I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 14620

The UK Productivity Shortfall in an Era of Rising Labour Supply

Andrew Benito
Garry Young

JULY 2021

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 14620

The UK Productivity Shortfall in an Era of Rising Labour Supply

Andrew Benito
NIESR and IZA

Garry Young
NIESR

JULY 2021

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

The UK Productivity Shortfall in an Era of Rising Labour Supply*

Labour productivity stagnated in the UK in the years between the financial crisis and the emergence of Covid-19. At the same time labour supply and employment grew strongly, driven primarily by net inward migration. Although labour productivity should be independent of labour supplied in the long run, this need not be the case in the medium-run while capital-per-worker adjusts. Our evidence suggests that around one-fifth, or 4½pp, of the 25 log point fall in productivity from its previous trend can be explained by increased labour supply, with idiosyncratic factors and a slowdown in TFP growth accounting for most of the shortfall.

JEL Classification: J11, J21, D24

Keywords: productivity, labour supply, capital deepening

Corresponding author:
Garry Young
NIESR
2 Dean Trench Street
London, SW1P 3HE
United Kingdom

E-mail: g.young@niesr.ac.uk

* We thank Charlie Bean for comments and discussions. All views, errors and omissions are our own.

1 Introduction

The UK's productivity shortfall dominated its economic challenges in the years between the global financial crisis of 2008 and the emergence of Covid-19 in 2020. Labour productivity stagnated for over a decade and contributed to the UK's real wage squeeze, prolonged fiscal consolidation, and, arguably, the Brexit vote. The productivity shortfall emerging since 2008 reached 25 log points by 2019 (Figure 1).[1]

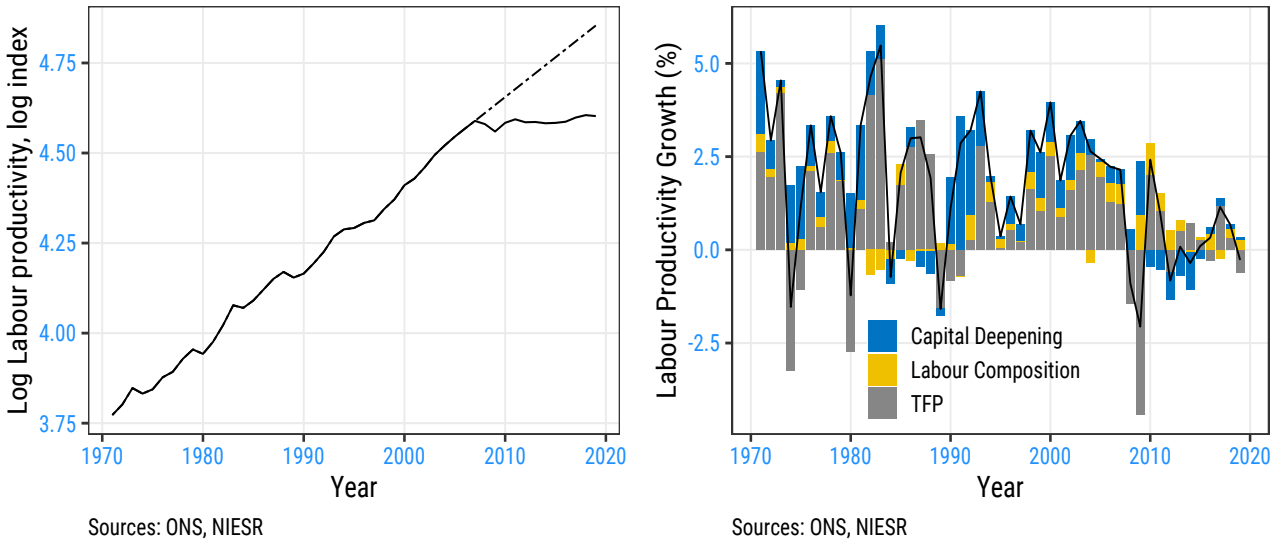
A growth accounting exercise indicates that reduced capital deepening – capital shallowing - accounts for between one-quarter and one-third of the slowdown. But what caused such capital shallowing? In our view it was partly due to an increase in labour supply that came at a time when capital markets were impaired. Between 2005 and 2019, the labour force expanded by almost 4 million, or 12.5%. That expansion was partly domestic (owing to rising participation rates, especially at older ages), but mostly external on account of inward migration.

