is largely in the past, but the cumulative change in GDP per capita has been moving down, slowly at first and then more rapidly, although the path levelled out in the most recent quarter. The employment rate and the total-economy-to-business-sector GDP ratio are continuing to make positive contributions, but the falling PR share of the population (equivalently the rising share of the NPR population) has become the largest downward driver of GDP per capita. As was discussed earlier in the article, there are strong reasons to believe the average productivity of NPRs, given the low-wage jobs most are working in, is much lower than that of the PR population. Their productivity contribution is lower and their weight in the overall population has been rising sharply, both factors contributing to declining overall Canadian GDP per capita. Decreasing labour productivity, the falling working-age

¹⁴ The postwar baby boom peaked in the mid 1950s after which birth rates began a gradual decline. Babies born in the late 1940s and 1950s, now adults, have been retiring since around 2010 and the numbers that are doing so have been increasing.

share of the population and declining average hours worked are additional negative factors.

Summing up: Why GDP per Capita is Dropping

Canada has recently experienced a number of quarters of shrinking real GDP per capita. If it occurred during a recession, one would attribute the fall to a shrinking economy. But the economy is not in recession. Real GDP growth remains positive and unemployment is still low, although rising. The drop in GDP per capita is, rather, accounted for by:

- the diminishing share of the most experienced labour force cohort due to ongoing baby-boomer retirements;
- decreasing labour productivity, a complex and high-priority longer-term problem with no simple or immediate solution in sight, although in the short term it is related to the next driver; and
- a burgeoning NPR population, a factor for which relatively quick fixes are fortunately available, but which require difficult political decisions and imply a short-term dampening effect on GDP growth.

Conclusion

Canada's real GDP per capita is on a downward track and this should be a matter of concern for all Canadians. GDP continues to grow at well below its long-term potential rate because productivity is flagging. Canada's population is rising too rapidly, beyond the economy's annual absorptive capacity, and its PR-NPR mix is greatly distorted. The problem is com-

pounded by the fact that Canada's most experienced workers, its seniors, are reaching normal retirement age at a more rapid rate as the baby boom generation enters old age, although this factor is mitigated by a rising median retirement age.

The immediate cause of this situation is the stunning increase in NPRs that came in 2022 and 2023. It was quite unexpected and has upset the forecasts and planning of policymakers at many levels. Although the spurt of NPRs did provide a kind of demand stimulus to GDP that helped avoid even weaker growth in 2023, the stimulus was small because the productivity and associated incomes of the jobs NPRs are filling are quite low. Part of the problem is that the filling of these jobs by additional NPRs has disincentivized business investment and thereby reduced Canada's overall labour productivity growth. The large influx of temporary foreign workers to fill low-wage jobs also served to limit Canada's unskilled PRs from realizing the opportunities and income benefits that would normally have come during the strong economic conditions of 2022, additional income that would have helped sustain consumer spending in 2023.

The government should set annual population growth targets, explain why those specific targets were chosen and use the various tools at its disposal to hit the targets. Recent statements by federal ministers indicate significant movement in this direction. Explicit landed immigration targets have been announced and largely implemented in this way for many years. Now an explicit three-year target for NPRs has also been set for the first time. This practice should continue at least until the ac-

knowledge excessive proportion of NPRs in the population has been reduced below the announced five per cent target. Further, the ways in which these targets are achieved also matters. Most importantly, an accompanying goal should be to upgrade the average knowledge, skills and experience of Canada's labour force as these targets are pursued. This implies minimal transitions of low-skilled NPRs to PR status and greater inflows of highly-skilled immigrants. This is a key part of the solution to Canada's chronic productivity challenge.

While the government's NPR reduction plan will have a short-term dampening effect on GDP growth and will cause financial problems for schools and businesses that had quickly become accustomed to the benefits accruing to them from the NPR surge, the policy changes that made this sudden bonanza possible were ill-advised, if well-intentioned, and must be reversed.

