BIROn - Birkbeck Institutional Research Online

Chadha, J.S. and Samiri, Issam (2025) Understanding UK productivity using a macroeconomic lens. Journal of Economic Surveys , ISSN 1467-6419. (In Press)

Downloaded from: https://eprints.bbk.ac.uk/id/eprint/55944/

*Usage Guidelines:*
Please refer to usage guidelines at https://eprints.bbk.ac.uk/policies.html or alternatively contact lib-eprints@bbk.ac.uk.

*Journal of Economic Surveys*

WILEY

ARTICLE OPEN ACCESS

# Understanding UK Productivity Using a Macroeconomic Lens

Jagjit S. Chadha[1,4,5] | Issam Samiri[2,3,5]

[1]University of Cambridge, Cambridge, UK | [2]The National Institute of Economic and Social Research (NIESR), London, UK | [3]Birkbeck, University of London, London, UK | [4]Centre For Macroeconomics, London, UK | [5]The Productivity Institute (TPI), Manchester, UK

**Correspondence:** Issam Samiri (i.samiri@niesr.ac.uk)

**Received:** 2 July 2024 | **Revised:** 14 April 2025 | **Accepted:** 22 May 2025

**Funding:** This study was supported by Economic and Social Research Council (ES/V002740/1).

**Keywords:** investment | macroeconomics | productivity | real interest rates

## ABSTRACT

We survey UK labor productivity over the long run, comparing it with other advanced economies, and focus on the sharp slowdown since the global financial crisis. Using a growth accounting framework, we highlight the primary role of total factor productivity (TFP), while noting that the contribution of capital shallowing is influenced by methodological choices. We assess the UK's productivity performance through standard neoclassical models and revisit the secular stagnation debate. Long-term trends, including a 30-year decline in real interest rates and increased labor supply since 2008 ought to have spurred investment, and yet private and public investment as a share of GDP has declined. The economic literature points to poor TFP growth, government decisions on public investment, flexible labor supply, heightened uncertainty and the distortion of investment decisions in an era of ultra-low interest rates as probable culprits behind the disappointing investment trends.

**JEL Classification:** E22, E24, E32, E44, E51, E62, O16, O42, O47

## 1 | Introduction

The material improvement in living standards, as measured by the increase in the production of goods and services, has been an artefact of the modern world. Britain has been characterized as the first industrial nation (Mathias 1969), and accordingly, with a sustained period of economic growth, it reached a peak in 1900 of 9.4% of world output (Maddison 2010). This fraction has declined with the increasing growth of emerging parts of the world but also because Britain's relative performance has tended to deteriorate. At present, the UK is at some 2.3% of world GDP and seems likely to fall to 2% or less over the next 20 years.[1] That observation does not necessarily imply that living standards, as measured broadly by per capita income, will fall but more that many other nations may see their living standards rise materially faster. This process has been emphasized by the phenomenon that has come to be known as the productivity puzzle: growth in measured productivity has fallen far behind previous trends and this has opened a large gap between anticipated and actual income per head (see Figure 1).

We might characterize "normal times" as involving the steady expansion of the economy's supply capacity with small jolts or shocks to demand, from changes in confidence, sentiment or from overseas markets, that lead to small fluctuations around that expansion path: these small fluctuations are called business cycles. The growth in capacity can most easily be thought about as the sum of the growth in inputs, typically capital and labor, and how they combine to produce a given level of output, total factor productivity (TFP): a residual representing technological progress, changes in management practices, organizational change, network effects and other factor affecting production

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). *Journal of Economic Surveys* published by John Wiley & Sons Ltd.

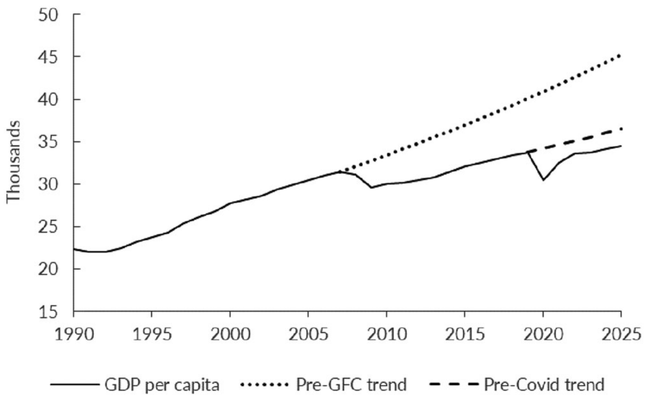


**FIGURE 1** | Recent trends in GDP per head in the UK.
*Note:* Real GDP per capita in the UK expressed in 2019 thousands of British pounds. *Source:* NIESR; NIESR 2022.

that are not captured by our measures of labor and capital. The growth in TFP is thus simply the difference between the growth rate in the index of outputs and the growth rate in the index of inputs in production and does not per se explain productivity performance. Providing short-run fluctuations in demand, which take the economy temporarily away from this level of supply capacity, do ebb away then we can concentrate on accounting for economic growth in terms of these factors alone. But such accountancy exercises, while useful and widely deployed, do not provide any causal measure and thus are not a guide to the appropriate policy interventions to reverse observed trends.

The problem following the financial crisis of 2007–2008 is not so much that we cannot account for growth in output in this manner, but more that the growth in output seems concentrated in the increase of inputs, especially labor, rather than productivity. We document a marked increase in aggregate hours worked following the financial crisis, mostly driven by increased participation of older workers. And so, labor productivity, as measured by output per hour worked, stalled after 2008. It is as though the economy, rather than working harder and smarter, has been spending more time at the office.

Given the widespread productivity slowdown in advanced economies, questions related to productivity have garnered increasing attention from economists and policymakers alike. The result has been a voluminous literature, which has been consolidated into a number of surveys. Literature reviews addressing the measurement of productivity include Del Gatto et al. (2011), Van Beveren (2012), Ahmed and Bhatti (2020), Martin and Riley (2024). Other surveys explore the relationship between specific economic sectors and aggregate productivity performance. For instance, Cardona et al. (2013) and Draca et al. (2006) examine the role of information and communication technologies in driving productivity growth, while Heil (2019) investigates the link between finance and productivity.[2] Syverson (2011) surveys the literature addressing the persistent heterogeneity of measured productivity levels among businesses.

More closely aligned with the present study, Goldin et al. (2024) survey various explanations for the post-2005 productivity slowdown in advanced economies. They argue that this phenomenon is attributable to a confluence of factors, including measurement issues, reduced capital deepening, diminished spillovers from intangible capital, and a deceleration in trade.

Growing risk and uncertainty, at the domestic and global level, may also have acted to delay investment and hence an improvement in productivity performance, but identifying exogenous drivers of uncertainty is no simple matter. First, as productivity is a phenomenon of whole economy choices on output to input ratios, there are many other possible factors that uncertainty proxies may capture. Note also that poor forecasts of productivity since 2010 may well have driven indirect uncertainty measures (Forni et al. in press; Atkins and Lanskey 2023). That said, the three routes to measuring uncertainty: financial market variables, surveys and newspaper count are useful starts (Bloom 2023).

This paper documents the recent underperformance of productivity in the United Kingdom and addresses key macroeconomic questions related to the observed slowdown. The recent productivity slowdown is examined under the light of other macroeconomic trends. These include low real interest rates, low investment and increased labor supply. While drawing on existing literature that explores productivity slowdowns in the UK and other advanced economies, this paper places particular emphasis on interpreting productivity stagnation through the lens of macroeconomic theory. The discussion begins with the neoclassical growth framework and progresses to insights from more recent macroeconomic research.

We start by examining the UK's recent and long-term productivity trends and contrast these against trends in comparable economies (Section 2). We then apply modern growth accounting techniques to examine the recent productivity slowdown in the UK and show that the results and their interpretation are impacted by the choice of methodology. Section 3 examines recent UK productivity performance under the lens of standard neoclassical growth models. The 'secular stagnation' debate is reviewed in section 4. This section also focuses on the UK's labor demographics and comments on the country's investment dynamics to illustrate some of the arguments emanating from the "secular stagnation" literature. The UK economy suffers from chronic under-investment despite real interest rates trending down. We examine this puzzle in Section 5 and comment on some of the explanations brought by recent economic literature. Section 6 argues that aggregate TFP is not necessarily an exogenous process that remains out of the remit of economic policy and that there is scope to improve productivity growth through long-term policy commitments. The issue of government debt, fiscal policy, and their implications for productivity growth are discussed in Section 7, and Section 8 concludes.

## 2 | Productivity Trends in the United Kingdom

### 2.1 | Long-Term Trends of the UK Labor Productivity and the Recent Slowdown

By labor productivity, most economists refer to output per hour worked. We will adopt this convention in the remainder of this work.[3] We use the Bank of England millennium spreadsheet (Thomas and Dimsdale 2017) from 1760 to 2016 and complement it using ONS data from 2017 to 2021 to construct an



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

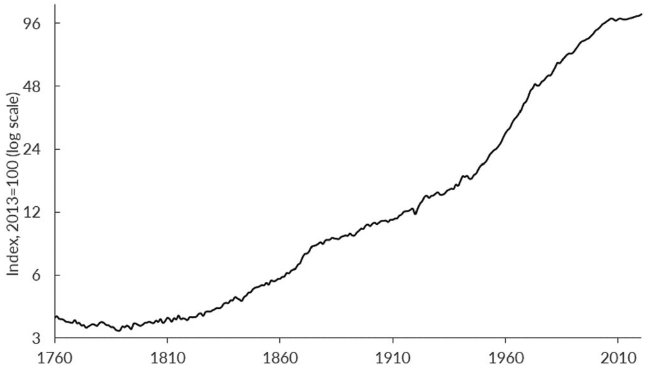


**FIGURE 2** | Long-term trends in GDP per hour in the UK (1760-2021).
*Note:* UK GDP/hours Index (2013 = 100). Data up to 2016 from Thomas and Dimsdale (2017), ONS data have been used for the remaining years (July 2022 data).

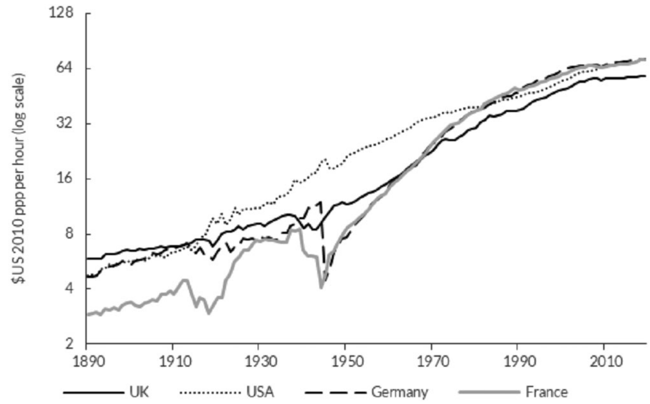


**FIGURE 3** | International comparison of labor productivity (1890–2019).
*Note:* Labor productivity in the UK, USA, Germany, and France, expressed in USD 2010 PPP per hour. *Source:* Bergeaud et al. (2016).

**TABLE 1** | Long-term trends in the growth of labor productivity, UK (1760–2021).

| Period | Growth rate |
|---|---|
| 1760–1790 | −0.40% |
| 1790–1840 | 0.60% |
| 1840–1873 | 1.50% |
| 1873–1914 | 0.90% |
| 1914–1945 | 1.40% |
| 1945–1974 | 3.70% |
| 1974–2008 | 2.30% |
| 2008–2020 | 0.50% |

*Note:* Average annual growth rates of the UK GDP/hours Index (2013 = 100). Data up to 2016 from Thomas and Dimsdale (2017), ONS data has been used for the remaining years (July 2022 data).

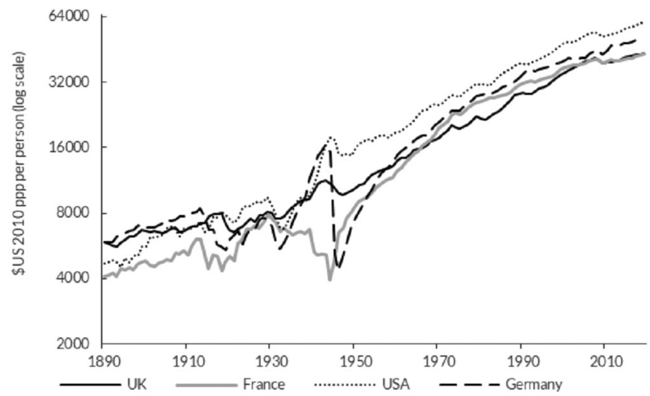


**FIGURE 4** | International comparison of GDP per person (1890-2019).
*Note:* GDP per person in the UK, USA, Germany, and France, expressed in USD 2010 PPP per person. *Source:* Bergeaud et al. (2016).

output per hour series for the UK covering the 1760–2021 period. The resulting time series in Figure 2 shows the exceptional period of labor productivity growth after the Second World War. In this so-called 'golden age' period (1946–1974), productivity grew by an average of 3.7% a year (Table 1). Labor productivity growth slowed down after the oil shock (1973) but remained robust at around an average of 2.3% a year until the onset of the global financial crisis (GFC). Very low levels of productivity growth have plagued the post-GFC period (2008–2021). This latest episode of productivity slowdown stands out as unprecedented since the onset of the industrial revolution (Crafts 2021).[4]

Revisions to national account data affect productivity measures, thus affecting the measured magnitude of the post-GFC slowdown (Table 2). Using data from the Blue Book 2013, the average annual growth of output per hour worked dropped from 2.4% for the 1997–2007 period to 0.1% for the 2009–2013 period, implying a slowdown of 2.3% in the average labor productivity growth rate. When using 2021 blue book data, the average growth rate of output per hour worked between 1997 and 2007 is revised down to 2%, thus implying that the average growth rate of labor productivity has slowed only by 1.3% after 2008. Nevertheless, the post-GFC slowdown remains substantial for all available data vintages and seems unlikely to be revised away.

## 2.2 | International Comparisons

Figure 3 compares the long-term labor productivity trends in the United Kingdom, the United States, France and Germany between 1890 and 2019. The figure shows that the UK economy remained more productive than the US economy until the First World War. The US subsequently increased its productivity advantage over the UK until the early 1970s.[5] The figure also shows that France and Germany's labor productivity surpassed the UK by the mid-1960s.

The long-term trends of GDP per capita of the UK, US, France, and Germany provide a different picture of the UK's economic performance evolution relative to other advanced economies (Figure 4). For instance, Germany's GDP per capita is already higher than the UK by 1957. In addition, the UK's GDP per capita caught up with the French GDP per capita again in 2002, and



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

**TABLE 2** | Average annual growth rates of output per hour worked using different Blue Book data vintages, UK.

| Blue Book | 1997 to 2007 | 2009 to latest year | Change in growth rate |
|---|---|---|---|
| 2011 | 2.1% | 1.1% | −1.0% |
| 2012 | 2.5% | 1.3% | −1.2% |
| 2013 | 2.4% | 0.1% | −2.3% |
| 2014 | 2.2% | 0.5% | −1.8% |
| 2015 | 2.2% | 0.5% | −1.8% |
| 2016 | 2.2% | 0.4% | −1.8% |
| 2017 | 2.1% | 0.4% | −1.7% |
| 2018 | 2.2% | 0.5% | −1.7% |
| 2019 | 2.3% | 0.6% | −1.7% |
| 2020 | 2.2% | 0.5% | −1.7% |
| 2021 | 2.0% | 0.7% | −1.3% |

*Note:* Average annual growth rates of output per hour worked, UK, various Blue Book vintages. The second period covers from 2009 to the Blue Book last year. Source: Martin and Mackenzie (2021).

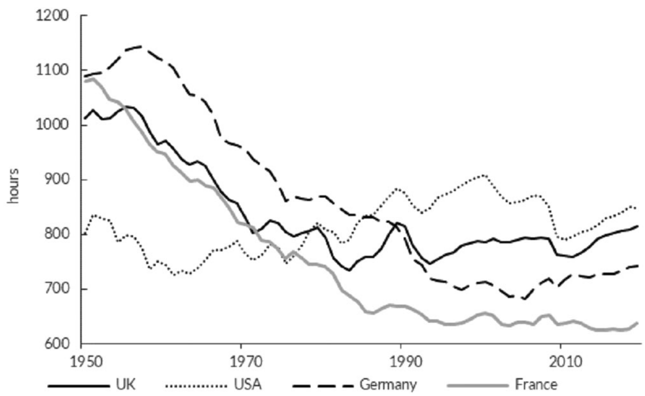


**FIGURE 5** | International comparison of hours worked per person (1950-2019).
*Note:* Hours worked per capita in the UK, USA, Germany, and France. *Source:* Penn World Tables, version 10.0 (Feenstra et al. 2015).

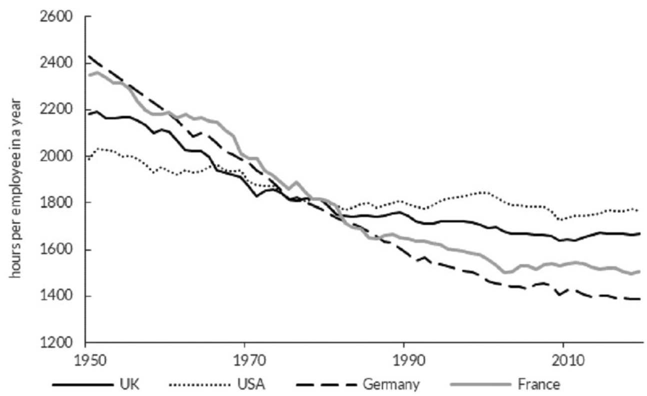


**FIGURE 6** | International comparison of the average yearly hours worked per employee (1950–2019).
*Note:* Average hours worked per year and employee in the UK, US, Germany, and France. *Source:* Penn World Tables, version 10.0 (Feenstra et al. 2015).

both countries had similar GDP per capita figures between 2002 and 2019.

These trends can be explained by the evolution of labor productivity (Figure 3) and that of hours worked per capita (Figure 5). Germany's higher hours worked per capita allowed it to catch up with the UK's GDP per capita as early as 1957, despite its lower levels of labor productivity at the time. On the other hand, France's decreasing hours worked per capita since the mid-1970s allowed the UK to catch up with French GDP per capita in 2002 despite the UK economy remaining less productive than the French economy in terms of output per hours worked.