In the long run, labour productivity should be independent of labour supplied. Our view, however, is that domestic and global sources of increased labour supply weighed on labour productivity growth during an extensive 'medium-run' from the mid-2000s. This depressed labour productivity and real wages during an adjustment phase. Consistent with the micro-economic evidence, the view does not imply that labour supplied by older persons or migrants 'undercut' wage-setting, it was just that greater labour supply pushed down on real wages generally.

Nevertheless, a prominent role for capital shallowing and rising labour supply still leaves a shortfall in total factor productivity (TFP) as the main factor behind the productivity shortfall during the medium-run. Looking ahead, while the role of rising labour supply and capital shallowing will subside in the long-run, and implies some incipient better news, the negative TFP shock will continue to weigh on the UK's longer-term productivity trend.

While Van Reenen and Pessoa (2014) emphasise the role of reduced capital deepening in contributing to the U.K. productivity shortfall up to 2012, they do not emphasise the role of rising labour supply. Most surveys of the productivity slowdown (eg Goldin *et al*,

[1]This estimate is relative to an extrapolated linear trend in log labour productivity estimated over 1971-2007.



(a) The productivity shortfall

(b) The composition of the slowdown

Figure 1: The UK productivity shortfall and its composition

2021) neither draw attention to, nor quantify, a role for labour supply. Oulton (2018) is a notable exception.

We reach three main conclusions. First, we quantify the impact of the U.K. labour supply shock in the past 15 years to 2019 as having lowered UK labour productivity by around a fifth of the 25 log point shortfall. While this is modest relative to the overall shortfall, it is still sizable in absolute terms.

Second, we reconcile our view that labour supply shocks lead to weaker labour productivity growth with standard growth theory by viewing the latter as applying in the long-run. Post-crisis, adjustment of the capital stock may have been further slowed down in the UK by credit imperfections and heightened risk aversion. This links the labour supply view with impaired capital adjustment.

Third, we reconcile our view that inward immigration, as a contributor to increased labour supply, weighed on labour productivity with the micro evidence suggesting immigration has had negligible effects on UK real wages or productivity. Most micro-based studies provide estimates that implicitly hold constant the macro-channel of reduced capital deepening that we highlight. Those that do not do this (eg, Ottaviano and Peri, 2012) emphasise an important role for slow capital adjustment to weigh on real wages in the

short-run, as do we.

The remainder of the paper is organised as follows. Section 2 outlines several facts about the UK labour productivity shortfall from aggregate and sector-level data. Section 3 turns to the key features of the rising labour supply view. Section 4 presents macroeconomic simulation results which help gauge the macro significance of these views. We include cross-country analysis as supplementary evidence of UK experience. Section 5 concludes.

2 The productivity shortfall: some stylised facts

Our analysis of UK productivity uses estimates from the Office for National Statistics for the UK market sector and component industries. These estimates are badged as 'experimental' and are subject to revision.

Relative to a simple extrapolative trend from 1970 to 2007, the UK labour productivity shortfall reached 25 log points in 2019. While growth in hourly labour productivity averaged 2.35% p.a. between 1971 and 2007, it slumped to just 0.11% p.a. from 2008 to 2019.

We explore the validity of assuming a break in 2008 through a break-point analysis. Our results suggest two break-points since 1970, occurring in 1999 (standard error: 2.3 years) and in 2006 (standard error: 0.6 years). The break-point analysis estimates trend labour productivity growth at 2.2%p.a. between 1970 and 1999, rising to 2.8% between 1999 and 2006 and then falling sharply to 0.2%p.a. between 2006 and 2019. This is consistent with (1) an ICT investment effect raising UK productivity growth temporarily from 1999; (2) a slowdown that started just before the financial crisis.[2]

A productivity slowdown that may have pre-dated the financial crisis is not a problem for our view suggesting strong labour supply accounted for part of the slowdown. As we describe below, significant components of the strong labour supply view also pre-dated the crisis. Moreover, there is nothing in that view, or in the break-point analysis, to suggest the crisis did not intensify the UK's productivity shortfall substantially.[3]

[2]Our break-point analysis in this section uses the method with unknown break-points from Muggeo (2003). Cette *et al.* (2016) find that the productivity slowdown in the U.S. and Euro area slightly preceded the great financial crisis. Oulton and Sebastia-Barriel (2016) investigate the effects of financial crises on labour productivity and suggest an insignificant long-run effect was typical of past financial crises in developed economies.