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Table A1: GDP per Capita and its Determinants, Quarterly Cumulative Log change, 2019Q4-2024Q1

Date	GDP per capita	Labour prod. (business GDP per hour worked)	Average hours worked per business job	Number of business jobs to working-age population	Ratio of the working-age population to the permanent resident population	Permanent residents share of total population	Ratio of total GDP business sector GDP
2019 Q4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020 Q1	-2.09	4.99	-2.11	-5.27	-0.1	-0.01	0.69
2020 Q2	-13.07	18.69	-3.1	-27.17	-0.20	0.06	3.74
2020 Q3	-5.01	6.78	-2.40	-10.43	-0.34	0.24	1.84
2020 Q4	-3.09	4.68	-1.61	-7.54	-0.41	0.27	1.88
2021 Q1	-2.05	3.41	-0.38	-6.04	-0.62	0.24	1.55
2021 Q2	-2.54	2.13	-0.12	-5.77	-0.85	0.22	2.00
2021 Q3	-1.42	1.45	-0.90	-2.57	-1.13	0.04	1.76
2021 Q4	-0.16	0.87	-0.79	-0.39	-1.28	0.11	1.36
2022 Q1	0.45	1.76	-0.03	-1.08	-1.33	0.08	1.08
2022 Q2	0.70	1.76	-0.59	0.31	-1.46	-0.24	0.97
2022 Q3	0.43	1.66	0.07	-0.03	-1.56	-0.75	1.11
2022 Q4	-0.19	0.59	-0.31	0.53	-1.46	-1.11	1.65
2023 Q1	-0.15	-0.19	-0.39	1.88	-1.38	-1.37	1.40
2023 Q2	-0.93	-0.56	-0.13	1.47	-1.05	-1.92	1.37
2023 Q3	-2.10	-1.02	-0.20	0.88	-0.62	-2.65	1.62
2023 Q4	-2.61	-0.83	-0.65	0.53	-0.12	-3.00	1.58
2024 Q1	-2.70	-1.10	-0.67	0.08	0.49	-3.29	1.91

Employment, Output and Productivity Adjustment During the Great Recession: The Role of Managerial Quality

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Abstract

This study investigates empirically how differences in managerial practices shaped the macroeconomic recovery from the 2008 Great Recession. We build a country-industry panel over the 2007-2015 period for eighteen industries in nine OECD countries, using an indicator of management quality at the country level based on the categorical scores of managerial practices collected at the firm level by Bloom *et al.* (2012) and an indicator measuring the industry level shocks caused by the 2008 economic crisis. We then rely on the local projection method pioneered by Jordà (2005) to estimate the impact of the shocks on post-2009 macro developments at different levels of managerial quality. We find that both production and employment were more resilient in countries where management quality is higher, resulting in no significant cumulative impact of management quality on productivity over the recovery. The effects of management on production and employment resilience are stronger for industries deeply affected by the 2008 crisis and go along with wage moderation and a slight increase in the labour share.

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Past research has amply documented the effects of differences in managerial practices on firm-level and sectoral productivity outcomes in the medium to long-run (Syverson, 2011; Bloom *et al.*, 2014, 2016; Giorcelli, 2019). In this study, we instead analyze how differences in managerial practices shaped the macroeconomic recovery from the 2008 Great Recession.² We focus on five interrelated key economic variables: value-added, employment, the average real wage per employee, labour productivity and the labour share, relying on a country-industry panel that covers 18 industries in 10 OECD countries over the 2007-2015 period. We measure managerial quality drawing on firm-level data from the World Management Survey (WMS) (Bloom and Van Reenen 2007; and Bloom *et al.* 2009, 2012, 2016), which display a wide dispersion in managerial practices across countries and across firms within countries.³

Using the local projection approach developed by Jordà (2005) and Teulings and Zubanov (2014), we investigate how the co-variation of average (country-level) managerial quality with five important economic variables was affected by the 2008 crisis. We find that, in countries with better managed firms, employment losses and declines in production have been moderated partly through wage restraints, which preserved pre-crisis productivity levels and labour shares. The positive effects of managerial quality on employment resilience increase with the depth of the shock suffered

at sectoral level. Thus, our study suggests that better managed firms are more able to cope with changes and thus perform better in times of crisis. This is consistent with findings by Schivardi *et al.* (2022) of a significant positive effect of management practices on firm performance during the spread of COVID-19 in Italy.