## 2.3 | An Important Measurement Issue: Hours Worked

Aggregate labor supply can be explained by the employment rate (extensive margin) and the average number of hours worked per employee (intensive margin).[6] Figure 6 contrasts the average number of hours worked by UK employees against averages in the US, France, and Germany. The figure shows that the French and German workers, unlike their British and American counterparts, reduced their intensive margin of supply since 1970. The differences in terms of intensive labor supply are large enough to warrant a closer look at how these averages are measured. Marianna et al. (2018) find that countries, such as the UK, that use labor force surveys (LFS) data without further adjustments tend to overestimate the number of hours worked. To illustrate the size of this bias, the authors adjust the measures of hours using information available in the LFS and other complementary sources such as administrative or business statistics. They find that the hours worked measurement bias accounts for 10% or more of the relative labor productivity gap in many countries. For instance, the US-UK productivity gap is reduced by a third when applying adjustments to the measurement of hours worked.

However, the country-specific hours worked adjustments introduced in Marianna et al. (2018) do not display disproportionate



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

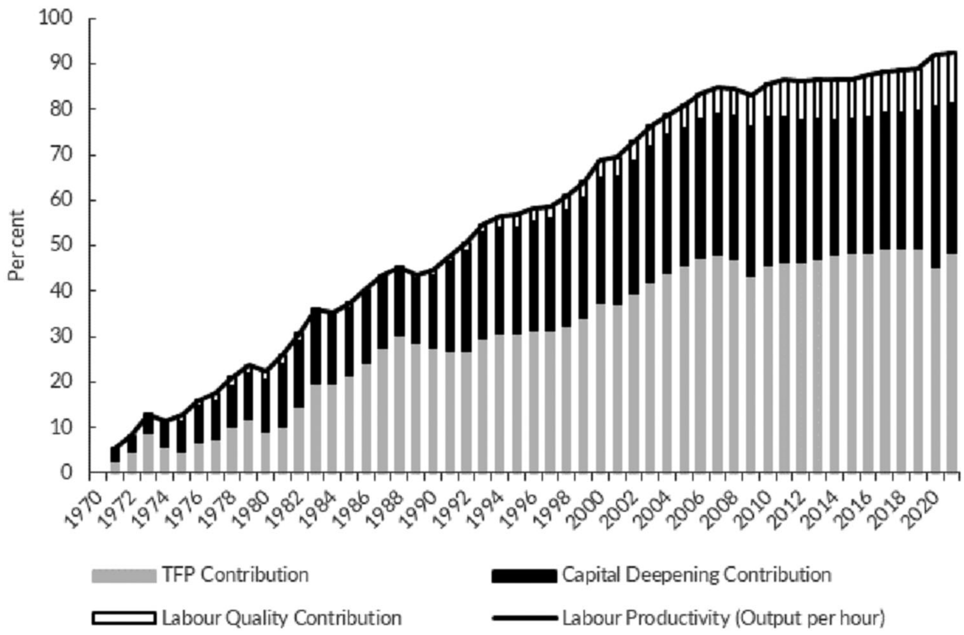


**FIGURE 7** | Standard growth accounting (1970–2021).
*Note:* Cumulative Decomposition of labor productivity from 1971 using standard growth accounting. Labor productivity is calculated as the market sector GVA per hour worked. ONS data, authors' calculations (July 2022 data).

changes over time. This implies that while differences in hours worked measurements explain some of the international differences in productivity levels, they are less likely to explain international differences in labor productivity growth. Goldin et al. (2024) survey alternative sources of mismeasurement, including the changing boundaries of GDP and issues related to deflators' measurement. The authors, however, do not report on the effects of mismeasuring hours worked.

### 2.4 | Productivity Growth Accounting

The standard productivity growth accounting framework decomposes the growth of GVA per hour worked ($Y/N$) into three components: labor composition ($Q$), predominantly representing the skills of the workforce; capital deepening ($K/N$), representing the availability of capital per hour worked; and a TFP residual. The standard growth accounting framework is derived from the definition of TFP as a residual that captures changes in output unexplained by changes in production inputs (capital and labor)[7]

$$\Delta \ln(Y/N) = \Delta \ln TFP + \alpha \Delta \ln(K/N) + (1-\alpha)\Delta \ln Q, \quad (1)$$

where $Y$ represents output, $N$ hours, $Q$ a labor composition index, $K$ capital and $\alpha$ is the share of capital.[8] Figure 7 presents the UK's market sector cumulative gains in log labor productivity from 1970 to 2021 and its decomposition using the standard growth accounting method. The figure shows that 56% of the growth in the market sector output per hour between 1970 and 2019 is explained by improvements in TFP, about 34% can be attributed to capital deepening, measured as a capital over hours ratio. An improved composition of the UK workforce from the mid-1990s onward culminates in contributing to 12% of the cumulative gains in output per hour by 2021.

Fernald et al. (2017) adopt a different approach to productivity growth accounting. They use a complementary decomposition of labor productivity in terms of the capital–output ratio

$$\Delta \ln(Y/N) = \frac{1}{1-\alpha}\Delta \ln TFP + \frac{\alpha}{1-\alpha}\Delta \ln(K/Y) + \Delta \ln Q. \quad (2)$$

This approach, which also derives from the definition of TFP, accounts better for the endogeneity of capital formation.[9] In neo-classical growth models, slower TFP growth leads to slower capital deepening as measured using capital per hours worked ($K/N$) and no change in the capital–output ratio ($Y/K$). Changes to the capital–output ratio would then capture capital formation effects beyond what would occur endogenously due to changes in the TFP growth rate in the Solow-Swan model (Solow 1956; Swan 1956). Figure 8 shows the decomposition of the cumulative gains in the UK's market sector labor productivity between 1970 and 2021 using the method in Fernald et al. (2017). Unlike the results from standard growth accounting, gains in labor productivity are almost exclusively driven by improvements in TFP until the mid-1990s when the effects of better labor composition start to be visible. The cumulative contribution of improved capital–output ratios remains close to zero throughout the studied period, with a slight positive effect for most of the great moderation period (1993–2004) and a small negative effect from the onset of the great recession until the start of the Covid-19 pandemic. The capital–output ratio improves following sudden drops in output, as it takes longer for capital to adjust. While the impact of the capital–output ratio on the cumulative gain in labor productivity since 1970 can turn from positive to negative and vice versa, its overall



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

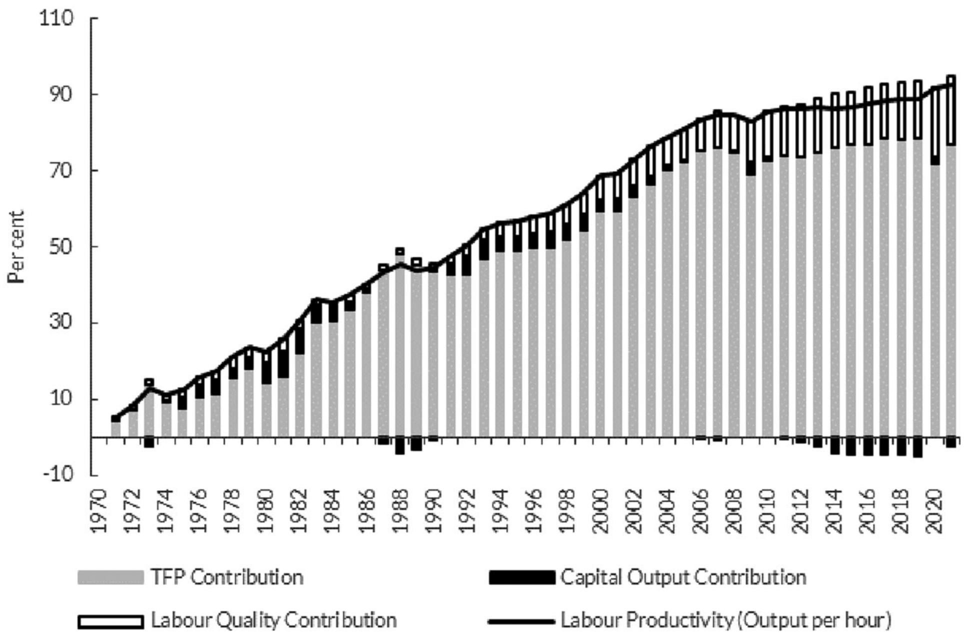


**FIGURE 8** | Fernald et al. (2017) growth accounting (1970-2021).
*Note:* Cumulative Decomposition of labor productivity from 1971 using the growth accounting methodology in Fernald et al. (2017). Labor productivity is calculated as the market sector GVA per hour worked. ONS data, authors' calculations (July 2022 data).

**TABLE 3** | UK growth accounting, two methodologies.

| Period | GVA/hour | Standard method | | | Fernald et al. (2017) | | |
|---|---|---|---|---|---|---|---|
| | $\ln Y/N$ | $\ln TFP$ | $\alpha \ln(K/N)$ | $(1-\alpha)\ln Q$ | $\frac{\ln TFP}{1-\alpha}$ | $\frac{\alpha \ln(K/Y)}{1-\alpha}$ | $\ln Q$ |
| 1997–2007 | 2.43 | 1.52 | 0.62 | 0.28 | 2.41 | −0.43 | 0.45 |
| 2009–2019 | 0.40 | 0.20 | −0.13 | 0.33 | 0.33 | −0.45 | 0.52 |
| Slowdown | −2.03 | −1.32 | −0.75 | 0.04 | −2.08 | −0.02 | 0.07 |
| Contribution to slowdown | | 65% | 37% | −2% | 102% | 1% | −3% |

*Note:* Average GVA per hour growth rate in the UK's market sector in the 1997-2005 and 2009-2019 periods in % points, and its decomposition using the standard growth accounting method and the method in Fernald et al. (2017). The slowdwon row represents the difference in the growth between the later and the earlier period. ONS data, authors' calculations (July 2022 data).

contribution is never significant. This is indicative of a stable capital–output ratio in the long run.

The growth of the UK's market sector labor productivity has slowed down substantially following the GFC. Table 3 shows that the average growth rate of output per hour in the market sector has dropped from 2.4% in the 1997–2007 period to 0.4% in the 2009–2019 period. The standard growth accounting and the Fernald et al. (2017) method draw different pictures when decomposing the post-GFC productivity slowdown. Standard growth accounting explains about a third of the slowdown by capital shallowing while the capital–output method attributes nearly all the slowdown to weaker TFP growth.[10] Both methods show that the improvements in labor compositions since 2009 marginally attenuated the post-GFC productivity slowdown.[11] We are thus drawn to an examination of why the growth in TFP and capital accumulation has disappointed so.

## 2.5 | Accounting for More

Standard growth accounting techniques attribute all changes in productivity that cannot be explained by variations in labor and capital to the TFP residual. Alternative approaches to accounting for production inputs-such as incorporating energy resources used or natural capital consumed-can yield different residuals. Furthermore, TFP captures the influence of prevailing financial conditions, management quality, organizational institutions, global spillovers, and other determinants of aggregate production. As Abramovitz (1956) aptly described it, TFP is "a measure of our ignorance." Additionally, as an aggregate measure, TFP overlooks the impact of sectoral composition.

Looking "below the aggregate," Riley et al. (2018) find that manufacturing, the information and communication technology (ICT) sector, and finance account for 80% of the productivity slowdown, despite constituting only 35% of market sector GVA.[12] Similarly,



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Coyle and Mei (2023) report that the UK productivity slowdown is largely driven by the manufacturing and information and communication sectors, with the significance of these industries in explaining the slowdown extending beyond the UK to most advanced economies.[13]

Riley et al. (2018) also note that the industry sections responsible for most of the aggregate slowdown saw rapid productivity growth before the global financial crisis, are more competitive and more dependent on global demand than other industries. This indicates that weak global demand and the reduced scope of convergence toward industry-level productivity frontiers have a role in the UK's productivity slowdown.

Consistent with an open economy perspective, Harris and Moffat (2017) contend that the import prices of intermediate inputs paid by UK producers increased significantly between 2007 and 2014, driven by currency depreciation. They argue that this rise reduced intermediate labor intensity, contributing to the weak productivity performance observed in the UK after 2008.[14]

Standard growth techniques ignore the use of natural capital in the production process. Agarwala and Martin (2022) propose an emissions-adjusted measure of Gross Value Added (GVA) that accounts for the negative effects of greenhouse gas emissions and other pollutants. The authors are then able to include environmental considerations into the calculation of UK labor productivity (emission-adjusted GVA per hour worked). Although this adjustment generally produces a higher productivity growth rate over the period 1990–2019, it does not explain the UK's productivity slowdown, as the GVA adjusted for emissions exhibits a slowdown comparable to that observed with conventional GVA measures.

## 3 | The Recent Productivity Slowdown Under the Neoclassical Lens

We put the recent UK productivity slowdown under the lens of the Solow-Swan standard growth framework and show that this framework cannot predict the rise in hours worked after 2008. Higher labor since 2008 was not however accompanied by more investment as would be suggested by neoclassical economic theory. We then attempt to reconcile the slowdown of TFP and the lower real interest rates using the capital accumulation neoclassical growth model. We find that the drop in real interest rates after 2008 is only consistent with post-GFC TFP slowdown for extreme values of the households' elasticity of intertemporal substitution.

### 3.1 | The Solow-Swan Model and Long-Term Trends

The Solow-Swan model (Solow 1956; Swan 1956) is the standard literature framework for studying long-term economic growth. The model relies on exogenous TFP, saving rate and population growth to explain the long-term trends of other macroeconomic variables. In the Solow-Swan model, production is constrained by a Cobb-Douglas technology using two inputs: labor hours and capital; TFP represents the residual output unexplained by changes in the two production inputs.

In addition to hours and capital, modern accounting frameworks consider the impact of labor composition (or labor quality) on production. We, therefore, modify the Cobb-Douglas production function used in the Solow-Swan model to account for the labor composition index Q

$$Y = TFP \times K^{\alpha}(Q.H)^{1-\alpha}, \tag{3}$$

where $Y$ is output, $K$ is capital, $H$ hours, and $\alpha$ is the share of capital. In the modified Solow-Swan framework, long-term growth of labor, capital, and hours is

$$g(Y) = g(K) = \frac{g(TFP)}{1-\alpha} + g(Q) + g(N), \tag{4}$$

$$g(H) = g(N), \tag{5}$$

where the function $g$ is used to designate the long-term growth rate and $N$ is the population size. These are textbook Solow-Swan long-term growth results (e.g., Romer 2012), with the additional contribution of labor quality to the long-term trends of output and capital.

Table 4 shows the average growth rates of TFP, labor composition, working-age population, hours worked, output, capital and the average growth rate predicted by the model for hours, capital and output for the pre-GFC period (1990–2007) and the post-GFC period (2008–2019). Except for the average growth of hours worked, Solow-Swan trends account well for the pre-GFC long-term trends. Over the 1990–2007 period, the average growth rate of hours worked (0.17%) is about a third of the average growth rate of the UK's working-age population (0.5%). Given the long-term growth rates of the working-age population, labor composition and TFP, the model predicts long-term growth of capital and output of around 2.69% between 1990 and 2007. Historical data show that output grew on average at a rate slightly below the one expected by the model (2.46%) and that capital grew at a rate close to the one expected by the model (2.6%).

In the post-GFC period, hours worked grew at an average of 1.07% per year, significantly outpacing the growth of the working-age population (0.34%). On the other hand, capital grew at a rate close to the one expected by the model (0.87% in the data and a model-implied growth of around 1%). The discrepancy between the model-implied growth of output and the much higher average output growth in the data (1.41%) is mainly explained by the unusual growth of hours worked in the decade that followed the global financial crisis.

Admittedly, labor supply is exogenous by design in the Solow-Swan model so this neoclassical growth framework can hardly be criticized for missing the changing trends in the UK's labor market. Textbook expositions of the model assume that labor supply is inelastic and driven by population growth. This is also the main interpretation of the exogenous labor supply in Solow (1956). We use the working-age population as a slightly better demographic proxy of aggregate labor supply.[15] Within the Solow-Swan framework, the rapid rise in hours post-2008 should have led to an increase in the marginal product of capital, thus leading to substantially more investment than recorded after the great financial crisis. As noted above, capital



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

**TABLE 4** | Average growth rate of UK macro variables and the prediction of the Solow-Swan model.

| | Data | | | | | | Solow-Swan model | |
|---|---|---|---|---|---|---|---|---|
| | TFP | $Q$ | $N$ | Hours | $Y$ | $K$ | Hours | $Y$ and $K$ |
| Pre-GFC | 1.08 | 0.44 | 0.50 | 0.17 | 2.46 | 2.60 | 0.50 | 2.69 |
| Post-GFC | 0.12 | 0.48 | 0.34 | 1.07 | 1.41 | 0.87 | 0.34 | 1.00 |

*Note:* Average growth of macroeconomic variables and the Solow model's predicted output and capital average growth rates expressed in percentage terms. The pre-GFC period covers from 1990 to 2007 and the post-GFC period covers 2008 to 2019. The model predictions in both periods are made using the period's average growth rates of TFP, labor quality $Q$, and working-age population $N$ to predict the average growth of hours worked $H$, output $Y$ and capital $K$. ONS data for the UK's market sector economy and the UK's population aged between 16 and 63, authors' calculations (ONS data from July 2022).

growth in the post-GFC period was in line with the Solow prediction, while hours grew faster than expected by the Solow-Swan model. This means that the Solow-Swan model cannot reconcile investment levels with the growth of aggregate hours worked.

In summary, the Solow-Swan model accounts well for the long-term trends of capital, labor hours and output in the pre-GFC period. Given that it assumes labor supply to be exogenous, the Solow-Swan framework is unable to predict the post-GFC increase in aggregate hours. Crucially, while this growth framework predicts a constant capital-output ratio, post-GFC capital grows at a slower pace than output. The lack of investment despite abundant labor supply and cheap financing costs after 2008 is a puzzle that evades the explanatory power of standard neoclassical growth theory.