[3]For a recent review of UK productivity, see Crafts and Mills (2020).

2.1 Reduced capital deepening in a growth accounting exercise

Table 1 summarises a growth accounting exercise for the UK's market sector since 1971. As usual, estimates of total factor productivity in such decompositions are derived as a residual and in the short run can reflect labour hoarding and other cyclical influences. We draw attention to the following:

- While output growth during 2008-19 was on average slightly lower than in earlier periods, at 1.19%pa, its composition was unusually skewed towards growth in labour input (1.07%pa) rather than growth in labour productivity (0.11%pa).
- A turn-around in capital deepening. Capital deepening accounted for one-fifth (0.6pp) of average annual labour productivity growth during 2002-07. By contrast, a declining capital/labour ratio was an important drag on labour productivity after 2010 (-0.1pp).
- Earlier periods of steady growth in hours worked occurred alongside solid growth in labour productivity growth and capital deepening. In the 1980s, for instance, hours worked rose by an average 0.85%pa, with labour productivity rising by 1.91%pa and capital deepening contributing 0.52pp per year to labour productivity growth.
- By contrast, the 1970s and 1990s witnessed weak growth in total hours worked occurring alongside solid growth in labour productivity and contributions from capital deepening.
- Overall, the turn-around in capital deepening between 2002-07 and 2008-19 (0.7pp) accounted for between one-quarter and one-third of the slowdown in labour productivity growth (2.6pp). The slowdown in total factor productivity accounts for most of the observed slowdown.

Standard neoclassical economics offers little explanation for long-term movements in TFP beyond attributing it to technical progress.[4]

Many different stories can be consistent with any growth accounting exercise. Yet, the consistency of our story with other key labour market facts for the UK lends some weight

[4] A recent TFP literature highlights roles for allocation and misallocation of resources as key drivers of TFP (eg. Hsieh and Klenow, 2014).

Table 1: A growth accounting exercise

	Output growth (%pa)	TFP growth (%pa)	Labour Productivity growth (%pa)	Contribution of K/L to Productivity growth (pp)	Growth in Capital services, K (%pa)	Growth in Hours worked, L (%pa)
1974-1979	1.01	0.48	1.79	1.12	2.94	-0.77
1980-1990	2.77	1.46	1.91	0.52	2.37	0.85
1991-2001	2.45	0.96	2.40	1.17	3.09	0.05
2002-2007	3.05	1.80	2.67	0.58	2.01	0.39
2008	-0.43	-1.44	-0.89	0.55	2.00	0.46
2009	-6.24	-4.43	-2.06	1.43	-0.20	-4.18
2008-2019	1.19	-0.11	0.11	-0.09	0.85	1.07
1971-2019	2.24	0.97	1.80	0.63	2.24	0.44

* Note: UK market sector, average annual rates.

† Sources: ONS, NIESR

to our interpretation that strongly rising labour supply led to capital shallowing; this, in turn, weighed on labour productivity growth during an extensive medium-run.

2.2 A sector-level perspective

More light can be shed on the drivers of the overall productivity slowdown by looking at changes in trends in different parts of the economy.

Sector contributions to the productivity growth slowdown

Figure 2 illustrates the sector-level contributions to whole economy labour productivity growth. For ease of comparison, we initially focus on six sectors in three sub-periods since 2000. The six sectors are: IT, Business Services, Finance, Manufacturing, Public Services and a residual 'Other'. The three sub-periods are 2002-07, 2008-09, 2010-19. These allow us to highlight the following:

- Average annual productivity growth slowed from 2.02% during 2002-07 to 0.53% during 2010-19, with insufficient productivity growth in the latter period to make up

for falls in 2008 and 2009.