In the following four sections, we successively present our empirical approach, data construction, estimation results and conclusion.

Empirical Approach: The Local Projection Method

The local projection approach (Jordà, 2005) is a flexible time-series (and panel data) statistical method to estimate the dynamic effects of the “impulse responses to shocks”, defined as the differences between outcomes of a shock and counterfactual outcomes without the shock. We apply this method to analyze how the recovery following the industry-level shocks induced by the Great Recession (GR) has been affected by managerial practices. Over the seven post-crisis years (2009-2015) covered by our sample, we focus on movements in five interrelated economic variables: value-added (VA), employment (L), the average real wage per employee (W), labour productivity (LP) and the labour share (LS). Our conjecture is that firms’ ability to deal with shocks depends on management quality (MQ): precisely that movements in these variables have been influenced by MQ

² A longer version of this study is available in Cette *et al.*, 2020.

³ Several government agencies (e.g. in the United States, Canada, Australia, Ireland and New Zealand) have used the WMS approach to collect management information for benchmarking purposes. Survey data gathered by the OECD (2019) also found a wide dispersion of those practices across and within countries.

and increasingly so with the size of the shocks.

We thus estimate a system of 35 (5 variables x 7 years) stacked regressions, where the five dependent variables are the log-changes of our variables of interest (VA, L, W, LP, LS) between 2007 and each of the seven years of our study period (2009, 2010, ..., 2015), and the regressors are simply measures of the industry-level shocks (SH), the country indicators of MQ before 2008, as well as the interaction between industry-level shocks and country-level MQ (SH*MQ).

Denoting respectively the different countries, industries and years by the indices c , i and t , we can write as follows these 35 stacked regressions for the generic dependent variable X for $t = 2009, \dots, 2015$:

$$\begin{aligned} \ln(X_{cit}) - \ln(X_{ci07}) = \\ \alpha_t^X SH_i + \theta_t^X MQ_c + \beta_t^X (SH_i * MQ_c) + \\ \sum_k \gamma_t^{X,k} Z_c^k + \phi_t^X + \varepsilon_{cit}^X \end{aligned} \quad (1)$$

where α is the direct effect of the shock, θ and β are the parameters of interest measuring the influence of MQ on outcomes, γ^k are the parameters of country-specific control variables Z_w^k and ϕ and ε stand respectively for year fixed effects and idiosyncratic random effects. We also introduce country and industry fixed effects in our sensitivity analysis. Our results are very

robust to these sensitivity tests.⁴

Data construction

We use the OECD SStructural ANalysis (STAN) database to measure the 2008 shock as well as the subsequent economic adjustment in our variables of interest, and data from Bloom *et al.* (2012) to build our MQ indicator. Merging these sources, we obtain a balanced panel over the period 2007-2015 for nine countries (France, Germany, Ireland, Italy, Japan, Poland, Spain, Sweden, United Kingdom and United States) and eighteen industries.

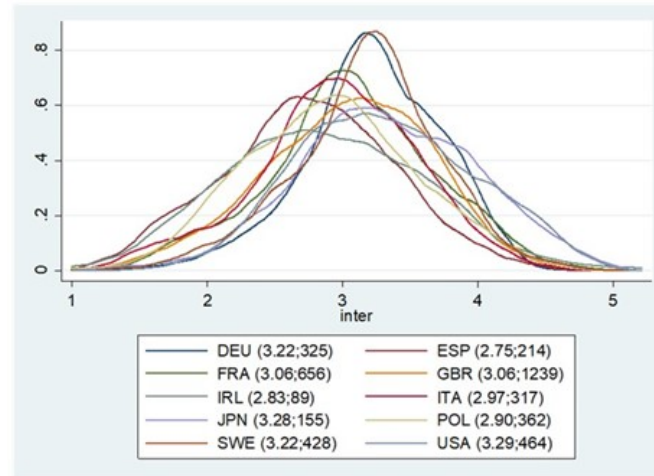
To avoid a potential source of endogeneity, instead of using country-specific industry-level production losses, we proxy such shocks in all countries with the industry production losses between 2007 and 2009 in the United States, where the economic crisis started. We therefore exclude the United States from our estimation sample. Our choice is corroborated by the fact that, while industry-specific 2007-2009 production losses differ widely *within* countries, industry production losses *between* countries are strongly correlated.