### 3.2 | Long-Term Interest Rates Trends Under a Neoclassical Lens

The Ramsey rule is a good starting point for discussing long-term saving behavior under a neoclassical lens. The rule stipulates that the marginal product of capital $r$ is a function of the rate of time preferences $\rho$, the expected real growth rate of per-capita consumption $g(c)$ and the elasticity of marginal utility of consumption $\sigma$ (hereafter called EMU)

$$r = \rho + \sigma g(c). \tag{6}$$

The original contribution by Ramsey (1928), was developed further by Cass (1965) and Koopmans (1965), leading to the now standard Ramsey-Cass-Koopmans growth model (hereafter RCK).[16] The model assumes that households' utility is a function of the per-capita consumption $c$

$$U = \frac{c^{1-\sigma}}{1-\sigma}, \tag{7}$$

where $\sigma$ is the same EMU that appears in the Ramsey rule and $1/\sigma$ corresponds to the elasticity of intertemporal substitution (EIS). In addition, the RCK model also assumes that the representative households seek to maximize their lifetime utility, discounted at a rate $\rho$. Similarly to the previous subsection on the Solow-Swan model, we modify the Cobb-Douglas production assumed in the standard version of the RCK model to allow for changes in labor quality as in expression (3). As in the Solow-Swan model described above, the growth rate of consumption per head is

$$g(c) = \frac{g(TFP)}{1-\alpha} + g(Q). \tag{8}$$

The Ramsey rule is then derived from households' optimal behavior and can be written as

$$r = \rho + \sigma\left\{\frac{g(TFP)}{1-\alpha} + g(Q)\right\}. \tag{9}$$

Notwithstanding a change in the model parameters $\rho$ and $\sigma$, the modified RCK growth model predicts that, as TFP growth slows down following the global financial crisis (GFC), real rates drop by $-\Delta r$

$$\Delta r = \sigma\left[\frac{g(TFP_2)}{1-\alpha_2} - \frac{g(TFP_1)}{1-\alpha_1} + g(Q_2) - g(Q_1)\right], \tag{10}$$

where $TFP_2$ is the post-GFC long-term growth rate, $Q_2$ is the post-GFC labor composition index growth rate, $\alpha_2$ is the post-GFC capital share and subscript 1 is used for the pre-GFC quantities.

The standard business cycle model enables the modeling of economic fluctuations at the business cycle frequencies (Kydland and Prescott 1982; Long and Plosser 1983). These models can be overlaid on top of the discrete-time version of the RCK model, thus generating both the RCK long-term trends and the business cycle fluctuations.[17] However, the business cycle fluctuations vanish in the long run and only the trends remain. Future households' utility is discounted using a factor $\beta$ that depends on the rate of time preference $\rho$ and TFP growth rate $g(TFP)$

$$\beta = e^{-\rho-\sigma\left\{\frac{g(TFP)}{1-\alpha}+g(Q)\right\}}. \tag{11}$$

A slowdown in TFP growth leads to an increase in the discounting factor $\beta$.[18]

The Ramsey rule underpins the determination of the social discount rate (SDR) crucial to the social welfare function used by many government agencies in their cost-benefit analysis of long-term projects. This is the practice in the UK (HMT 2023), France (Lebègue 2005) and many other countries. Moreover, the Ramsey rule is consistent with the integrated assessment models used in climate change economics (Nordhaus 2014).

From its inception, much of the debate around the Ramsey rule focused on the rate of pure time preferences $\rho$. While providing the theoretical basis for a positive $\rho$, Ramsey argued



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

that "we do not discount later enjoyments in comparison with earlier ones, a practice which is ethically indefensible and arises merely from the weakness of the imagination" (Ramsey 1928). In Ramsey's altruistic tradition, Stern (2006) adopted a pure rate of time preferences of $\rho = 0.1\%$, solely justified by "[the] uncertainty about [the] existence of future generations arising from some possible shock which is exogenous to the issues and choices under examination". Nordhaus (2014), on the other hand, assumes a higher rate of time preference at $\rho = 1.5\%$, thus heavily discounting the long-term benefits (beyond a century) of climate change investment.

Data from the Bank of England show that the 1-year real rates dropped from an average of around 4.1% in the 1970–2007 period to an average of -1.3% between 2008 and 2016, which is a drop of 5.4%.[19] Notwithstanding a change in the rate of pure time preferences $\rho$ and the EMU $\sigma$, expression (10) can be used to understand the drop in real interest rates. The RCK model-implied interest rate drop would depend on the assumed value of $\sigma$. Borrowing the EMU value from the UK's Green Book ($\sigma = 1$) the model implies that interest rates are 1.5% lower in the post-GFC period. Best et al. (2020) survey the literature on estimating the UK's EMU and find significant heterogeneity in the values of $\sigma$. The authors' retained central value ($\sigma = 1.5$) implies a post-2008 interest rate drop of 2.3%. Best et al. (2020) exploit a quasi-experimental variation in the UK mortgage interest rates to estimate a small EIS of around 0.12 for the UK (or an EMU of around 8), thus implying a post-2008 drop in interest rates that can hardly be reconciled with the data (12%).

Conversely, one can use expression (10) to estimate the UK's EMU. Referring to the 1-year real interest, the RCK model implies an EMU of 3.5. On the other hand, if one uses the drop in the loan rate facing safer UK non-financial corporations[20], the RCK model implies the EMU value $\sigma = 2.3$. Naturally, considering the higher interest rate environment post-2021 would moderate the drop in real rates, thus leading to lower model-implied EMUs for the UK. One can refer to the notion of natural real interest rates to do away with the effects of business cycle fluctuations. Holston et al. (2017) estimates point to a 1.1% drop in the natural interest rate between 2017 and 2017, implying an EMU around 0.7. Rachel and Summers (2019) document a drop in R* of about 50 bp in advanced economies following the GFC. This would imply a much lower value of $\sigma$ around 0.3.[21]

A potential secular stagnation in productivity growth is likely to impact how economists discount the future. The change of discounting can happen because of a lower consumption growth rate, a change in estimates of the EMU as argued above, or increased uncertainty over future consumption trends.[22] Given the nature of the UK productivity slowdown all three factors will likely lower discount rates. Nonetheless, debates on discounting are far from settled and given their relevance to public investment and the green transition policies, they are likely to persist and attract further research effort.

### 3.3 | Beyond the Neoclassical Growth Theory

The Solow-Swan and Ramsey-Cass-Koopmans models yield important insights on the dynamics of economic growth and, as demonstrated above, provide a good framework to quantify and decompose recent national productivity trends. However, these neoclassical growth models assume that TFP and human capital are determined exogenously. This assumption may not be appropriate if one believes that technological progress is endogenous (e.g., Romer 1990; Aghion and Howitt 1992) or that investment in human capital depends on agents' behavior and the incentives they face (e.g., Lucas Jr 1988; Mankiw et al. 1992).[23] In addition, the Cobb-Douglas technology assumed in the standard neoclassical growth model does not capture complementarities between production inputs (e.g., Krusell et al. 2000).

Mankiw et al. (1992) study an augmented Solow-Swan model featuring both physical and human capital accumulation. They show that the inclusion of human capital accumulation slows down the conditional convergence, thus significantly improving the ability of the Solow-Swan model to describe the cross-country variation in income per capita. The results in Table 4 suggest that, unlike physical capital, human capital did not slow down in the post-GFC period. Although these results are not consistent with the model presented in Mankiw et al. (1992), where human and physical capital grow at the same rate in the balanced growth path, they may reflect significant lags between the time the investment of human capital takes place and the time the change in the stock of human capital that can be measured by national statistical agencies.

Krusell et al. (2000) amend the Cobb-Douglas production function typically assumed in neoclassical growth to introduce capital-skill complementarity. The authors use this technology specification to comment on the observed increases in wage inequality. Under this framework, capital accumulation increases the productivity of skilled labor more than the productivity of unskilled labor, thus driving skill premia that are consistent with empirical observation. In the case of the UK economy, capital-skill complementarity should have made capital more productive. While providing a possible explanation of the steady increase of human capital in the UK, capital-skill complementarity deepens the post-2008 underinvestment puzzle, given the documented growth paths of capital and the labor composition index.[24]

Economic growth is also likely to be affected by potential climate-related economic damage. Fankhauser and Tol (2005) consider the dynamic impact of climate costs through capital accumulation. The authors modify standard neoclassical growth models, including Solow-Swan and Ramsey-Cass-Koopmans, by introducing the negative effects of climate through higher capital depreciation rates and lower growth of effective labor. They show that climate change leads to lower capital accumulation and therefore lower consumption in advanced economies.[25]

## 4 | The UK Demographic Trends and Productivity

This section reviews the "secular stagnation" debate sparked by the inability of advanced economies to bounce back following the global financial crisis, focusing on the ramifications of population ageing on economic growth. We then examine the UK's demographics of labor supply post-2008 and ask questions as to how the UK's specific labor supply dynamics may have affected productivity growth.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

## 4.1 | The Revival of the Secular Stagnation Debate

The question of the impact of demographic trends on economic growth is not new. Hansen (1939) coined the concept of "secular stagnation" in his study of the possible long-term slowdown of the US economy due to a reduction in population growth in the 1930s. Hansen, in turn, relied on the much older ideas put forward by Adam Smith regarding the positive effects of population growth in fostering demand and improving the production of new ideas. The original argument by Hansen (1939) was that slower population growth would depress real interest rates as capital will be combined with less labor input at the margin. However, this argument ignores the observation that aging populations with higher dependency ratios will decrease aggregate savings. On this basis, Goodhart and Erfurth (2014) predict that real interest rates will return to their historical equilibrium value of around 2.5%–3%, as did Chadha and Dimsdale (1999) in earlier work.

Larry Summers brought the term "secular stagnation" back to life in 2014 (Summers 2014). Summers noted (i) the persistent negative gap between measures of potential and actual output in most advanced economies and that (ii) US and world real interest rates have declined since the mid-1980s. He concluded that this indicated a much lower full employment real interest rate (FERIR). He argued that the nominal interest rates' zero lower bound and the low inflation environment prevent the real interest rate from dropping low enough to meet the FERIR required to bring unemployment down.

Rachel and Summers (2019) point to the high capital mobility between advanced economies and the limited fluctuations in their aggregated current account. On this basis, they argue that the natural real interest rate R* is better estimated for an economic bloc of all advanced economies. The authors document a decrease of R* by 300 bp in the advanced economies bloc between 1970 and 2017 and argue that but for extraordinary fiscal policy, the natural real interest rate may have fallen by an extra 400 bp. They argue that the increases in government spending have obscured the substantial shifts in private saving and investment propensities since the early 1970s.

Estimates of potential output have been revised downward as economists started to factor in the lower productivity growth regimes in the United States and most advanced economies after 2008 (e.g., Kahn and Rich 2007; Gordon 2014; Fernald 2015). Figure 9 shows the series of downward revisions to productivity trend forecasts by the UK's Office for Budget Responsibility. The repeated downward revisions to productivity trends and potential output measures moved the debate from the issue of a large negative output gap, as in Summers (2014), to the anemic growth in potential output as productivity growth slows down (Gordon 2014). Discerning new productivity growth trends from cyclical fluctuations is crucial for short-term economic policy. For instance, many economists argue that the failure to detect the productivity slowdown after the 1973 oil shock contributed significantly to the economic instability of the 1970s (e.g., Kahn and Rich 2007). More recently, Philippon (2022) argues that the assumption of exponential TFP growth contributed to overestimating productivity growth, thus overestimating potential output after 2008. Philippon suggests that a linear TFP growth model is more suitable for forecasting productivity. If linear TFP growth is indeed the way forward, the current practice of assuming exponential TFP growth would lead to further overestimation of productivity trends and potential output.

Greenwood et al. (1997), Fisher (2006) and others argue that the relative prices of investment goods have been trending lower since the early 1950s, with a notable acceleration in the rate of decline in the early 1980s.[26] IMF (2014) finds that the trend of decreasing investment prices extends to many other advanced and emerging economies. The increase in savings supply from emerging economies and the drop in capital demand due to cheaper capital goods are then presented as a potential justification for the secular decrease in real rates after 1980.

Both Gordon (2015) and Fernald (2015) explain the productivity slowdown as the end of an exceptional productivity growth period that started in the mid-1990s with the improvements in the IT producing and using industries. Fernald (2015) dates the slowdown in US TFP to circa 2005, i.e., several years before the onset of the great recession. Focusing on the UK productivity puzzle, Fernald and Inklaar (2022) argue that most of the UK's TFP slowdown follows from the slowdown in the US frontier. There is a view that productivity improvements do not happen at a steady, even pace. Instead, productivity improves much faster in some eras (Gordon 2016). According to this view, some inventions are more important than others; while improvements in IT-related technologies were responsible for the most recent episode of productivity revival (1995–2005), earlier inventions such as electricity and the combustion engine were far more favorable to productivity growth as they could sustain productivity gains in advanced economies for a century (1870–1970).

The effects of demographic dynamics on macroeconomic variables have been subject to intense debates since the re-emergence of secular stagnation as an important line of inquiry. On the one hand, older segments of the population tend to save less and this contributes to increasing real interest rates. On the other hand, longer life expectancy makes the active part of the population keener on saving to fund consumption for extended retirement periods, pushing real interest rates lower. There is also no agreement in the literature on the effects of ageing in advanced economies on economic growth. Acemoglu and Restrepo (2017) argue that ageing societies are more likely to adopt new automation technologies, thus increasing GDP per capita, while Aksoy et al. (2019) show that ageing decreases innovation, causing slower economic growth and less investment, thus depressing real interest rates. Consistent with the idea that population ageing hinders innovation, Jones (2022) uses standard growth models with exogenous population growth and a model with endogenous fertility to show that knowledge and living standards stagnate when demographic growth turns negative. In a recent paper, Hopenhayn et al. (2022) argue that a decrease in population growth can reduce firm entry, thus affecting firm dynamics in a way that increases industry concentration, reduces the labor share and harms productivity growth.

## 4.2 | The Demographics of UK Labor Supply

The UK labor market reforms in the last three decades of the 20th century created the conditions for a flexible response to



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

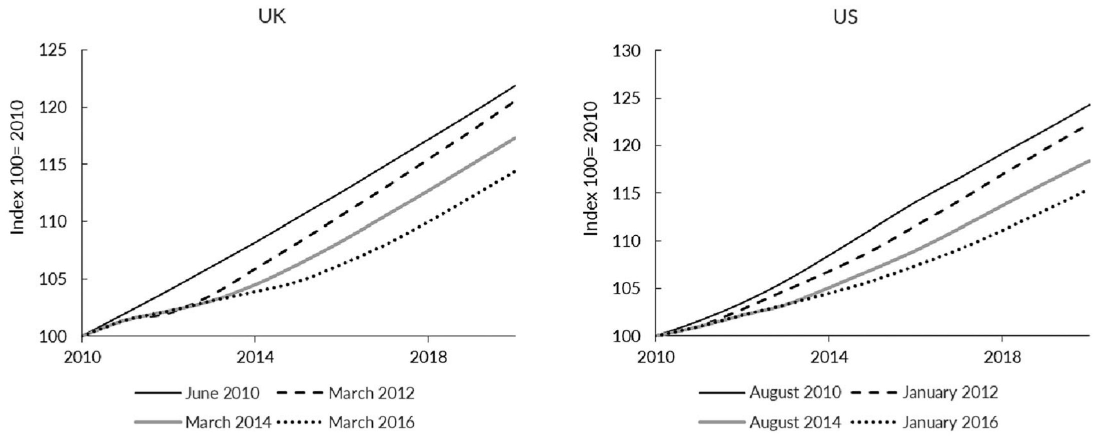


**FIGURE 9** | Vintages of UK and US trend productivity forecasts.
*Note:* UK trend productivity is defined as potential non-oil GVA over potential hours, while US trend productivity is defined as the potential non-farm business output divided by potential hours worked in the non-farm business sector. *Source:* OBR (2016).

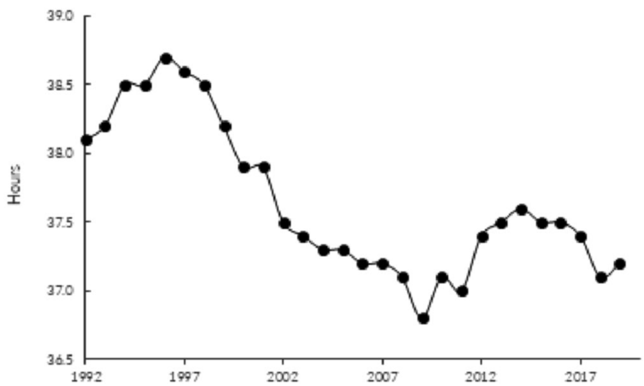


**FIGURE 10** | Full-time workers' average weekly hours (1992–2019).
*Note:* Average actual weekly hours of work for full-time workers. ONS data (June 2022 data).

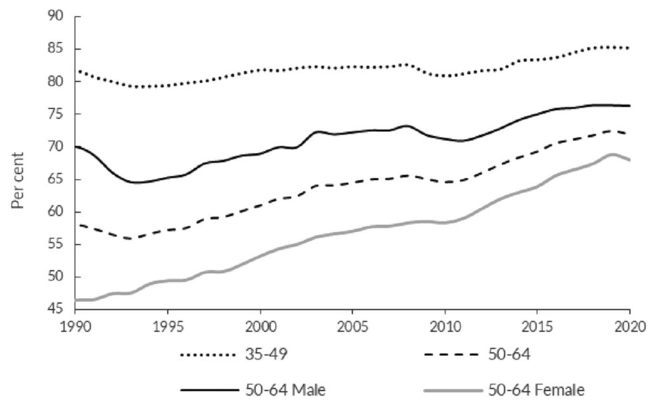


**FIGURE 11** | Employment rates by gender and age band (1990–2020).
*Note:* Employment rates, by gender and age bands, 1990–2020, UK (except for 1992–1994 which is GB only). *Source:* Department for Work and Pensions (September 2020).

the recession. Tax reforms were used to shift employers' incentives and unemployment (and non-participation) was reduced. There was also an increase in the labor market's flexibility with some trade union powers and employment protection legislation reform. Trade union power also diminished because of the decline in traditional manufacturing and public sector monopolies. In effect, we may have stumbled on a low wage, low productivity and high employment equilibrium. This outcome limited the impact on unemployment from the Great Recession and may have played a role in reducing the extent to which households increase their savings ratios. The maintenance of relatively elevated employment levels may have helped limit the impact on house prices from the recession and thus limited spillovers to a vulnerable financial sector. The other side of this high employment outcome might be an anemic productivity growth path.