- Two sectors – Finance and Manufacturing – account for two-thirds of the fall in average productivity growth between 2002-07 and 2010-19.[5] The reduction in productivity growth in Finance has accounted for 0.50pp of the 1.5pp fall in annual average productivity growth.[6] The Manufacturing sector also accounts for 0.50pp of the fall. Finance and manufacturing account for 18.5% of total value added.
- But it would be incorrect to attribute the weakness is productivity to those two sectors alone. While in several sectors, productivity growth during 2010-19 was similar to that in 2002-07. In the right-hand panel these are subsumed into the 'Other' category and include Wholesale and Retail, Accommodation and food services and Administrative and support activities. As can be seen, this group experienced a material fall in productivity in 2008 and 2009 that has not been subsequently recovered.

Sector variation

Variation in labour productivity (across 18 sectors) is shown in Figure 3a, from 1970. Figure 3b shows the equivalent profiles for capital deepening at the sector-level and total market sector.[7] Both in aggregate and for most sectors the productivity slowdown coincided with an abrupt end to capital-deepening. Figure 3c shows that total factor productivity stagnated in all sectors from 2010.

Figure 4 shows that a fall in labour productivity was a common experience, with most sectors showing lower labour productivity growth after the financial crisis.

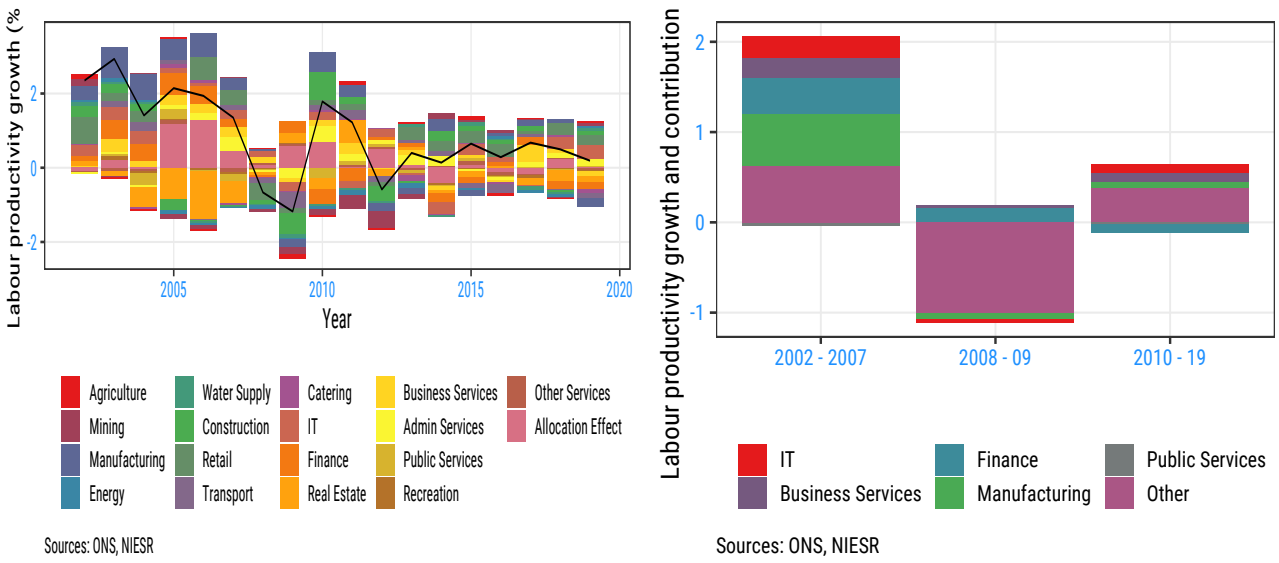
Estimated break-points indicate that only 4 out of 18 sectors have a break-point in the 2007 to 2009 period – notably, including the Financial services sector.[8]

[5]This point is highlighted by Tenreyro (2018) for the period up to 2015 and it still applies when extending the post-crisis period by four years. See also Riley *et al* (2015, 2018).

[6]Doubt can clearly be cast on the sector's large pre-crisis contribution when the Finance sector's measured productivity rose sharply. That doubt partly owes to measurement issues, as well as being partly conceptual. Both interpretations are related to the pre-crisis build-up of leverage. Bean (2016) describes how better regulation since then will have raised the quality of financial services without such improvements being fully captured in official measures of financial services output.

[7]Capital deepening is measured as Capital services / Hours worked.

[8]Our estimates allow for two break-points per sector at unrestricted dates over the 50-year period since 1970.