Our empirical investigation hinges largely on our MQ measures, which are based on the firm-level surveys of Bloom *et al.* (2012). Their surveys focus on some managerial firm practices that can be deemed ‘good’ or ‘bad’ irrespective of their environment.⁵

⁴ Detailed results of these econometric estimates are available upon request from the authors.

⁵ To assess the soundness of such a claim, Bloom and Van Reenen (2007) show that their MQ indicators are significantly associated with higher firm productivity, sales growth rates, profitability, Tobin’s Q, and survival rates. Managerial quality, however, is particularly difficult to measure. For example, the use of incentives is scored as high managerial quality in the survey we use, but a standard result in dynamic incentive models is that high-powered incentives can lead to unproductive outcomes.

Chart 1: Distribution of Managerial Quality at Firm Level by Country during the Pre-crisis Period (2003-2008)



Note: The first number in the parenthesis after the name of each country corresponds to the median value of the MQ indicator and the second number corresponds to the number of firms covered by the survey in the country. Source: Authors calculations using Bloom *et al.* (2012) data.

Their survey includes eighteen questions asked to medium- to large-sized manufacturing firms, with 50 to 10.000 workers.⁶ They cover four areas:

- *Monitoring*: How well do organizations monitor developments inside the firm, and use this information for continuous improvement?
- *Targets*: Do organizations set the right targets, track the right outcomes, and take appropriate action if the two are inconsistent?
- *Incentives*: Are organizations promoting and rewarding employees based on performance, prioritizing careful hiring, and trying to keep their best employees?
- *Operations*: Introduction and utilization of lean production methods.

All the survey replies are scored on a

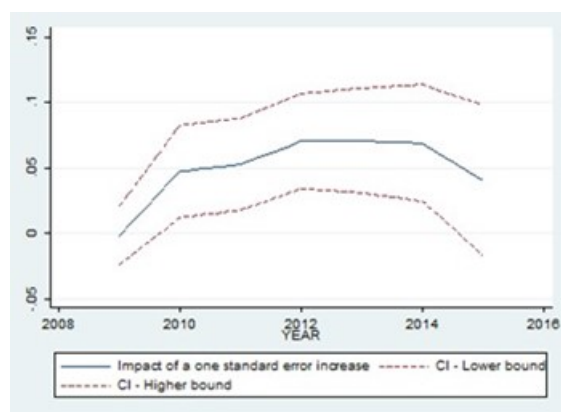
scale from 1 to 5, increasing in the quality of practices. The unweighted average of these scores is our MQ measure at the firm level, which we turn into a country-level variable (MQc) by taking the median of the firm level measures in each of our nine countries. We rely on MQ data before the 2008 Great Recession to avoid a potential source of endogeneity. The countries with the highest MQc are Japan and the United States and the ones with the smallest MQc are Poland, Ireland and Spain.

Chart 1 shows the distribution of the firms' values of our composite management quality indicator at firm level during pre-crisis period (2003-2008). It indicates also in the legend the median values of the MQ indicator for each of our nine countries, as well as the number of individual firm observations underlying the country distri-