Taking a closer look at the demographics of labor supply in the UK in the post-GFC period, two clear trends emerge. First, the average hours worked remained relatively stable since 2008 (Figure 10), making the increase in aggregate hours a consequence of higher participation and low unemployment rates. In other words, there was no noticeable change in labor supply at the intensive margin, with a marked increase in supply at the extensive margin. In addition, the increase in aggregate labor hours is primarily driven by higher employment rates among older workers (50 and older), especially older women. This is clearly displayed in Figure 11. The figure shows that the employment rate for the 50–64 age group increased from 65% in 2007 to 72% in 2019. In contrast, the employment rate of the 35–49 age group has only increased by 3% in the same period. Decomposing the growth of aggregate labor hours by age group, an ONS study (ONS (2019)) shows that the drop in hours worked during the post-GFC recession was concentrated in the younger workers demographic (16–29 years old). After the end of the recession, employment hours among young workers remained low while the work hours supplied by older workers soared (Figure 12).

The increase in labor supply by older women gives some credence to the flexible labor supply explanation, as the increase coincides with changes in the state pension age (SPA) after 2007 that pushed the retirement age for women from 60 to 65. Following



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

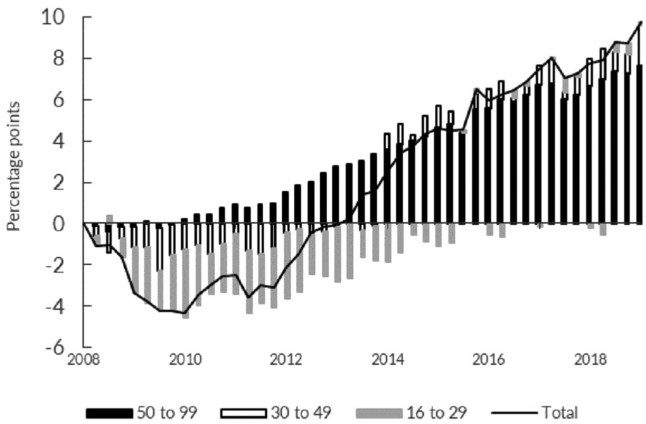


**FIGURE 12** | Total hours worked by age band.
*Note:* Cumulative contributions to growth in total hours worked, by different age bands, Quarter 1 2008 to Quarter 1 2019, UK. *Source:* ONS (2019).

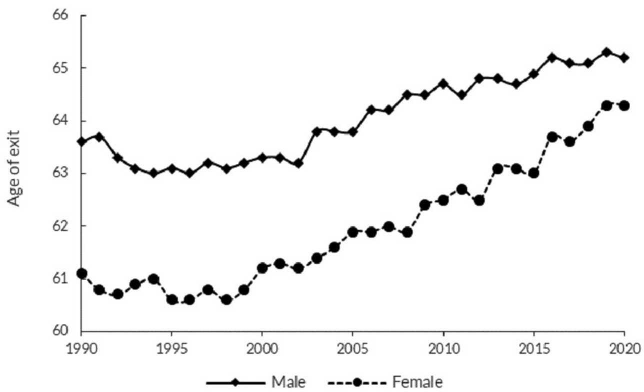


**FIGURE 13** | Average age of exit from the labor market by gender (1990–2020).
*Note:* Average age of exit from the labor market, by gender, 1990–2020. *Source:* Labour Force Survey (LFS) responses and HM Revenues data compiled by ONS (June 2022 data).

these changes, women delayed their permanent exit from the labor market by an average of 2 years, with the average exit age increasing from 62 in 2007 to over 64 in 2019 (Figure 13).

Another remarkable change in the composition of the UK workforce is the marked increase in measures of workers' skills. The share of hours supplied by workers with a university degree increased from 25% in 2008 to 35% in 2018 (ONS (2019)).

In summary, the increase in aggregate hours after 2008 has been driven by older workers, especially older women. This trend is not merely a reflection of the ageing of the UK population. It also reflects higher employment rates among older workers and a decrease in employment among younger workers. Experienced workers are usually assumed to possess more human capital, so this compositional change deepens the UK's productivity slowdown puzzle. Similarly, the productivity puzzle is deepened by the increase of the portion of workers with higher education qualifications.

The role of the flexible labor market in increasing aggregate hours after 2008 has been a subject of interest in the literature. For instance, Pessoa and Van Reenen (2014) note that wages, deflated by the GDP deflator, fell by 4% in the 4 years following Q2 2008. This drop in real wages, they argue, is unprecedented for a post-war recession, reflecting the effect of a long-term policy in favor of flexible labor supply in the UK (weaker unions; work search pressure on benefit claimants, etc.). They attribute low post-2008 investment to high capital costs and the uncertainty plaguing the UK economy. However, the latter explanation for weak investment is more likely, considering the data regarding the cost of capital after 2014 and the additional uncertainty brought about by Brexit (Sampson 2017).

Blundell et al. (2014) study individual data on employment and wages in the UK and find evidence confirming the hypothesis of an increased and more flexible labor supply. The increased labor supply argument gains further support from Douch et al. (2023), who suggest that the abundant labor may have contributed to the underwhelming productivity performance in the UK. They focus on the cohort effect of firms established after 2008, showing a post-GFC redeployment of labor from the slowing high-productivity financial services industry toward lower productivity service industries. This phenomenon, which they dub a productivity "leveling down", highlights the impact of labor market flexibility on productivity trends.

An alternative explanation for the higher labor supply by the UK workforce lies in the increase of households' debt during the credit expansion that preceded the global financial crisis. Bunn et al. (2021) exploit data from the LFS and the Wealth and Assets Survey (WAS) to show that a negative shock to income leads to a reduction in labor force participation among outright homeowners while increasing the desired hours of mortgage holders. In addition, the authors find that households with higher debt levels increase their labor supply by more following shocks that decrease their ability to service debt (adverse income shocks; higher interest rates). The authors then argue that the increase in UK households' debt in the years leading to the financial crisis has the potential to explain, at least partly, the subsequent behavior of employment, hours and wages.

Post-pandemic ONS data show increased labor market tightening and an increase in unfilled job vacancies (ONS 2021). Employment dropped by 1.4% in the year ending September 2021, primarily driven by younger workers and elementary occupations. Other post-pandemic trends include the substantial increase in work from home (Barrero et al. 2023), the effects of which will require a longer history to be fully assessed.[27] It remains unclear if the post-pandemic labor trends will fade as the economy recovers from the successive shocks of Brexit and Covid-19 or if they represent permanent new trends triggered by the pandemic shock.

Both the flexibility of the labor market and households' indebtedness are likely to have contributed to the increase in aggregate hours supplied by the UK workforce in the post-GFC decade. However, important questions remain. As noted above, the compositional changes to the UK workforce deepen the country's productivity puzzle. Moreover, the increase in labor supply was not accompanied by an increase in investment, as economic



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License


**FIGURE 14** | Gross fixed capital formation shares of GDP, an international comparison (1960–2023).
*Note:* Gross fixed capital formation to GDP in current prices in the UK, US, France, and Germany. Prior to 1991, West German data is used for Germany. *Source:* Eurostat (2022 data).


**FIGURE 15** | UK business investment's share of GDP (1965–2021).
*Note:* Business investment in current prices as a percentage of GDP in current prices. *Source:* ONS and authors' calculations (June 2022 data).

theory would predict. The following subsection takes a closer look at the investment trends in the UK.

### 4.3 | Investment Trends in the UK

The UK economy suffers from chronic underinvestment. Figure 14 shows that the UK's investment share of GDP has been significantly lower than the ratios in France, Germany, and the United States for most years since 1965 and continuously since the early 1990s. The share of GDP dedicated to business investment has trended downward since 1965 (Figure 15), while the long-term average net public investment fell from 4.5% of GDP between 1949 and 1978 to 1.5% from 1979 to 2019 (Figure 16). As a result of these weak investment trends, the net capital stock to GDP ratio trended downward after 1960 (Figure 17).

There are structural reasons for these trends. For instance, capital goods' prices decreased substantially relative to other goods over the last half-century. Figure 18 shows that the relative price of investment trended downward in the UK after 1990, with improved ICT industries and computing power often cited as an important factor behind lower relative investment prices. León-Ledesma and Moro (2020) build a two-sector structural change model with a high productivity growth good sector and a low productivity growth services sector and show that as the share of services in the economy increases, the relative price of investment decreases, thus accelerating investment-specific technological change. The authors assume a unitary capital elasticity of labor, which implies that the nominal investment share of GDP remains constant in their model while the real investment share increases.[28] Thwaites (2015) documents the drop in the relative price of investment in several advanced economies before building an overlapping generations model parameterized with a less-than-unit elasticity of substitution between labor and capital. The low substitutability of labor for capital means that the economy reacts to lower relative prices of capital by reducing the share of investment in nominal GDP. As shown in Figure 18, other advanced economies witnessed similar, if not larger, drops in the relative investment price to the UK after 1991. Moreover, Podkaminer (2019) finds no evidence of the low relative price of investment goods Granger-causing the decline of investment shares in industrial countries. This means that the UK's secular underinvestment trends remain a puzzle.

OECD (2013) highlights that "knowledge-based capital," also referred to as intangible capital, is crucial for future economic growth. However, intangible investments and capital are inherently challenging to measure. These challenges include accurately assessing the flow of intangible investment, estimating their depreciation rates, and effectively aggregating firm-level capital to industry and national levels (Corrado et al. 2022).



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

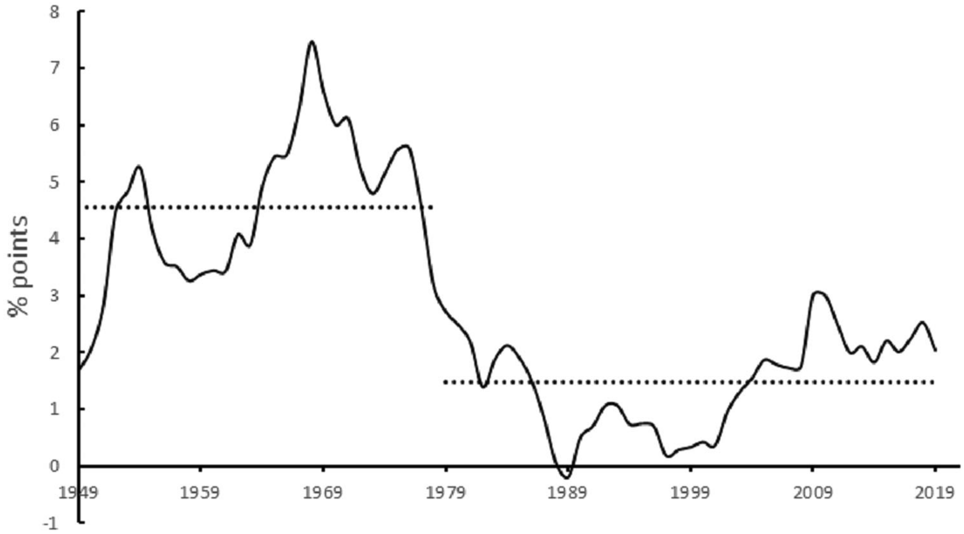


**FIGURE 16** | UK public investment (1949–1919).
*Note:* Public sector net investment as a percentage of GDP with the 1949–1979 and 1980–2019 averages. *Source:* Data from the Office for Budget Responsibility (March 2020) and ONS (June 2022); authors' calculations.


**FIGURE 17** | UK net capital stock (1960–2023).
*Note:* Net capital stock per unit of gross domestic product at constant prices index (1960 = 100). *Source:* Eurostat, authors' calculations (2022 data).

The mismeasurement of intangible capital can lead to inaccuracies in measuring productivity growth. Brynjolfsson et al. (2021) conceptualize this issue through the notion of "productivity J-curve." They argue that general-purpose technologies, such as artificial intelligence, necessitate substantial intangible investments that national accounting systems often capture in the form of intermediate expenditure. This leads to an initial underestimation of aggregate output and, consequently, of productivity growth. Over time, as the benefits of these investments are realized and output accelerates, the unmeasured intangible capital input leads to overstating productivity growth.

These measurement challenges are amplified by the increasing share of intangible capital in the UK (ONS 2024) and other advanced economies, including the United States (Corrado et al. 2022). Similar trends are evident in Germany, where Kaus et al. (2024) document firm-level heterogeneity in intangible investment. They argue that differences in unmeasured intangible capital partially explain the TFP gaps between firms at the productivity frontier and those lagging behind.[29] Nevertheless, Goodridge and Haskel (2023) find that the capitalisation of intangibles accounts for only 5% of the UK's productivity slowdown. These findings should be viewed in the context of ongoing efforts to refine methods for measuring intangible capital, which remain a work in progress and require further research.

The UK's withdrawal from the European Union and its trade consequences have increased uncertainty for UK businesses.[30] This



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

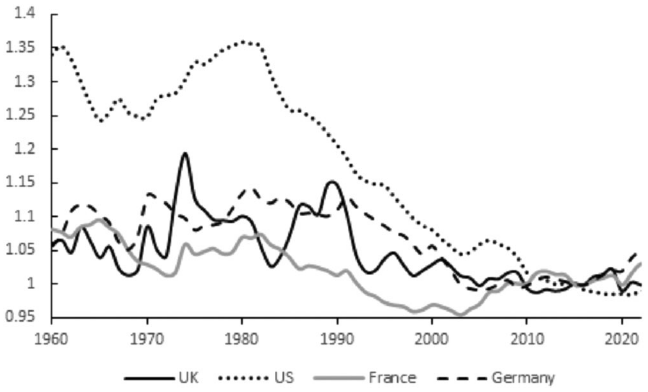


**FIGURE 18** | Relative price of investment (1960–2023).
*Note:* The ratio of price deflator of gross fixed capital formation to GDP deflator for the UK, US, France, and Germany. *Source:* Eurostat (2022 data).

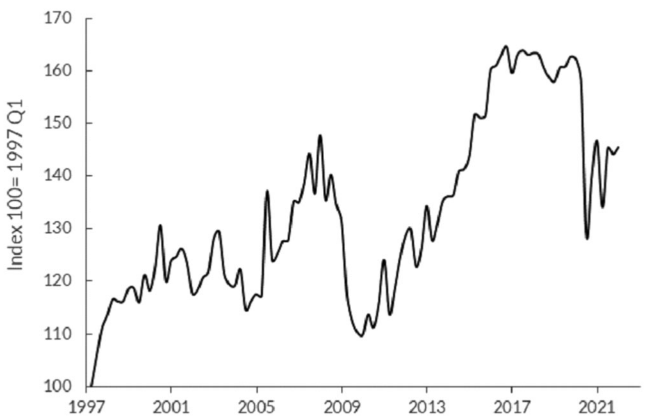


**FIGURE 19** | UK real business investment (1997 Q1–2021 Q4).
*Note:* UK real business investment index (1997 Q1 = 100). *Source:* ONS (February 2022 data).

uncertainty is likely to have contributed to reversing the short-lived gains in the GDP share of business investment between 2014 and 2016 (Figure 15). Górnicka (2018) uses firm-level data to show that potential trade costs have had a considerable and statistically significant negative impact on firm investment in the UK after the referendum. The pandemic-related economic disruptions compounded the terms of trade uncertainties and are likely to have further depressed business investment (Figures 15 and 19).

Another feature of the weak investment puzzle in the UK is that it is happening in the context of low real interest rates. This deepens the weak investment puzzle in the UK. The following section looks at this issue in more detail by considering the UK's financial landscape and how it might impact investment.

## 5 | Finance and Productivity

The link between finance and productivity is complex. It is unclear whether finance ignites productivity or flows from expected future productivity gains, making causal identification difficult to achieve. To deal with these endogeneity issues, Butler and Cornaggia (2011) exploit an exogenous shift in demand for corn to study how the depth of the local banking sector impacts farmers' productivity. The results indicate that productivity increases more in areas with better financial intermediation as measured by aggregate deposits in local banks.

Consistent with the causal finance to productivity link documented in Butler and Cornaggia (2011), Levine and Warusawitharana (2021) use firm-level data to show that an increase in financial frictions post-2008 led to a higher sensitivity of productivity growth to the availability of external finance.[31]

Baqaee and Farhi (2020) demonstrate that improvements in allocative efficiency, driven by the reallocation of market share toward- more productive firms, account for half of the aggregate TFP growth in the United States during the period 1997-2015. Given the critical role of financing in the allocation of resources within a country's business population, financial conditions exert a significant influence on aggregate productivity. For instance, Gopinath et al. (2017) show that the lower interest rates in southern European economies, resulting from the euro convergence process, redirected resources toward higher net worth firms that were not necessarily the most productive. The authors argue that this misallocation adversely impacted aggregate productivity growth in these countries.

Accordingly, this section examines the UK business and financial landscape, documenting the puzzlingly low business investment trends despite the decline in real interest rates. We then turn to theoretical explanations of the low real rates-low investment puzzle, starting with the zombie firms' explanation before considering more recent theoretical developments.

### 5.1 | The UK Business Finance Landscape

Following the period of volatile credit markets and a tight supply of credit associated with the global financial crisis (GFC), the Bank of England reacted by bringing its main interest rate to 0.5% in March 2009, down from 5.25% a year earlier. Low bank rates were accompanied by a large asset purchase program, as the Bank of England accumulated £895 billion in UK government bonds and £20 billion in UK corporate bonds by the end of 2020. While the Bank of England's easing pushed real interest rates into negative territory post-2008, the downward trend in real interest rates predates the global financial crisis. Figure 20 shows that real interest rates have trended down since the early 1990s. After the global financial crisis, the real interest rates facing safer non-financial private companies have collapsed from a long-term average of 3.6% to a post-GFC average near zero (Figure 23).