(a) Industry contributions, annual

(b) Industry contributions, grouped

Figure 2: The slowdown and its industry composition

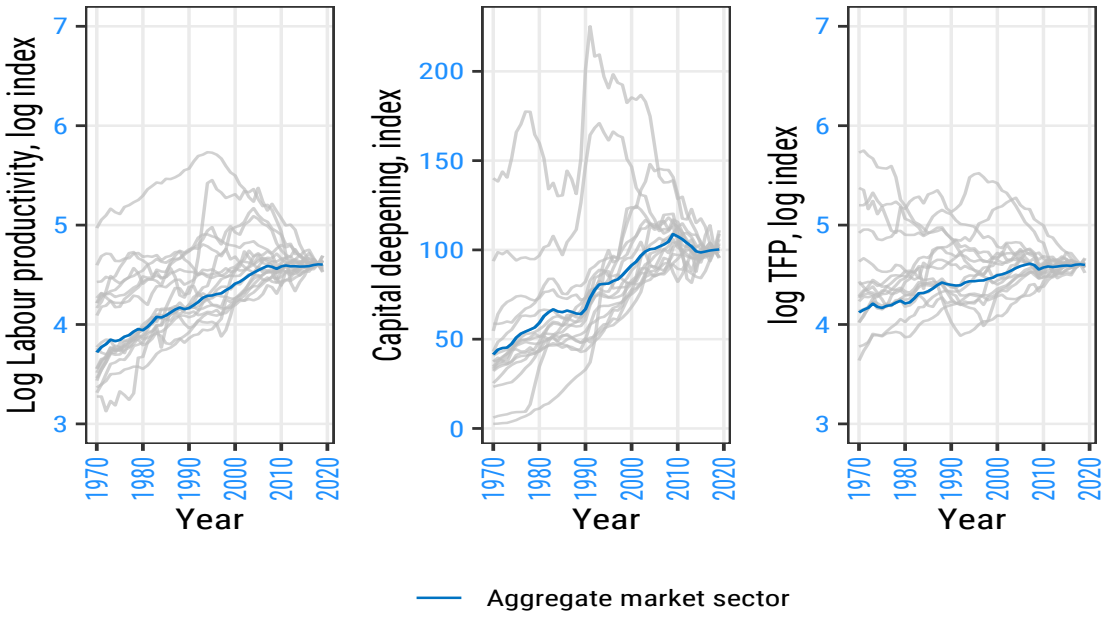
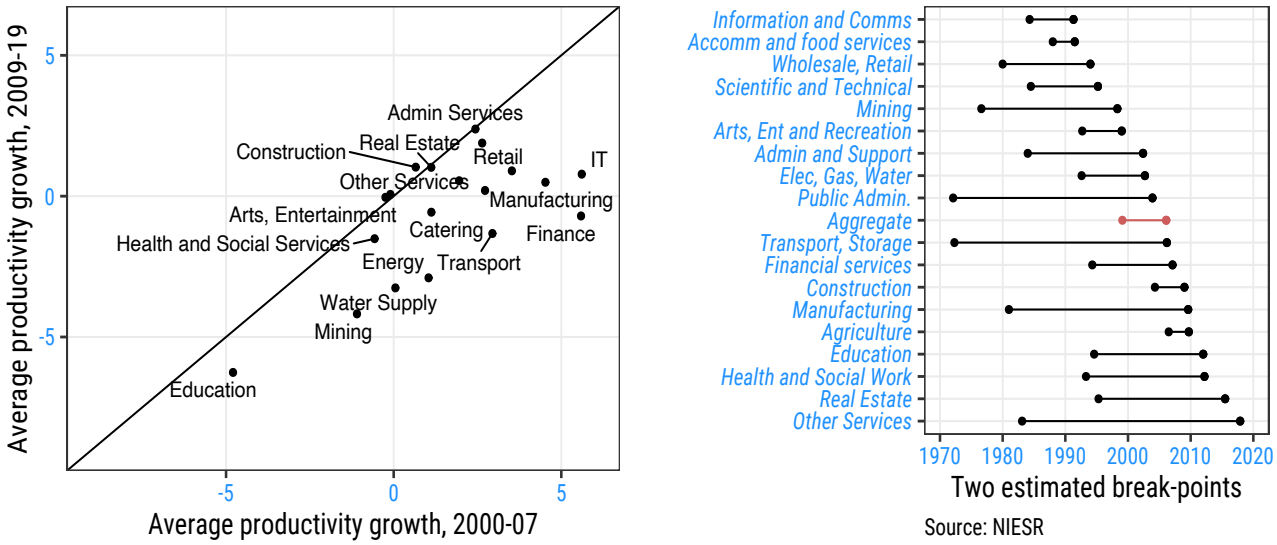