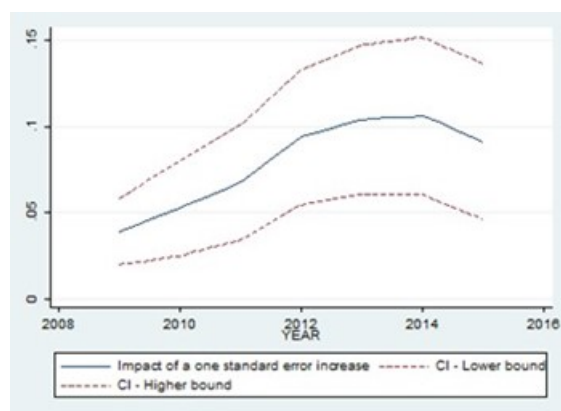
⁶ Our main study sample is a country-industry panel covering both manufacturing and non-manufacturing industries, while all the firms surveyed in Bloom, Genakos, Sadun and Van Reenen (2012) are manufacturing firms. Therefore, one of our sensitivity analyses restricts the estimation sample to the manufacturing industries (see the section "Estimation results"), leaving results broadly unchanged.

Chart 2: Average Impact of a One Standard Error Increase of Pre-crisis Country-level Management Quality

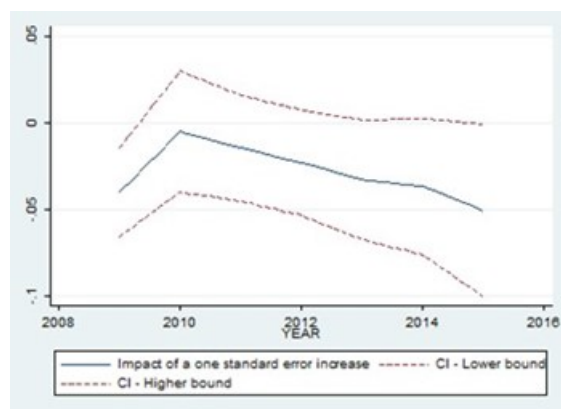
Panel A: Value-added



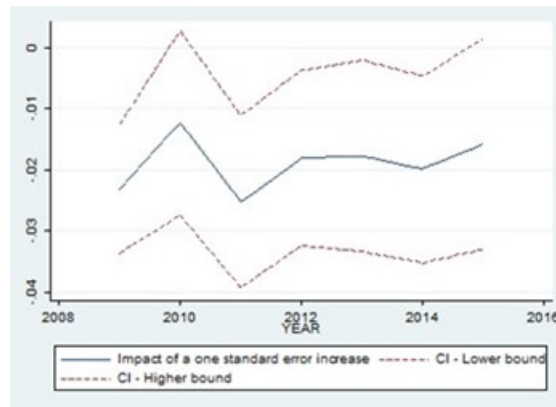
Panel B: Employment



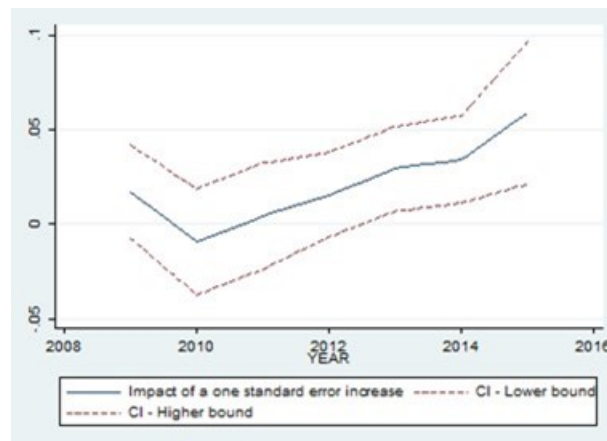
Panel C: Labour productivity



Panel D: Wage per worker



Panel E: Labour share



Note: For each variable of interest, dashed lines correspond to the confidence intervals. Higher and lower bounds correspond to the estimated value of the coefficient plus and minus two estimated robust standard errors.

butions.⁷ The countries with the highest MQ median value are Japan (3.28) and the United States (3.29), and the ones with the smallest are Poland (2.90), Ireland (2.83) and Spain (2.75). As can be seen on the Chart 1, Ireland and Japan are also the two countries with the most spread-out distributions.