Against this backdrop of low real interest rates, investment, particularly business investment, remained sluggish for most of the decade following the GFC. Figure 19 shows that it took 8 years for the UK's real business investment to reach its 2007 level. This recovery was short-lived, however, as business investment stalled in 2016 following the Brexit referendum result and reversed with the start of the pandemic-related economic disruptions.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

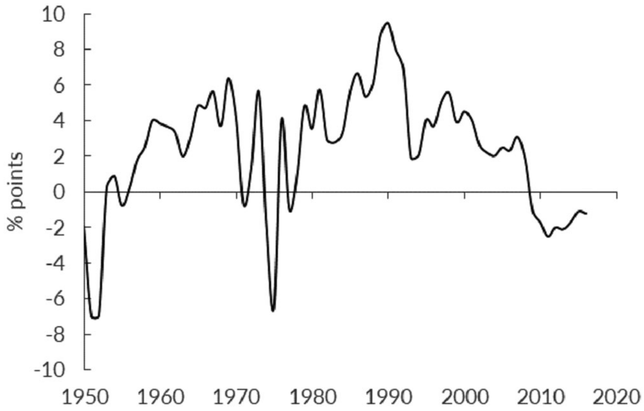


**FIGURE 20** | UK real interest rates (1950–2016).
*Note:* UK real interest rates. *Source:* Bank of England (Thomas and Dimsdale 2017).

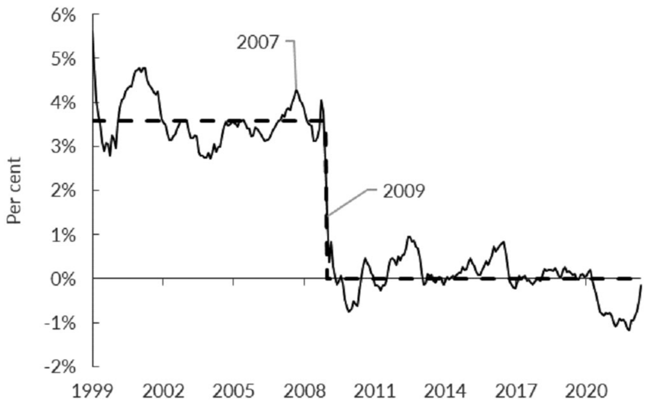


**FIGURE 21** | UK corporate loan real interest rates (1999–2022).
*Note:* The real loan interest rate facing safer non-financial private companies (NFPC), calculated as the Banks' average loan rate to safer NFPCs -Minus- 5-year Inflation Implied Forward. The figure also displays the 1999-2008 and 2009-2021 average of real loan rates. *Source:* Bank of England data, authors' calculations.

Despite the abundant liquidity and low real interest rates, small and medium enterprizes (SMEs) continued to be credit-constrained, pushing them to rely on more expensive forms of credit. Brown et al. (2019) report that in the fourth quarter of 2015, 17.1% of UK SMEs used credit card financing and that a similar portion of SMEs used bank overdrafts (17.4%). Only 7.7% of UK SMEs used the typically much cheaper bank loans and commercial mortgages in Q4 2015, indicating that the SME sector may face severe credit constraints. The behavior of credit markets during the Covid-related economic disturbances is another indication of the credit constraints facing SMEs. The UK government launched multiple loan guarantee programs to ease the credit conditions in the context of weaker business cash flows caused by the pandemic-related restrictions. The UK's private non-financial corporations raised around £75.5 billion of debt between March 2020 and May 2020. Almost all of this figure (£75 billion) was raised through the government's Covid-19 lending schemes. Of the £75 billion borrowed through these schemes, only £5.6 billion is estimated to have gone to larger businesses (Samiri 2022). The important loan take-up by SMEs through the government's Covid guarantee schemes indicates unsatisfied financing demand within the SME sector. The European Investment Fund's SME Access to Finance Index shows that the United Kingdom underperforms competing EU economies such as Germany and France in supplying finance to SMEs (Torfs 2021). Subcomponents of the SME Access to Finance index show that UK SMEs struggle to access loan financing while being better served in the equity finance markets.

The UK financial system is concentrated in London and a few secondary cities. Wójcik and MacDonald-Korth (2015) find that the UK financial system concentrated further between 2008 and 2012, with London's share of the UK's financial employment moving from 31% to 34% in the 4 years period following the global financial crisis. Figure 22 shows that the concentration of the financial industry in London continued after 2012. By 2019, over half of the UK's Banking and Insurance sector's GVA came from the Great London area (as opposed to 48% in 2012 and 46% in 2007).

Given the uneven geography of equity finance, particularly that of venture capital (Mason and Pierrakis 2013), it is likely that SMEs in peripheral regions are more dependent on loan financing. Figure 23 shows that SMEs outside London and the England South East had a higher bank debt financing to turnover ratio in 2016. This figure, however, fails to disentangle the demand-side from the supply-side effects. Using firm-level data from Q1-2011 to Q3-2013, Lee et al. (2015) find that SMEs in the 10% least accessible NUTS2 regions (peripheral regions) applied for more loans than SMEs in the non-peripheral areas. The authors also find that innovative SMEs in remote regions suffer from a "liability of distance" when attempting to access funding. After controlling for financial history and other financial risk indicators, the authors find that these SMEs are more discouraged from applying for bank loans and face higher rejection rates. However, the authors find no significant adverse geographic effect impacting the access to bank loans of non-innovating firms located in peripheral regions.

Uncertainty, resulting from significant news, might delay and defer financial investment, thus hampering improvements in human and physical capital. Capital allocation may be quite impressively allocated from the City of London to the rest of the world, but this does not necessarily mean that capital finds its way to small and medium-sized enterprizes outside London and the South East. Daams et al. (2023) use commercial real estate investment data to show that the GFC triggered a flight to safety of capital into London, thus deepening the UK's regional inequalities.

The UK's SME funding gap is an old question first tackled by the Macmillan Committee in 1931 (Cressy 2002). One study estimates this gap at around £22 billion (NAO 2013).[32] More recent studies argue that an SME regional funding gap is concentrated in equity financing (Stansbury et al. 2023; Oliver Wyman 2024). This debate, however, remains unsettled and is likely to attract more research effort in the future.

In the remainder of this section, we draw on the economic literature to describe several theoretical mechanisms that help



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

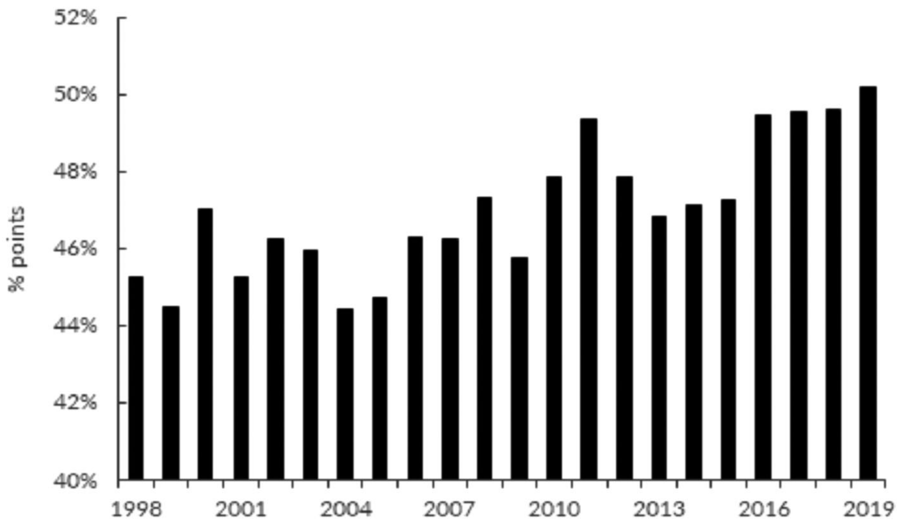


**FIGURE 22** | The financial sector is concentrated in London.
*Note:* Greater London's Banking and Insurance sector GVA to the UK's overall GVA of the sector in current prices. *Source:* ONS, authors' calculations (June 2021 data).

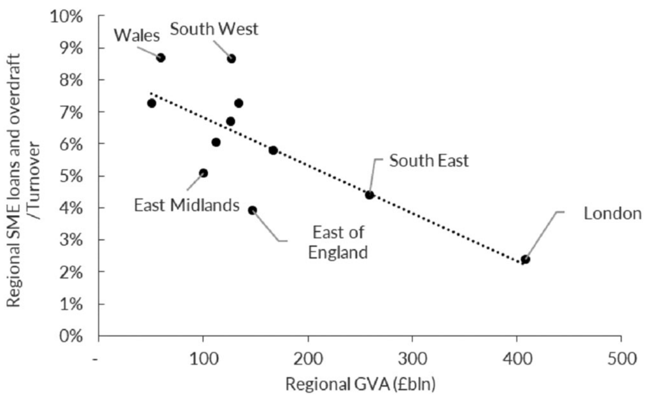


**FIGURE 23** | Regional GVA and the SME loan financing.
*Note:* Regional SME loans and overdraft over turnover and regional GVA in March 2016. *Source:* UK Finance and ONS data, authors' calculations.

shed light on the reasons behind the UK's weak productivity growth in the context of the financial landscape described above.

### 5.2 | Banks and Zombie Firms

Since the global financial crisis, banks have undergone a process of repairing their balance sheets and building up capital and liquidity buffers. In the immediate aftermath of the crisis, there had been a relatively low level of insolvencies, given the depth of the recession. The argument has been made that the forbearance shown by banks toward existing firms and the lack of availability of finance to new firms had acted to reduce the introduction of new technologies into the overall production function. Arrowsmith et al. (2013) found that forbearance might account for some of the shortfall in productivity, but as they only measure the impact on SMEs, the whole economy impact may be considerably larger. In a Euro Area analysis, Andrews and Petroulakis (2019) suggest that relatively undercapitalized banks were more likely to show forbearance and may have played a role in starving credit to healthier firms. Acharya et al. (2019) argue that while Outright Monetary Transactions helped re-establish stability in the banking sector, they did not fully translate into economic growth. The authors explain that banks were more likely to extend loans to distressed firms that built up their cash reserves rather than invested, thus misallocating funding in sectors with a high prevalence of zombie firms.

Firms that have tended to be unprofitable over time and have a low stock market valuation tend to invest less and be more vulnerable to shocks. Using low market stock valuations and low-profit rates to identify zombie firms, Banerjee and Hofmann (2022) document the rise of their share from some 4% in the 1980s to 15% by 2017 across advanced economies and over 20% in the UK. In earlier work, Banerjee and Hofmann (2018) present evidence of a positive link between low rates and the number of zombie companies at the country and sectoral levels. That said, Favara et al. (2021) do not think the zombie firm issue is that significant in the US and only accounts for a "small share of credit to non-financial firms". But Gouveia and Osterhold (2018), who focus on Portugal, argue strongly that the prevalence of zombie firms has dragged down aggregate productivity and their tendency to stay in the market affects intra-sectoral productivity. Extending this analysis to the set of OECD economies, McGowan et al. (2017) document that an increasing share of industry capital has become attached to zombie firms. This has tended to limit the expansion of healthy firms and led to market congestion, which heightens barriers to entry. They argue that the rise of such firms has affected potential output growth, investment and the accrual of TFP.

Focusing on the UK, Douch et al. (2023) find that weak productivity performance during the 2011-2016 period was primarily driven by service sector firms that entered the market after 2008. These findings align with those of Andrews et al. (2019), which highlight an increasing divergence between firms at the productivity frontier and those below it in OECD countries.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

More work is required to obtain consensus on a working definition of zombie firms in the UK. This would help in documenting further the zombie firms' issue in the UK before estimating its effects on aggregate productivity growth.

### 5.3 | Theoretical Arguments for Low Productivity Growth in a Low Interest Rate, Ample Liquidity Environment

Real interest rates are at a historic low (Figures 20 and 21), yet business investment did not soar following the GFC. This puzzle is difficult to explain in the context of standard macroeconomic models that usually focus on frictions at the financial intermediation level. For instance, Stiglitz and Weiss (1981) argue that, under imperfect information, interest rates can be used by the lending bank to sort borrowers. The crux of the argument is that only risky borrowers are more likely to take loans at a high interest rate (selection effect). To increase the average quality of its loan portfolio, the representative bank would then avoid supplying credit at an interest rate that it deems high enough to attract bad borrowers, thus preventing the credit market from clearing and rationing credit for the riskiest subgroup of borrowers. However, it is unclear if this and other similar credit rationing models are consistent with low aggregate investment in a low interest rates environment.

A new generation of models focuses on the firm's behavior when financing is cheap. Liu et al. (2022) describe a mechanism where low interest rates can lead to more market power for industry leaders, thus stifling innovation and productivity gains in the long run. When interest rates are low, the safe profits emanating from a permanent monopoly position are discounted at a lower rate. This increases the value of the permanent monopoly position from the perspective of a market leader. The market leader is then incentivized to invest in innovation to capture the permanent monopoly profits. The market follower can also invest in research and development (R&D) to improve its competitive position. However, in the case of successful innovation, the market follower would enter a fierce 'neck to neck' competition with the former market leader for permanent monopoly profits. The 'neck to neck' competition would be costly for both parties, dissuading the market follower from investing to reach this position of equality in the first place. On the other hand, the market leader has an extra incentive to invest in R&D and secure the permanent monopoly position as they would seek to avoid 'neck to neck' competition in the future. This results in market leaders having a much stronger incentive to invest in innovation than market followers, thus making permanent monopolies more likely. Once in a situation of permanent monopoly, both the market leader and the market follower reduce their R&D spending as innovation is unlikely to impact their respective market shares. In the aggregate, permanent monopolies imply less R&D spending and weaker productivity growth. The main mechanism of the model in Liu et al. (2022) is illustrated in Figure 24.

Acharya and Plantin (2019) argue that when interest rates are low enough, it is optimal for shareholders to use leverage to issue early cash payouts in the form of dividends and share buybacks (leveraged payouts). This happens when the cost of financing is less than the discounting applied by shareholders to future consumption. In this situation, the firm's manager might act on behalf of the shareholders and bring future payouts forward using leverage. Higher leverage, however, would mean less skin in the game for shareholders, thus pushing them to exert less effort to ensure that the firms' projects succeed, which would hurt aggregate productivity growth. Such a mechanism is especially powerful when the firm's leverage is unconstrained, as would be the case when the firm does not rely on commercial banks for funding (capital markets, shadow banking). The authors argue that if such a mechanism is powerful enough, the optimal monetary policy may consist of leaning against the wind, i.e., not stimulating the economy, in order to contain leveraged payouts and maintain productive efficiency.

Kiyotaki et al. (2021) present a framework where persistently low interest rates can stifle investment, productivity and economic growth and even lead to a drop in the welfare of everyone in the domestic economy. Within this framework, a resource-constrained engineer/plant founder needs to sell the plant to finance investment. However, workers with human capital (engineers) cannot commit to providing the services required in the future to maintain and improve the plant's productivity. As a result, engineers sell their services in a competitive labor market and receive their forward-looking marginal product, representing their contribution to future productivity. This reduces the new owner's share of future revenues as more and more of the longer-term revenues are used to compensate engineers for maintaining productivity. However, the plant owner still has an obligation to pay fixed costs. This mismatch between long-term fixed costs and short-term revenue shares implies that a permanent drop in interest rates reduces the value of the plant from the owner's perspective. Given that the value of the plant determines the financing available to fund productivity-enhancing investment, low-interest rates lead to a decrease in investment and productivity growth, thus reducing welfare (the model's mechanism is summarized in Figure 25). The authors' policy recommendation focuses on spurring productivity and economic growth by enhancing investment through investment subsidies. The investment subsidies are financed by taxing the engineers' wages, as the sub-optimal aggregate outcome results from the engineers' wages being inflated by the friction at the core of this model: the inability of engineers to commit future effort.

Li (forthcoming) explores the impact of the transition to intangible-intensive economies, emphasizing the increased fragility of financial intermediation and its role in protracted recessions. The study argues that firms increasingly depend on internal savings to finance intangible investments due to their limited pledgeability, which restricts access to external funding. This drives firms to accumulate liquidity in the form of banks' liabilities, creating a corporate savings glut that depresses banks' funding costs. Banks respond by leveraging this cheap and abundant funding, inflating the prices of tangible assets. Higher tangible asset values relax firms' credit constraints, facilitating greater investment in both tangible and intangible assets, and generating a productivity-enhancing virtuous cycle. However, when negative shocks arise, financial intermediaries are forced to deleverage, transferring assets to households who face higher funding costs and consequently value these assets less. The resulting collapse in tangible asset prices leads to a



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

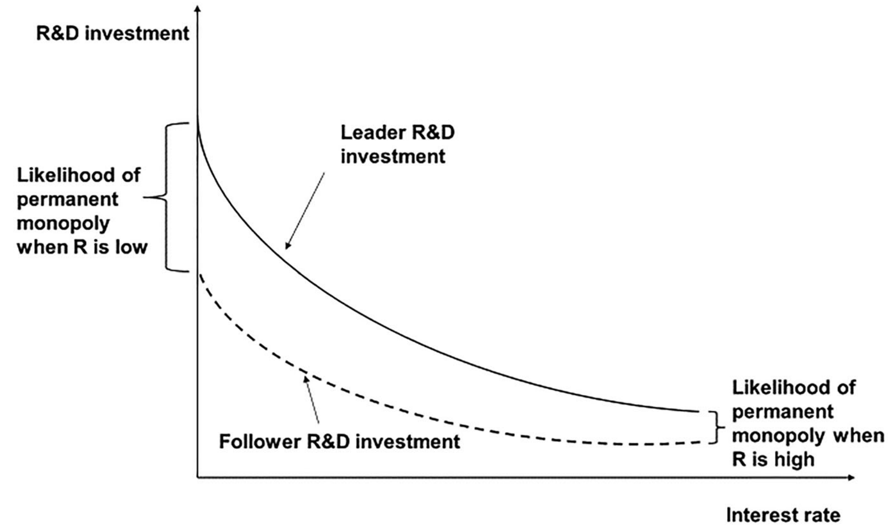


**FIGURE 24** | The main mechanism in Liu et al. (2022).
*Note:* As interest rates get closer to the zero lower bound (ZLB), the value of a permanent monopoly position grows, spurring the market leader's R&D investment. Close to the ZLB, the market follower understands that catching up on the market leader would put the two in a situation of fierce competition to capture the permanent profits. This moderates the increase the market follower's R&D investment near the ZLB. As a result, the market leader invest much more in R&D near the ZLB and is much more likely to secure a permanent monopoly situation.