Figure 3: Labour productivity, capital deepening and TFP across sectors



(a) Pre- and Post-Crisis

(b) Estimated break-points in labour productivity

Figure 4: The slowdown across sectors

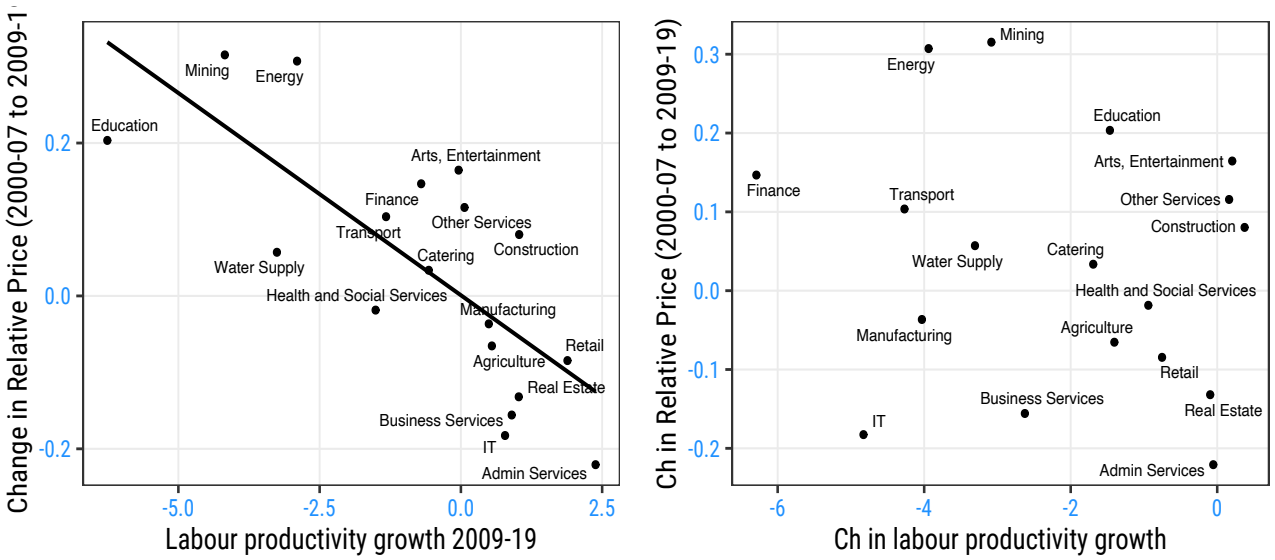
More light can be shed on the sector-level picture by relating sector-level developments to two other features of the UK economy: sector-level relative output prices and expansions in labour input at the sector-level.

Relative prices

If a sector's productivity slowdown reflected primarily cyclical demand factors then its output prices might be expected to have weakened in relative terms. If its slowing instead reflected primarily supply-side factors then its relative output prices might be expected to have risen.

Figure 5a suggests that, during 2009-19, those sectors with the stronger labour productivity growth tended to have more pronounced falls in relative prices, consistent with a supply-driven effect. Yet, the *change* in labour productivity growth (between 2000-07 and 2009-19) and relative output prices is likely to be more informative about whether weaker sector productivity was driven by predominantly demand- or supply-related factors.

Figure 5b suggests the relationship between the productivity growth slowdown at the sector-level and the change in relative prices likely differs across groups of sectors.