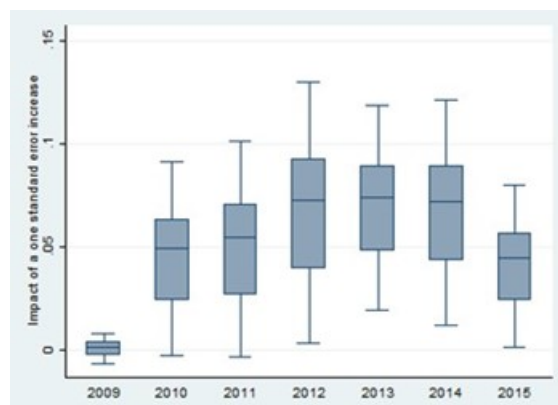
Estimation Results

For heuristic purposes, we first report findings concerning the average impact of MQ on our variables of interest and then report its industry-specific impact, which depends on the industry-specific size of the shock. Detailed estimates are available in

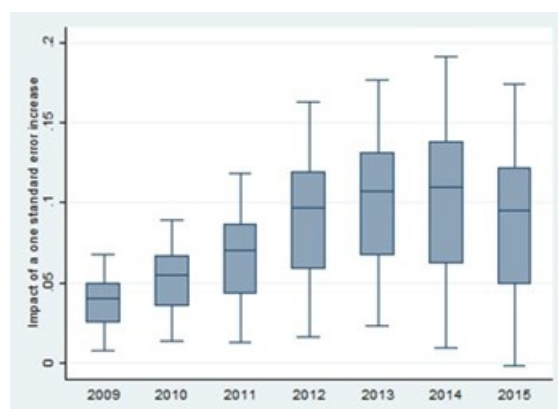
⁷ Unfortunately, the number of firms observed per country does not allow to build reliable indicators at the industry level.

Chart 3: The Industry-specific Impact of Management Quality

Panel A: Value-added



Panel B: Employment



Note: The impact of a (pre-crisis) one standard error increase of MQ on the change in value-added (employment) in 2015 compared to 2007 would be 0.1 per cent (-0.1 per cent) in industries where the shock was nil, 2.6 per cent (5.0 per cent) for the first quartile of shock, 4.3 per cent (9.3 per cent) for the median shock, 5.7 per cent (12.3 per cent) for the third quartile of shock and 8.2 per cent (17.9 per cent) for the most important shock.

Cette *et al.* (2020).

Chart 2 shows the yearly evolution (i.e. cumulative effect at year t as measured by the coefficient $\hat{\theta}_t^X$) of the estimated average impacts of a pre-crisis one standard error increase of MQ on each of our variables of interest. Overall, good managerial practices may have helped counteract the detrimental direct impacts of the Great Recession on employment with a moderating effect on wage resulting in an upward push on the labour share after a few years. As

MQ has a positive and significant impact on both value-added and employment for most of the post-crisis period, there is no significant impact on productivity, except in the first year.

Chart 3 presents our main result: the estimated impact of a one standard error increase of the pre-crisis MQ , as in Chart 1, but in terms of box plots showing the effects across industries that experienced

shocks of different sizes.⁸ As conjectured, the positive influence of MQ on these two variables is related to the size of the shocks: the bigger are the shocks the larger are both their direct detrimental impacts and the countervailing influence of good managerial practices on employment and value added.

These results are robust to changes in the estimation sample, in the set of fixed effects and in the estimation method of standard errors (bootstrap s.e. as well as clustered s.e. at the country level) as well as to including control variables (such as OECD measures of labour and product market regulations, and human capital) and using instrumental variables (Cette *et al.*, 2020).

Conclusion

Countries where management quality was higher than average at the outset of the Great Recession weathered the crisis better than other countries in terms of employment and production outcomes. This was partly due to the ability to moderate real wage growth and resulted in stronger resistance of labour shares. Our results, which are robust to several sensitivity tests, point to the potential gains to be obtained from raising the level of managerial abilities not only in terms of growth but also in terms of better resilience to cyclical downturns.

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⁸ We present only the effects on value-added and employment for which the MQ impact (i.e. the (β_t^X) coefficients) depends significantly on the size of the shock.