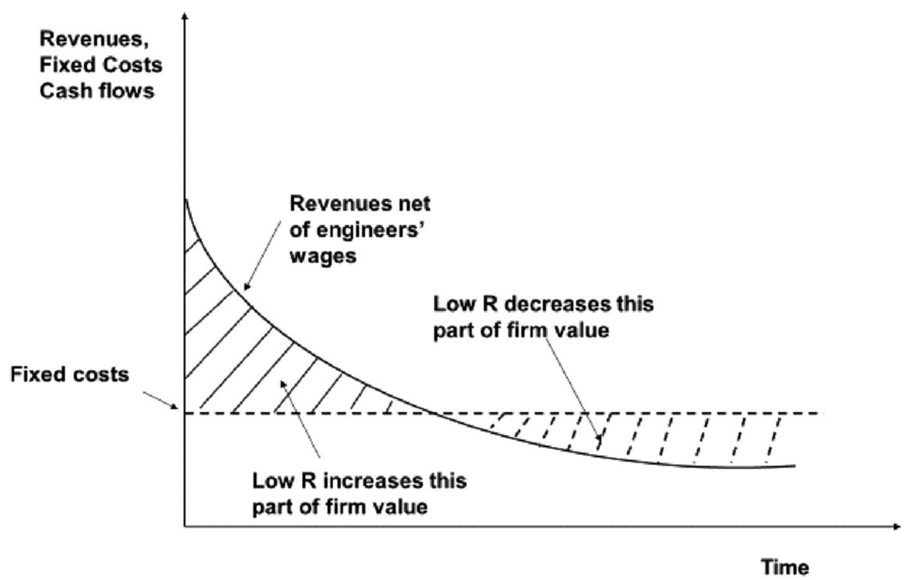


**FIGURE 25** | The firm value and interest rates in Kiyotaki et al. (2021).
*Note:* The external owners' share of revenues is lower for longer horizons. Long term revenues drop lower than fixed costs as a result. Lower interest rate ($R$) decrease the firm's value by increasing the contribution of the long horizons negative cash flows.

sharp contraction in firm investments, exacerbating productivity losses and intensifying the downturn.

The mechanisms used in the papers above all focus on the behavior of economic agents in a low real interest rates context. Liu et al. (2022) differentiate between market leaders and market followers. On the other hand, the other aforementioned papers adopt a representative firm approach and ignore supply sector heterogeneity. One, however, can imply what sort of firms the authors had in mind when building their models. For instance, Kiyotaki et al. (2021) focus on investment in new plants that might end up being credit constrained in a low-interest rates environment. On the other hand, Acharya and Plantin (2019) study the behavior of larger corporate entities with access to the market financing required to finance externally shareholders' payouts. What is the effect on aggregate productivity when larger, more established firms benefit disproportionately from low interest rates compared to their younger, smaller counterparts? Bai et al. (2018) demonstrate that the deregulation of the banking sector in the United States enhanced productivity by easing financing



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

constraints for more productive young firms, thereby promoting a more efficient allocation of production inputs. This evidence supports the idea that financial conditions have differentiated effects across the business population. Specifically, while lower interest rates might stimulate investment by established firms, they could hinder the emergence of more productive smaller firms if these firms are unable to capitalize on favorable borrowing conditions. As a result, aggregate productivity growth may suffer due to the reduced business dynamism.

## 6 | Managing Growth and the Keynesian Growth Synthesis

The canonical macroeconomic models of economic fluctuations do not have a role in explaining trends and patterns in productivity. Indeed, productivity trends are largely treated as exogenous. This means that the capacity of the economy is treated as a constraint on demand and, as a result, policy concentrates on ensuring that demand does not exhaust notions of fixed supply. This paradigm has dominated the approaches to monetary and fiscal policy in the post-war period. Indeed, attempts to boost activity by a succession of Chancellors, for example, by Barber, Lawson and Brown, have ended in busts rather than any sustained increases in prosperity. Yet, at the same time there is considerable evidence to suggest that aggregate productivity growth is neither fixed nor unaffected by well-designed policy interventions; that said, it is more of a question for the medium term rather than for the day to day of politics (Syverson 2011).

There is a rich literature on endogenous growth, where the long-term growth of residual TFP results from the economy's agents' (rational) behavior. As indicated above, standard endogenous growth theory concerns itself with the long-term improvements in the economy's capacity, as opposed to the study of economic management at business cycle frequencies through nominal interest rates. The recent macroeconomic practice has relied on what became known as the 'new neoclassical synthesis' in its attempts to bring aggregate demand in line with aggregate supply in a way to keep price inflation under control. The 'new neoclassical synthesis' combined the neoclassical intertemporal optimization and rational expectations with the imperfect competition and the nominal rigidities of the New Keynesian models (Goodfriend and King 1997; Goodfriend 2004). Until recently, endogenous growth theory and New Keynesian economics represented two distinct traditions and interacted very little to study economic trends or help inform economic policy. However, things started to change after the global financial crisis after output in most advanced economies failed to revert to pre-2008 trends. As advanced economies emerged from the chaos created by severe financial disruptions, the L-shaped output recovery indicated that something has put these economies on a new trend for potential output and productivity. The standard framework used to manage business cycle fluctuations ignores the effect of shocks on long-term growth and found itself unable to answer the new set of questions brought by the post-2008 economic realities.

In the stylized representation of the standard framework outlined in Figure 26, the level of economic growth ($\dot{g}$) is independent of labor employed (labor force, labeled as $l^f$) or other measures of economic inputs. However, aggregate demand will tend to increase with employment and may shift out with expansionary monetary and fiscal policies from AD1 to AD2, where AD signifies aggregate demand. In this setting, an exogenous fall in the economic growth rate from G1 to G2 would move the economy from A to B where there would be lower levels of factor employment. Unless, of course, if expansionary policies were used to boost aggregate demand and create a high employment low growth equilibrium at C. One may wish to interpret the period since the financial crisis through this lens.

Figure 27 further illustrates that if growth is also influenced by the demand for factor inputs such as labor, stemming from investment, trade, and public goods provision, then a downward shock to productivity growth can lead to an amplified reduction in both growth and labor employment. In this scenario, growth and labor employment may fall to point D. This is because growth is no longer exogenous to the factors employed. If, as in this case, the active labor force falls when demand falls it reduces trend growth, for example, from the loss of firm-specific knowledge or underinvesting in innovation (Benigno and Fornaro 2018).[33] But even here with appropriate demand management policy, the level of employment per se can ultimately be independent of the growth rate, as lower levels of economic growth can still provide full employment if aggregate demand rises to fully match employed labor supply—prior to Covid-19 and since the global financial crisis we had full employment with lower growth, and we look set to return to that level again. Even if the Covid-19 shock scars growth prospects then full employment can be obtained with expansive demand management policies and to an extent this is what we may have in prospect. But that high employment will not be accompanied by rapid increases in productivity and prosperity unless sustained policies shift up the endogenous growth path.

In this world, when there are demand shocks and an upward-sloping growth curve, output and employment volatility will tend to be higher. And, if we allow expectations of this variance to matter for the decision rules of firms, this may have then had an effect on ongoing investment as firms may defer their immediate investment plans, particularly if carrying debt in the face of uncertainty. Persistently poor productivity performance may well then be a low equilibrium trap. It is one that has arguably trapped the UK, particularly in some of its regions. The point is that a failure to control output fluctuations through active demand management may have permanent, or at least long-lived, consequences for growth and employment patterns. But if we consistently rely on aggregate demand to reach full employment, we may then run into other traps that we now see. These will hamper future demand management options, as fiscal space may evaporate, and monetary policy may get stuck at the Effective Lower Bound with quantitative easing acting to distort bond prices.

A new class of models are taking us away from a strict distinction between supply and demand. From the supply side, Guerrieri et al. (2022) and Baqaee and Farhi (2022) have explored a disaggregated model with multiple sectors, multiple factors, input–output linkages, downward nominal wage rigidities, credit constraints, and a zero lower bound. Here various complementarities can mean that a negative supply shock can be amplified through a further negative shift in demand. However, annoyingly, it



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

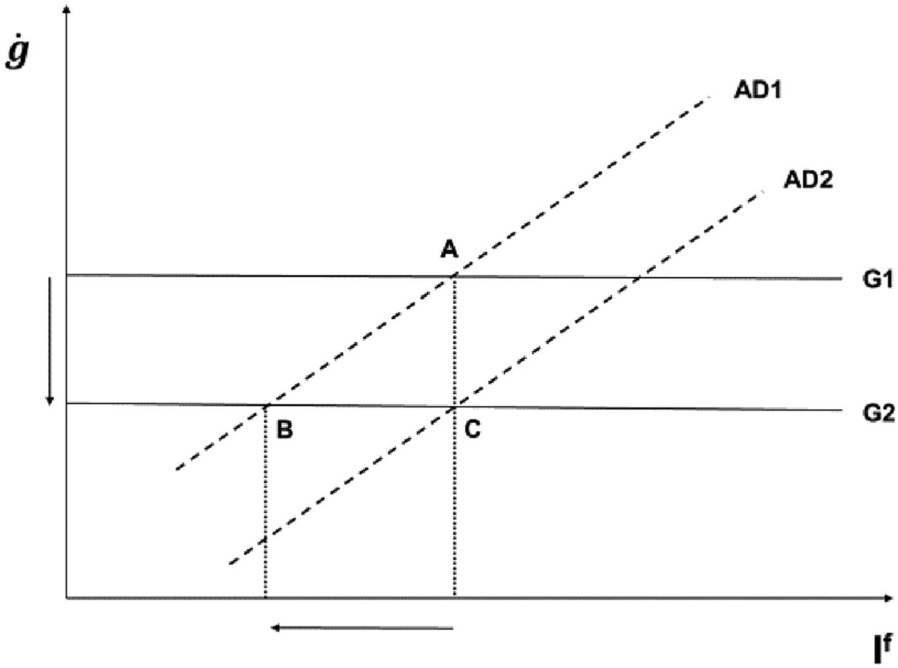


**FIGURE 26** | Exogenous supply with demand.
*Note:* $l^f$ is labor force and $\dot{g}$ is the trend rate of economic growth.

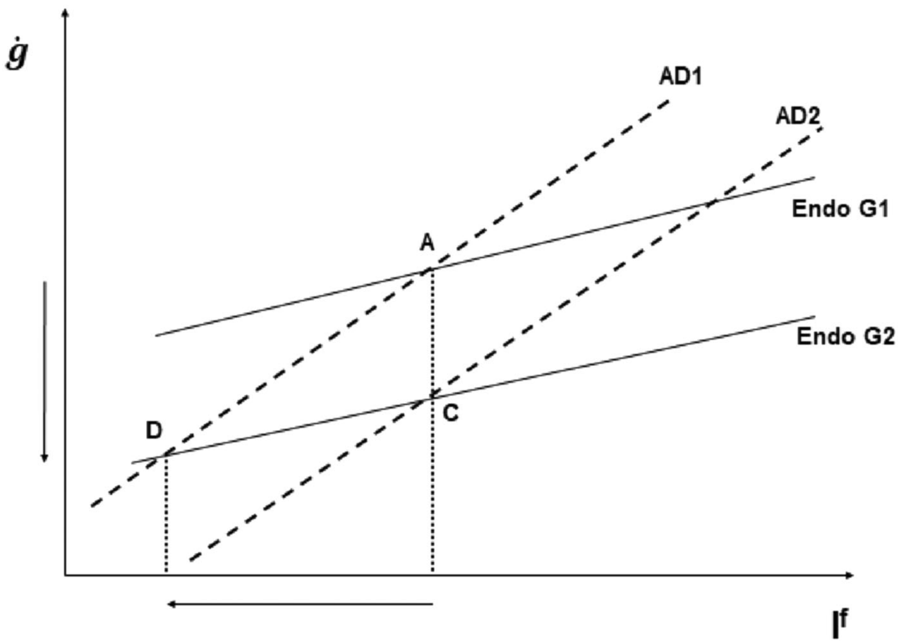


**FIGURE 27** | Endogenous supply with demand.
*Note:* $l^f$ is labor force and $\dot{g}$ is the trend rate of economic growth.

does not follow, with this approach, that demand management is necessarily more effective. It depends. Fiscal policy needs to be targeted, e.g., furlough or skills training and monetary policy directed at firm births and exits. This means a more granular approach to nurture a return to higher productivity. In Chadha et al. (2021), monetary and fiscal policy matter because they can combine to support financial conditions and support bank lending.

## 7 | Government Debt and Fiscal Policy

The global financial crisis heralded a sharp increase in the public debt-to-GDP ratios in advanced economies as current public expenditure rose sharply in 2010. The UK was particularly sensitive to the financial crisis as it focused on financial services, which accounted for some 10% of nominal GDP in 2010 (Chadha et al. 2017). Further increased public borrowing, following the



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

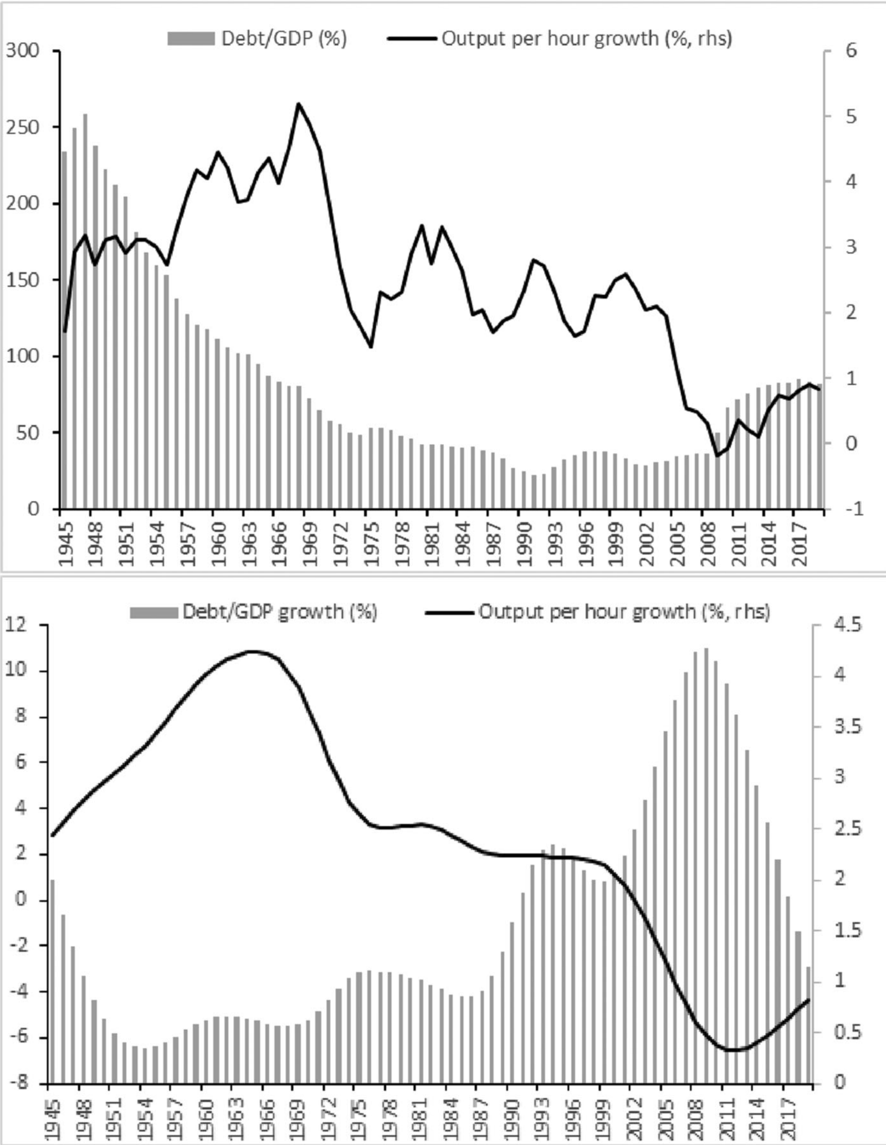


**FIGURE 28** | Debt to GDP ratio and productivity trends (1945-2019).
*Note:* The top panel represents the debt UK to GDP ratio and the 5-year centered averages growth of labor productivity in the UK between 1945 and 2019. The bottom panel represent HP-filtered growth series of debt to GDP and labor productivity in the UK (HP multiplier = 100). *Source:* Thomas and Dimsdale (2017), Office for Budget Responsibility (March 2024) and ONS (July 2022); authors' calculations.

Brexit referendum, during the Covid lockdowns and in the midst of the "cost of living crisis," which have combined higher spending without an increase in revenue performance means that public debt is likely to stay in the neighborhood of 100% of GDP for some time. The objectives for low and stable public debt levels at under 40% of GDP now seem like a half-forgotten dream (OBR 2023).

One possible reason for poor productivity performance is that higher current and expected levels of public debt may imply a fundamental and underlying deterioration in the fiscal position. In the long run that can only be closed by higher taxes on capital and/or labor in order to provide a credible solution to the government's present value budget constraint. If households and firms anticipate increases in taxes then labor and capital, as factors of production, will expect to lose some of the incentive to be more productive because the post-tax return would fall. There is some form here. Cooley and Ohanian (1997), with careful calibration of a growth model, suggest that higher capital taxes in the UK during WW2 and in the postwar period played a significant role in relatively poor macroeconomic performance. They compare outcomes to a tax-smoothing alternative and find that such a strategy would have been significantly more preferable. The sharp increase in public debt as a share of income over the recent past may be leading to expectations of substantial increases in taxes.

To illustrate this point, the upper panel of Figure 28 shows the path of public debt against a 5-year moving average of growth in income per head. The lower panel filters both series to remove high and low frequencies and suggests some correlation that might fit the hypothesis that public debt has played some role in



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

acting in a deleterious manner on the growth in income per head, particularly as public investment has been regularly constrained with current expenditure dominating any fiscal impetus.

Public investment peaked recently at 3.3% of GDP in 2009 and has subsequently fallen to around 2.0% of GDP since 2010. Fiscal policy has been constrained by commitments to current expenditure and this has limited the room for manoeuvre under successive fiscal rules for greater levels of public investment. Switching fiscal policy toward more carefully assessed public investment to include infrastructure may make a great deal of sense, especially if the fiscal multiplier of public investment is greater than one as reported in many studies (Gechert 2015).