(a) Productivity growth

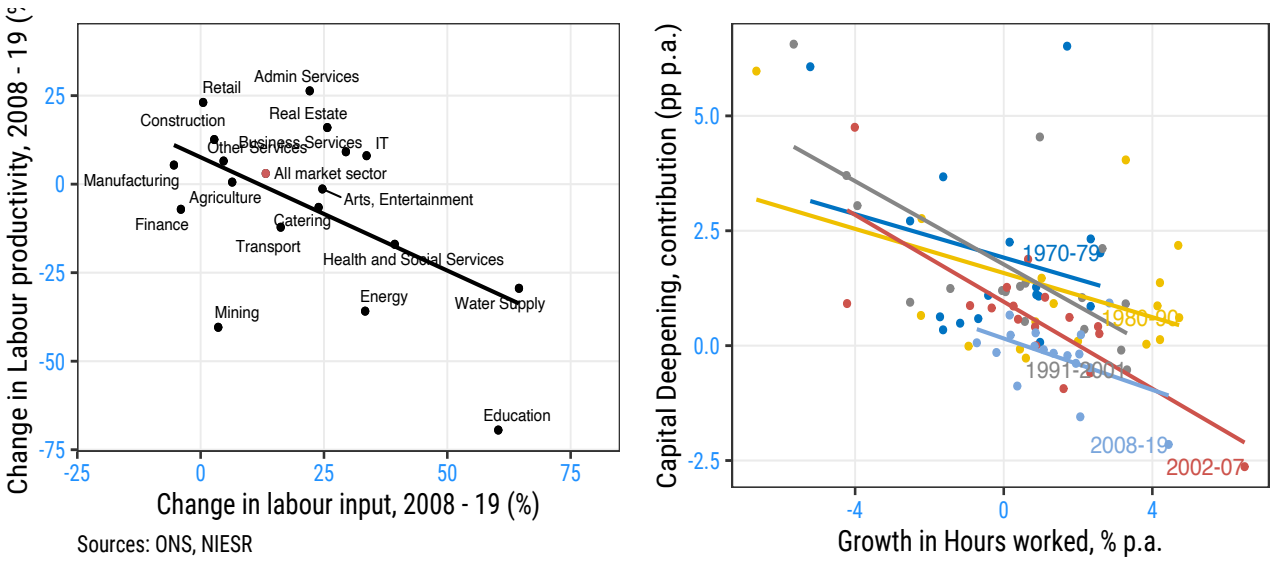
(b) Change in Productivity growth

Figure 5: Sector-level Productivity and Relative Prices

First, we view productivity trends in Finance, Energy and Mining as likely driven by idiosyncratic factors, such as re-regulation in Finance following the financial crisis and the need to reduce carbon emissions in energy. Second, in more internationally tradable sectors, such as Manufacturing and Business Services, weaker productivity growth was associated with lower relative prices - consistent with a role for weak international demand. Third, more domestically-oriented service sectors such as Arts and Entertainment, Construction, Catering and 'Other Services' were associated with more modest falls in productivity growth and higher relative prices, consistent with a supply effect, possibly associated with stronger labour supply.

Labour expansions

There is some evidence that those sectors with the weakest productivity trends since the mid-2000s also experienced the largest increase in hours worked and labour input (Figure 6). This is contrary to what would be expected if industry-level demand shocks dominate the pattern of productivity and hours worked. But it is consistent with a shifting labour supply curve tracing out different points along a negatively-sloped industry labour demand curve



(a) Labour expansions and sector productivity growth (b) Capital deepening and labour expansions

Figure 6: Productivity, Capital deepening and labour expansions

and could imply an important role for shifting labour supply. We explore this possibility further below.[9]

Is there an association between a sector's labour expansion and capital deepening? How has this differed across UK business cycles?

We compare average growth in hours worked and in the capital deepening contribution, averaged within five distinct business cycles since 1971 for each sector. Figure 6 suggests those sector/period averages with larger labour expansions were associated with a significantly lower capital deepening contribution. Plotting the relationship separately for each business cycle, suggests a broadly similar relationship in each period. At a descriptive level, larger labour input expansions are associated with a lower contribution from capital per worker to productivity growth.

[9]Measurement error in hours worked would induce a negative correlation with labour productivity (via its denominator). To gauge this factor we can compare the cross-sector correlation with an earlier period (for 1999-2007). As expected, this reveals an inverse association but a milder one compared with the later 2008-19 period. The slope coefficient ('t-value') for the later period is -0.64 (-2.58), compared with -0.40 (-1.70) in the earlier period.