## 8 | Conclusion

Modern growth accounting is usually the first step in analyzing national productivity performance. This approach decomposes the performance of labor productivity into a capital deepening component and a (residual) total (multi) factor productivity component. Recent twists on this framework show that the post-2008 slowdown of the UK's labor productivity can be fully accounted for by the anemic growth of residual TFP following the global financial crisis. Unfortunately, beyond the assumption that TFP is decided in some productivity frontier overseas, this does not allow us to say much about the UK's specific productivity performance. TFP is a residual where many factors are lumped together, including credit conditions, network effects, technology improvements, and firm-level organizational methods. Thus, allocating the UK's poor labor productivity performance to weaker TFP growth keeps the UK's productivity question wide open. Moreover, this framework cannot address what is potentially the central issue in the UK productivity debate: chronic underinvestment. We still need to establish the links between investment and TFP.

Public investment as a share of GDP dropped to a much lower long-term average after 1979, and the GDP share of business investment has trended downward since the early 1990s. This is puzzling, given that interest rates have trended downward since the 1990s. The Solow-Swan growth model assumes that aggregate investment is an exogenous constant fraction of output and is, by construction, unable to relate capital investment to interest rate levels.

The Ramsey-Cass-Koopmans model derives aggregate investment from microeconomic foundations. In this model, the aggregate investment outcomes are linked to the level of interest rates and the growth of TFP. We find that the RCK model's household saving equation can match both the drops in interest rates and in TFP after 2008 for certain values of the parameter driving the households' elasticity of intertemporal substitution. The debates on the value of this elasticity in the literature are not settled, with microeconomic and macroeconomic studies pointing to different values. In any case, the experience from the post-2008 decade can inform us about how advanced economies adjusted to a loss in aggregate productivity growth that is likely to be repeated as these economies, including the UK, find their way toward greener modes of production and consumption.

The relative price of investment goods has been trending downward since the 1980s. This trend partly explains the decline of the UK's investment share, as purchasing the same quantity of capital goods costs less in GDP terms. However, the UK's underinvestment puzzle remains unsolved as UK business investment underperforms other countries with similar trends in investment goods' prices.

Labor supply has increased, responding to a more flexible market favouring employers and increasing households' indebtedness. Standard macroeconomic models lack a mechanism to reflect post-2008 trends in the labor market and therefore have missed the increase in aggregate hours. This increase in aggregate hours should have made capital more productive, spurring investment. However, this surge in investment never materialized, deepening the UK's underinvestment puzzle.

Much of the recently revived "secular stagnation" debate centered around the effects of population ageing in advanced economies. In the UK, population ageing was compounded by higher participation rates of older workers and higher unemployment rates among younger workers in the period between the global financial crisis and the onset of the Covid-19 pandemic. A more experienced workforce translates into higher human capital in national accounting. This and the increase in the share of workers with a university degree thus deepen the UK's productivity puzzle.

Emerging literature provides theoretical arguments explaining the low investment despite low real interest rates. Liu et al. (2022) argue that low interest rates favour more industry concentration, which decreases competition and stifles investment in research and development. Kiyotaki et al. (2021) argue that low interest rates might not help entrepreneurs invest in new projects because it increases the present value of their fixed costs more than the external valuation of the cashflow they may generate. This reduces the value of the new projects from the perspective of outside funders, thus reducing external financing and stifling investment. We therefore focus on the primacy of the decline in real rates and financial mechanisms for understanding low growth outcomes, which have over time built up debt relative to GDP as the demand for public services has grown. In this sense the lack of productivity growth has most likely fostered an increase in public and private indebtedness as a temporary solution in maintaining living standards and supporting public services.

**Acknowledgments**

Special thanks to Nick Crafts, Miguel Leon-Ledesma and Tiago Cavalcanti for their valuable comments. We acknowledge comments from participants at the NIESR-Bank of England conference in November 2021 on Macroeconomics and Productivity and comments from colleagues at the ESRC's Productivity Institute, particularly Bart van Ark, Hande Küçük, Catherine Mann, Stephen Millard, Adrian Pabst, John Tsoukalas, John Turner and Tony Venables. We also thank three anonymous reviewers for their valuable comments. Finally, we thank Emma Chaplin for her excellent research assistance. We acknowledge the support of The Productivity Institute, funded by the UK Economic and Social Research Council (grant number ES/V002740/1). This work was realised as part of The Productivity Institute's Macroeconomic Theme and is a revised version of The Productivity Institute Working Paper 030 published in December 2022.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

**Conflicts of Interest**

No conflict of interest to report.

**Data Availability Statement**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Endnotes**

[1] Data from NiGEM database, accessed October 2022, NIESR's July 2022 forecast and NiGEM stochastic simulations; NIESR 2022.

[2] See also Bournakis and Vecchi (2025) for a study of the relationship between technical change and employment in the UK.

[3] Another possible definition is output per worker. However, this definition ignores intensive labor supply, thus showing an improvement in productivity when workers increase labor input by supplying more hours.

[4] New estimates of long-run productivity by Bouscasse et al. (2025) are worth noting.

[5] This is consistent with the findings in Mason et al. (2018).

[6] Employment rates can be decomposed into unemployment and participation rates.

[7] See Appendix A for derivation details.

[8] The capital shares $\alpha$ are also assumed to vary over time and are borrowed from ONS own growth accounting exercise.

[9] See Appendix A for derivation details.

[10] The results emanating from the standard decomposition are consistent with other studies providing an accounting of the labor productivity slowdown in the UK using ONS data (e.g., Mason et al. 2018; Goodridge et al. 2018).

[11] Goldin et al. (2024) use EU KLEMS instead of ONS data and find a more substantial contribution of labor composition to the slowdown of labor productivity in the United Kingdom. As noted by the authors, the EU KLEMS implied labor composition index differs across vintages, hence our preference for the more consistent ONS data.

[12] Riley et al. (2018) note that productivity measurement is particularly challenging in finance and ICT.

[13] Harris and Moffat (2017) point to a TFP decline in the services sector between 2008 and 2012.

[14] Coyle et al. (2024), documenting a decrease in quality-adjusted within-firm TFP in UK manufacturing and ICT, also point to a possible role played by spillovers from international producers with higher product quality and technical efficiency relative to UK-based producers.

[15] Fernández-Villaverde et al. (2023) argue that considering GDP per working-age adult instead of GDP per capita explains away much of the apparent weak performance of the Japanese economy relative to the United States.

[16] For a more detailed treatment of the continuous-time version of the Ramsey-Cass-Koopmans growth model, see Chapter 2 of Romer (2012). For a treatment of the discrete-time version of the model, see Novales et al. (2009).

[17] This exercise, however, requires non-trivial conditions on both agents' preferences and the technology constraining production (King et al. 1988).

[18] This guarantees that the return on capital, derived from the business cycle standard steady-state Euler saving condition, yields the same return on capital as the RCK model $r = 1/\beta - 1 \approx \rho + \sigma \left\{ \frac{g(TFP)}{1-\alpha} + g(Q) \right\}$.

[19] See Figure 20.

[20] See Figure 21. The figure shows that the long-term average of real loan rates facing safer non-financial UK corporates dropped from 3.5% to about 0%.

[21] The estimates of R* in Holston et al. (2017) and Rachel and Summers (2019) both use the methodology introduced by Laubach and Williams (2003).

[22] Gollier (2012) corrects the Ramsey rule to allow for uncertainty in the growth rate of per-capita consumption is *i.i.d* normal with mean $\bar{g}$ and variance $Var(g(c))$: $r = \rho + \sigma\bar{g} - 0.5\sigma(1+\sigma)Var(g(c))$.

[23] See Aghion et al. (1998) and Aghion and Howitt (2008) for surveys of endogenous growth theory.

[24] Krusell et al. (2000) distinguish between capital structures and capital equipment. Moreover, they assume that equipments are produced using a faster-improving technology.

[25] The authors argue that consumption per worker could increase in the most vulnerable poor countries, where capital intensity is low and the health impacts of climate change may be very high.

[26] Greenwood et al. (1997) build on the work of Hulten (1992).

[27] For more on the of the Covid-19 pandemic effects on productivity see Fernald et al. (2021); de Vries et al. (2021); Mortimer-Lee and Pabst (2022); Bloom et al. (2023).

[28] León-Ledesma and Moro (2020) calibrate their model to the United States, where the nominal share of investment remains approximately stable in the period they study. This is consistent with the behavior of the US nominal investment share in Figure 14.

[29] Drydakis (2024) reports that graduates with advanced artificial intelligence skills gain a competitive edge in the labour market, underscoring the value firms place on skills that complement intangible investments.

[30] See, e.g., Bloom et al. (2007) for the effects of uncertainty on investment by UK firms.

[31] The authors deal with endogeneity issues by decomposing TFP into expected and unexpected components (as in Levinsohn and Petrin (2003)).

[32] This figure of £22 billion has been used by others (e.g., Carney 2019).

[33] See León-Ledesma and Shibayama (2023) for a model where temporary non-technology shocks can lead to permanent TFP growth slowdowns (super-hysteresis) and Cerra et al. (2023) for a literature survey on the hysteresis effects on growth.

**References**

Abramovitz, M. 1956. *Resource and Output Trends in the United States Since 1870*, NBER, 1–23.

Acemoglu, D., and P. Restrepo. 2017. "Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation." *American Economic Review* 107, no. 5: 174–179.

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch. 2019. "Whatever It Takes: The Real Effects of Unconventional Monetary Policy." *The Review of Financial Studies* 32, no. 9: 3366–3411.

Acharya, V. V., and G. Plantin. 2019. "Monetary Easing, Leveraged Payouts and Lack of Investment." Working Paper 26471, National Bureau of Economic Research.

Agarwala, M., and J. Martin. 2022. "Environmentally-Adjusted Productivity Measures for the UK." Tech. rep., The Productivity Institute.

Aghion, P., and P. Howitt. 1992. "A Model of Growth Through Creative Destruction." *Econometrica* 60, no. 5: 323–351.

Aghion, P., and P. W. Howitt. 2008. *The Economics of Growth*. MIT Press.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Aghion, P., P. W. Howitt, M. Brant-Collett, C. García-Peñalosa, et al. 1998. *Endogenous Growth Theory*. MIT Press.

Ahmed, T., and A. A. Bhatti. 2020. "Measurement and Determinants of Multi-Factor Productivity: A Survey of Literature." *Journal of Economic Surveys* 34, no. 2: 293–319.

Aksoy, Y., H. S. Basso, R. P. Smith, and T. Grasl. 2019. "Demographic Structure and Macroeconomic Trends." *American Economic Journal: Macroeconomics* 11, no. 1: 193–222.

Andrews, D., C. Criscuolo, and P. N. Gal. 2019. "The Best Versus The Rest: Divergence Across Firms During the Global Productivity Slowdown." Tech. Rep. 1645, Centre for Economic Performance, LSE.

Andrews, D., and F. Petroulakis. 2019. "Breaking the Shackles: Zombie Firms, Weak Banks and Depressed Restructuring in Europe." Working Paper Series 2240, European Central Bank.

Arrowsmith, M., M. Griffiths, J. Franklin, E. Wohlmann, G. Young, and D. Gregory. 2013. "SME Forbearance and Its Implications for Monetary and Financial Stability." *Bank of England Quarterly Bulletin*.

Atkins, G., and L. Lanskey. 2023. "Working paper No. 19: The OBR's forecast performance-Graham Atkins." Tech. rep., Office for Budget Responsibility.

Bai, J. J., D. Carvalho, and G. M. Phillps. 2018. "The Impact of Bank Credit on Labor Reallocation and Aggregate Industry Productivity." *Journal of Finance* 73, no. 6: 2787–2836.

Banerjee, R., and B. Hofmann. 2018. "The Rise of Zombie Firms: Causes and Consequences." *BIS Quarterly Review*.

Banerjee, R., and B. Hofmann. 2022. "Corporate Zombies: Anatomy and Life Cycle." *Economic Policy* 37, no. 112: 757–803.

Baqaee, D., and E. Farhi. 2022. "Supply and Demand in Disaggregated Keynesian Economies with an Application to the COVID-19 Crisis." *American Economic Review* 112, no. 5: 1397–1436.

Baqaee, D. R., and E. Farhi. 2020. "Productivity and Misallocation in General Equilibrium." *Quarterly Journal of Economics* 135, no. 1: 105–163.

Barrero, J. M., N. Bloom, and S. J. Davis. 2023. "The Evolution of Work from Home." *Journal of Economic Perspectives* 37, no. 4: 23–49.

Benigno, G., and L. Fornaro. 2018. "Stagnation Traps." *The Review of Economic Studies* 85, no. 3: 1425–1470.

Bergeaud, A., G. Cette, and R. Lecat. 2016. "Productivity Trends in Advanced Countries Between 1890 and 2012." *Review of Income and Wealth* 62, no. 3: 420–444.

Best, M. C., J. S. Cloyne, E. Ilzetzki, and H. J. Kleven. 2020. "Estimating the Elasticity of Intertemporal Substitution Using Mortgage Notches." *Review of Economic Studies* 87, no. 2: 656–690.

Bloom, N. 2023. "Understanding and Measuring Uncertainty." Tech. rep., Econofact.

Bloom, N., S. Bond, and J. Van Reenen. 2007. "Uncertainty and Investment Dynamics." *Review of Economic Studies* 74, no. 2: 391–415.

Bloom, N., P. Bunn, P. Mizen, P. Smietanka, and G. Thwaites. 2023. "The Impact of COVID-19 on Productivity." *Review of Economics and Statistics* 1–45.

Blundell, R., C. Crawford, and W. Jin. 2014. "What can Wages and Employment Tell Us About the UK's Productivity Puzzle?" *The Economic Journal* 124, no. 576: 377–407.

Bournakis, I., and M. Vecchi. 2025. *Technology and Employment: Evidence for the UK Labour Market* Cham: Springer Nature Switzerland, 163–186.

Bouscasse, P., E. Nakamura, and J. Steinsson. 2025. "When did Growth Begin? New Estimates of Productivity Growth in England from 1250 to 1870." *Quarterly Journal of Economics* 1–54.

Brown, R., J. Liñares-Zegarra, and J. O. Wilson. 2019. "Sticking it on Plastic: Credit Card Finance and Small and Medium-Sized Enterprises in the UK." *Regional Studies* 53, no. 5: 630–643.

Brynjolfsson, E., D. Rock, and C. Syverson. 2021. "The Productivity J-Curve: How Intangibles Complement General Purpose Technologies." *American Economic Journal: Macroeconomics* 13, no. 1: 333–372.

Bunn, P., J. Chadha, T. Lazarowicz, S. Millard, and E. Rockall. 2021. "Household Debt and Labour Supply." Staff Working Paper, Bank of England Working Paper.

Butler, A. W., and J. Cornaggia. 2011. "Does Access to External Finance Improve Productivity? Evidence From a Natural Experiment." *Journal of Financial Economics* 99, no. 1: 184–203.

Cardona, M., T. Kretschmer, and T. Strobel. 2013. "ICT and Productivity: Conclusions From the Empirical Literature." *Information Economics and policy* 25, no. 3: 109–125.

Carney, M. 2019. "Enable, Empower, Ensure: A New Finance for the New Economy." Speech given by Mark Carney, Governor of the Bank of England at the Lord Mayor's Banquet for Bankers and Merchants of the City of London at the Mansion House, London.

Cass, D. 1965. "Optimum Growth in an Aggregative Model of Capital Accumulation." *Review of Economic Studies* 32, no. 3: 233–240.

Cerra, V., A. Fatás, and S. C. Saxena. 2023. "Hysteresis and Business Cycles." *Journal of Economic Literature* 61, no. 1: 181–225.

Chadha, J., L. Corrado, J. Meaning, and T. Schuler. 2021. "Monetary and Fiscal Complementarity in the COVID-19 Pandemic." Tech. rep., ECB Working Paper.

Chadha, J. S., and N. Dimsdale. 1999. "A Long View of Real Rates." *Oxford Review of Economic Policy* 15, no. 2: 17–45.

Chadha, J. S., A. Kara, and P. Labonne. 2017. "The Financial Foundations of the Productivity Puzzle." *National Institute Economic Review* 241: R48–R57.

Corrado, C., J. Haskel, C. Jona-Lasinio, and M. Iommi. 2022. "Intangible Capital and Modern Economies." *Journal of Economic Perspectives* 36, no. 3: 3–28.

Coyle, D., J. McHale, I. Bournakis, and J.-C. Mei. 2024. "Recent Trends in Firm-Level Total Factor Productivity in the UK: New Measures, New Puzzles." *Economica* 91, no. 364: 1320–1348.

Coyle, D., and J.-C. Mei. 2023. "Diagnosing the UK Productivity Slowdown: Which Sectors Matter and Why?" *Economica* 90, no. 359: 813–850.

Crafts, N. 2021. "The Sources of British Economic Growth since the Industrial Revolution: Not the Same Old Story." *Journal of Economic Surveys* 35, no. 3: 697–709.

Cressy, R. 2002. "Introduction: Funding Gaps: A Symposium." *Economic Journal* F1–F16.

Daams, M., P. McCann, P. Veneri, and R. Barkham. 2023. "Capital Shocks and UK Regional Divergence." Working Paper 34, The Productivity Institute.

de Vries, K., A. Erumban, and B. van Ark. 2021. "Productivity and the Pandemic: Short-Term Disruptions and Long-Term Implications: The Impact of the COVID-19 Pandemic on Productivity Dynamics By Industry." *International Economics and Economic Policy* 18, no. 3: 541–570.

Del, Gatto, M., A. Di Liberto, and C. Petraglia. 2011. "Measuring Productivity." *Journal of Economic Surveys* 25, no. 5: 952–1008.

Douch, M., H. Edwards, and S. Mallick. 2023. "Productivity Debacle in the UK: Do Post-crisis Firm Cohorts Explain the Performance Puzzle?" *British Journal of Management* 34, no. 3: 1459–1487.

Draca, M., R. Sadun, and J. Van Reenen. 2006. "Productivity and ICT: A Review of the Evidence." Tech. Rep. 749, London School of Economics and Political Science. Centre for Economic Performance. LSE.

Drydakis, N. 2024. "Artificial Intelligence Capital and Employment Prospects." *Oxford Economic Papers* 901–919.

Fankhauser, S., and R. S. Tol. 2005. "On Climate Change and Economic Growth." *Resource and Energy Economics* 27, no. 1: 1–17.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Favara, G., C. Minoiu, A. Perez, et al. 2021. "US Zombie Firms How Many and How Consequential?" Tech. rep., Board of Governors of the Federal Reserve System (US).

Feenstra, R. C., R. Inklaar, and M. P. Timmer. 2015. "The Next Generation of the Penn World Table." *American Economic Review* 105, no. 10: 3150–3182.

Fernald, J., and R. Inklaar. 2022. "The UK Productivity "Puzzle" in an International Comparative Perspective." The Productivity Institute, 20.

Fernald, J., H. Li, and M. Ochse. 2021. "Labor Productivity in a Pandemic." *FRBSF Economic Letter* 22.

Fernald, J. G. 2015. "Productivity and Potential Output before, during, and After the Great Recession." *NBER Macroeconomics Annual* 29, no. 1: 1–51.

Fernald, J. G., R. E. Hall, J. H. Stock, and M. W. Watson. 2017. "The Disappointing Recovery of Output after 2009." *Brookings Papers on Economic Activity* 1–58.

Fernández-Villaverde, J., G. Ventura, and W. Yao. 2023. "The Wealth of Working Nations." Tech. rep., National Bureau of Economic Research.

Fisher, J. D. 2006. "The Dynamic Effects of Neutral and Investment-Specific Technology Shocks." *Journal of political Economy* 114, no. 3: 413–451.

Forni, M., L. Gambetti, and L. Sala. (in press). "Macroeconomic Uncertainty and Vector Autoregressions." *Econometrics and Statistics*. https://doi.org/10.1016/j.ecosta.2023.07.002.

Gechert, S. 2015. "What Fiscal Policy is Most Effective? A Meta-Regression Analysis." *Oxford Economic Papers* 67, no. 3: 553–580.

Goldin, I., P. Koutroumpis, F. Lafond, and J. Winkler. 2024. "Why Is Productivity Slowing Down?" *Journal of Economic Literature* 62, no. 1: 196–268.

Gollier, C. 2012. "Pricing the Planet's Future: The Economics of Discounting in an Uncertain World. Princeton University." .

Goodfriend, M. 2004. "Monetary Policy in the New Neoclassical Synthesis: a Primer." *FRB Richmond Economic Quarterly* 90, no. 3: 21–45.

Goodfriend, M., and R. G. King. 1997. "The New Neoclassical Synthesis and the Role of Monetary Policy." *NBER Macroeconomics Annual* 12: 231–283.

Goodhart, C., and P. Erfurth. 2014. "Demography and Economics: Look Past the Past." *VoxEU.org* 4.

Goodridge, P., and J. Haskel. 2023. "Accounting for the Slowdown in UK Innovation and Productivity." *Economica* 90, no. 359: 780–812.

Goodridge, P., J. Haskel, and G. Wallis. 2018. "Accounting for the UK Productivity Puzzle: A Decomposition and Predictions." *Economica* 85, no. 339: 581–605.

Gopinath, G., Ş. Kalemli-Özcan, L. Karabarbounis, and C. Villegas-Sanchez. 2017. "Capital Allocation and Productivity in South Europe." *Quarterly Journal of Economics* 132, no. 4: 1915–1967.

Gordon, R. J. 2014. "The Demise of US Economic Growth: Restatement, Rebuttal, and Reflections." Working paper, National Bureau of Economic Research.

Gordon, R. J. 2015. "Secular Stagnation: A Supply-Side View." *American Economic Review* 105, no. 5: 54–59.

Gordon, R. J. 2016. "Perspectives on the Rise and Fall of American Growth." *American Economic Review* 106, no. 5: 72–76.

Górnicka, L. 2018. "Brexit Referendum and Business Investment in the UK." Working paper, International Monetary Fund.

Gouveia, A. F., and C. Osterhold. 2018. "Fear the Walking Dead: Zombie Firms, Spillovers and Exit Barriers." Tech. rep., OECD.

Gouveia, A. F., and C. Osterhold. 2020. "Productivity, Zombie Firms and Exit Barriers in Portugal." *International Productivity Monitor* 38: 29–49.

Greenwood, J., Z. Hercowitz, and P. Krusell. 1997. "Long-run Implications of Investment-Specific Technological Change." *American Economic Review* 342–362.

Groom, B., and P. Maddison. 2019. "New Estimates of the Elasticity of Marginal Utility for the UK." *Environmental and Resource Economics* 1155–1182.

Guerrieri, V., G. Lorenzoni, L. Straub, and I. Werning. 2022. "Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages?" *American Economic Review* 112, no. 5: 1437–1474.

Hansen, A. H. 1939. "Economic Progress and Declining Population Growth." *American Economic Review* 29, no. 1: 1–15.

Harris, R., and J. Moffat. 2017. "The UK Productivity Puzzle, 2008–2012: Evidence Using Plant-Level Estimates of Total Factor Productivity." *Oxford Economic Papers* 69, no. 3: 529–549.

Heil, M. 2019. *Finance and Productivity: A Literature Review*. Wiley Online Library, 151–182.

HMT. 2023. "The Green Book (2022)." Tech. rep., Her Majesty's Treasury, UK.

Holston, K., T. Laubach, and J. C. Williams. 2017. "Measuring the Natural Rate of Interest: International Trends and Determinants." *Journal of International Economics* 108: S59–S75.

Hopenhayn, H., J. Neira, and R. Singhania. 2022. "From Population Growth to Firm Demographics: Implications for Concentration, Entrepreneurship and the Labor Share." *Econometrica* 90, no. 4: 1879–1914.

Hulten, C. R. 1992. "Growth Accounting When Technical Change is Embodied in Capital." *American Economic Review* 82, no. 4: 964–980.

IMF. 2014. "World Economic Outlook: Legacies, Clouds, Uncertainties." Tech. rep., International Monetary Fund.

Jones, C. I. 2022. "The End of Economic Growth? Unintended Consequences of A Declining Population." *American Economic Review* 112, no. 11: 3489–3527.

Kahn, J. A., and R. W. Rich. 2007. "Tracking the New Economy: Using Growth Theory to Detect Changes in Trend Productivity." *Journal of Monetary Economics* 54, no. 6: 1670–1701.

Kaus, W., V. Slavtchev, and M. Zimmermann. 2024. "Intangible Capital and Productivity: Firm-Level Evidence from German Manufacturing." *Oxford Economic Papers* 76, no. 4: 970–996.

King, R. G., C. I. Plosser, and S. T. Rebelo. 1988. "Production, Growth and Business Cycles: I. The Basic Neoclassical Model." *Journal of monetary Economics* 21, no. 2-3: 195–232.

Kiyotaki, N., J. Moore, and S. Zhang. 2021. "Credit Horizons." Tech. rep., National Bureau of Economic Research.

Koopmans, T. 1965. "On the Concept of Optimal Growth, The Econometric Approach to Development Planning." *Econometric Approach to Development Planning*, 1st ed. North Holland, Amsterdam 225–287.

Krusell, P., L. E. Ohanian, J.-V. Ríos-Rull, and G. L. Violante. 2000. "Capital-skill Complementarity and Inequality: A Macroeconomic Analysis." *Econometrica* 68, no. 5: 1029–1053.

Kydland, F. E., and E. C. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica: Journal of the Econometric Society* 1345–1370.

Laubach, T., and J. C. Williams. 2003. "Measuring the Natural Rate of Interest." *Review of Economics and Statistics* 85, no. 4: 1063–1070.

Lebègue, D. 2005. "Revision du Taux D'actualisation Publique." Tech. rep., Commissariat General au Plan, France.

Lee, N., H. Sameen, and M. Cowling. 2015. "Access to Finance for Innovative SMEs Since the Financial Crisis." *Research policy* 44, no. 2: 370–380.




14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

León-Ledesma, M., and A. Moro. 2020. "The Rise of Services and Balanced Growth in Theory and Data." *American Economic Journal: Macroeconomics* 12, no. 4: 109–146.

León-Ledesma, M., and K. Shibayama. 2023. "(Endogenous) Growth Slowdowns." CEPR Disdcussion Paper 18506, CEPR Press, Paris & London.

Levine, O., and M. Warusawitharana. 2021. "Finance and Productivity Growth: Firm-Level Evidence." *Journal of Monetary Economics* 117: 91–107.

Levinsohn, J., and A. Petrin. 2003. "Estimating Production Functions Using Inputs To Control for Unobservables." *Review of Economic Studies* 70, no. 2: 317–341.

Li, Y. forthcoming. "Fragile New Economy: Intangible Capital, Corporate Savings Glut, and Financial Instability." *American Economic Review*.

Liu, E., A. Mian, and A. Sufi. 2022. "Low Interest Rates, Market Power, and Productivity Growth." *Econometrica* 90, no. 1: 193–221.

Long, J. B., and C. I. Plosser. 1983. "Real Business Cycles." *Journal of Political Economy* 91, no. 1: 39–69.

Lucas Jr, R. E. 1988. "On the Mechanics of Economic Development." *Journal of monetary economics* 22: 3–42.

Macqueen, R., S. Millard, U. Patel, K. Whyte, et al. 2022. "UK Economic Outlook: A risky present." *National Institute UK Economic Outlook* 6–36.

Maddison, A. 2010. "Historical Statistics of the World Economy: 1-2008 AD." Dataset.

Mankiw, N. G., D. Romer, and D. N. Weil. 1992. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics* 107, no. 2: 407–437.

Marianna, P., A. Ward, and M. B. Zinni. 2018. "International Productivity Gaps: Are Labour Input Measures Comparable?" OECD Statistics Working Papers 2018/12, OECD.

Martin, J., and S. Mackenzie. 2021. "Productivity Puzzle Revisited: What the Latest Official Data Tells Us About the UK's Biggest Economic Issue." Tech. rep., Office for National Statistics contribution to the UK's Productivity Commission.

Martin, J., and R. Riley. 2024. "Productivity Measurement: Reassessing the Production Function from Micro to Macro." *Journal of Economic Surveys* 1–34.

Mason, C., and Y. Pierrakis. 2013. "Venture Capital, the Regions and Public Policy: The United Kingdom since the post-2000 Technology Crash." *Regional Studies* 47, no. 7: 1156–1171.

Mason, G., M. O'Mahony, and R. Riley. 2018. "What is Holding Back UK Productivity? Lessons From Decades of Measurement." *National Institute Economic Review* 246: R24–R35.

Mathias, P. 1969. *The First Industrial Nation: An Economic History of Britain, 1700–1914*. Routledge.

McGowan, M. A., D. Andrews, and V. Millot. 2017. "The Walking Dead?: Zombie Firms and Productivity Performance in OECD Countries." .

Means, G. C., D. E. Montgomery, J. M. Clark, A. H. Hansen, and M. Ezekiel. 1939. *The Structure of the American Economy* vol. 1, US Government Printing Office.

Mortimer-Lee, P., and A. Pabst eds. 2022. *Covid-19 and Productivity: Impact and Implications*. National Institute of Economic and Social Research.

NAO. 2013. "Improving Access To Finance for Small and Medium-Sized Enterprises." Report, National Audit Office, UK.

Nordhaus, W. 2014. "Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches." *Journal of the Association of Environmental and Resource Economists* 1, no. 1/2: 273–312.

Novales, A., E. Fernández, J. Ruíz, et al. 2009. *Economic Growth: Theory and Numerical Solution Methods*. Springer.

OBR. 2016. "Economic and Fiscal Outlook - March 2016." Tech. rep., Office for Budget Responsibility.

OBR. 2023. "Fiscal Risks and Sustainability - July 2023." Tech. Rep. CP 870, Office for Budget Responsibility.

OECD. 2013. Supporting investment in knowledge capital, growth and innovation Organisation for Economic Co-operation and Development.

Oliver Wyman. 2024. "Improving Access To Finance for Small and Medium-Sized Enterprises." Report, Levelling-Up Advisory Council, UK.

ONS. 2021. "Changing Trends and Recent Shortages in the Labour Market, UK Changing Trends and Recent Shortages in the Labour Market, UK: 2016 to 2021." Tech. rep., Office for National Statistics.

ONS. 2024. "Statistical Bulletin: Investment in Intangible Assets in the UK: 2022." Tech. rep., Office for National Statistics.

Pessoa, J. P., and J. Van Reenen. 2014. "The UK Productivity and Jobs Puzzle: Does the Answer Lie in Wage Flexibility?" *Economic Journal* 124, no. 576: 433–452.

Philippon, T. 2022. "Additive Growth." Tech. rep., National Bureau of Economic Research.

Podkaminer, L. 2019. "The Decline in Investment Shares is Not Caused by Falling Relative Prices of Capital: A Note." *Empirica* 46, no. 2: 369–380.

Rachel, L., and L. H. Summers. 2019. "On Falling Neutral Real Rates, Fiscal Policy and the Risk of Secular Stagnation." *Brookings Papers on Economic Activity* 7: 1–54.

Ramsey, F. P. 1928. "A Mathematical Theory of Saving." *Economic Journal* 38, no. 152: 543–559.

Riley, R., A. Rincon-Aznar, and L. Samek. 2018. "Below the Aggregate: A Sectoral Account of the UK Productivity Puzzle." *ESCoE Discussion Papers* 6.

Romer, D. 2012. *Advanced Macroeconomics*. McGraw-Hill Companies, Inc.

Romer, P. M. 1990. "Endogenous Technological Change." *Journal of Political Economy* 98, no. 5, Part 2: S71–S102.

Samiri, I. 2022. "Firm Indebtedness, Investment and Productivity." in *Covid-19 and Productivity: Impact and Implications* ed. by P. Mortimer-Lee and A. Pabst, National Institute of Economic and Social Research, chap. 4, 34–46.

Sampson, T. 2017. "Brexit: The Economics of International Disintegration." *Journal of Economic Perspectives* 31, no. 4: 163–184.

Solow, R. M. 1956. "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics* 70, no. 1: 65–94.

Solow, R. M. 1957. "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39, no. 3: 312–320.

Stansbury, A., D. Turner, and E. Balls. 2023. "Tackling the UK's Regional Economic Inequality: Binding Constraints and Avenues for Policy Intervention." *Contemporary Social Science* 18, no. 3-4: 318–356.

Stern, N. 2006. "The stern Report." Tech. rep., Her Majesty's Treasury, UK.

Stiglitz, J. E., and A. Weiss. 1981. "Credit Rationing in Markets with Imperfect Information." *American Economic Review* 71, no. 3: 393–410.

Summers, L. H. (2014). "Reflections on the "new secular stagnation hypothesis"". In *Secular Stagnation: Facts, Causes and Cures* ed. by C. Teulings & R. Baldwin, London: CEPR Press, pp. 27–38.

Swan, T. W. 1956. "Economic Growth and Capital Accumulation." *Economic record* 32, no. 2: 334–361.

Syed, A., F. Massey, P. Pawelek, R. Korhonen, and M. Franklin. 2019. "Analysis of Compositional Changes in Hours Worked in the UK." Tech. rep., Office for National Statistcs.

Syverson, C. 2011. "What Determines Productivity?" *Journal of Economic Literature* 49, no. 2: 326–365.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Thomas, R., and N. Dimsdale. 2017. "A Millennium of UK Data." *Bank of England OBRA dataset*.

Thwaites, G. 2015. "Why are Real Interest Rates so Low? Secular Stagnation and the Relative Price of Investment Goods." Tech. rep., Bank of England Working Paper.

Torfs, W. 2021. "The EIF SME Access to Finance Index - October 2021 update." EIF Working Paper 2021/76, European Investment Fund (EIF), Luxembourg.

Van Beveren, I. 2012. "Total Factor Productivity Estimation: A Practical Review." *Journal of Economic Surveys* 26, no. 1: 98–128.

Wójcik, D., and D. MacDonald-Korth. 2015. "The British and the German Financial Sectors in the Wake of the Crisis: Size, Structure and Spatial Concentration." *Journal of Economic Geography* 15, no. 5: 1033–1054.

## Appendix A: Derivation of Growth Accounting Formulae

Both growth accounting formulae are derived from the definition of TFP as the output residual unexplained by changes in inputs

$$\Delta \ln TFP = \Delta \ln Y - \alpha\Delta \ln K - (1-\alpha)\Delta \ln N - (1-\alpha)\Delta \ln Q. \qquad (A.1)$$

Note that on the right hand side of (A.1) can be rearranged to

$$\Delta \ln TFP = \Delta \ln(Y/N) - \alpha\Delta \ln(K/N) - (1-\alpha)\Delta \ln Q. \qquad (A.2)$$

Rearrange to get the standard labor productivity growth accounting

$$\Delta \ln(Y/N) = \Delta \ln TFP + \alpha\Delta \ln(K/N) + (1-\alpha)\Delta \ln Q. \qquad (A.3)$$

To obtain the growth accounting expression in Fernald et al. (2017), remark that the right hand side of (A.1) can be rearranged as follows

$$\Delta \ln TFP = (1-\alpha)\Delta \ln(Y/N) - \alpha\Delta \ln(K/Y) - (1-\alpha)\Delta \ln Q. \qquad (A.4)$$

Divide by $1-\alpha$ and rearrange to get the labor productivity growth accounting in Fernald et al. (2017)

$$\Delta \ln(Y/N) = \frac{1}{1-\alpha}\Delta \ln TFP + \frac{\alpha}{1-\alpha}\Delta \ln(K/Y) + \Delta \ln Q. \qquad (A.5)$$

## Appendix B: Glossary of Acronyms

**AD**: aggregate demand; **EMU**: elasticity of marginal utility; **FERIR**: full employment real interest rate; **GFC**: global financial crisis; **GVA**: gross value added; **HMT**: Her Majesty's Treasury; **ICT**: information and technology technology; **IMF**: International Monetary Fund; **LFS**: Labour Force Survey; **NAO**: National Audit Office; **NUTS**: Nomenclature des unités territoriales statistiques (statistical territorial unit); **OBR**: Office for Budget Responsibility; **OECD**: Organisation for Economic Co-operation and Development; **ONS**: Office for National Statistics; **SDR**: social discount rate; **SPA**: state pension age; **R***: the natural rate of interest; **R&D**: research and development; **RCK**: Ramsey-Cass-Koopmans model; **SME**: small and medium entreprize; **TFP**: total factor productivity; **WAS**: Wealth and Assets Survey; **ZLB**: (interest rate) zero lower bound.



14676419, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/joes.70001 by Test, Wiley Online Library on [30/07/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License