2.3 Capital/labour substitution

The aggregate capital/labour ratio declined from the mid-2000s and, especially, post-crisis. This coincided with a fall in the relative price of labour (Figure 7), as well as the weaker TFP trend.

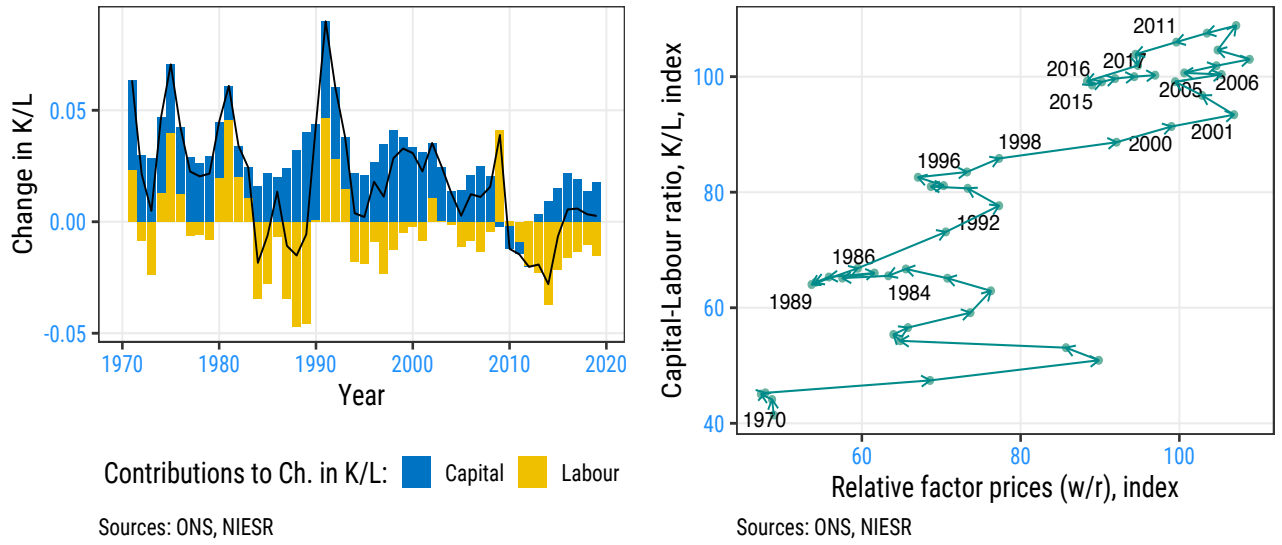
On a neo-classical view, greater abundance of labour would go hand in hand with a fall in its relative price. ONS data suggest that the relative price of labour fell quite substantially, by around 20%, in the 2009-15 period (Figure 7). [10]

If capital and labour are gross complements (and the elasticity of substitution $\sigma < 1$), an increase in the supply of labour raises the demand for capital. While there is no consensus about the precise value of σ, published estimates in the CES framework using aggregate US or sector-level data suggest $\sigma < 1$. We consider Figure 7 as simply suggestive of raw correlations between factor inputs and their relative prices. The sector-level data, and controlling for industry-specific fixed effects results in a short-run estimate $\sigma = 0.15$ (standard error = 0.013) with a long-run $\sigma = 0.69$ (standard error = 0.022).

Labour and capital are also likely 'q-complements' meaning that an increase in labour input raises the marginal product of capital. This assumption is widely employed in the immigration and labour market literature. It implies that an increase in labour will ultimately raise wages when the capital stock has adjusted, assuming a competitive labour market (Amior and Manning, 2021). We return to the adjustment of the capital stock in response to stronger labour supply below.

Overall, this suggests we should expect the capital/labour ratio to fall less than proportionately with the fall in the relative price of labour. That applies in the long-run and especially in the short-run. Adjustment of the aggregate capital stock plays a key role in transmitting the benefits of a larger labour force through the economy, but this takes time. More generally, a slower adjustment of capital will weigh on the capital/labour ratio (and

[10] As measured by the ONS, the price of capital is the implied average price of capital services from the existing stock. This is measured as gross operating surplus divided by the capital services index. The factor price of labour is calculated as compensation of employees divided by the quantity of labour index. Pessoa and Van Reenen (2014) argued that capital/labour substitution owed partly to increased wage flexibility and this contributed to a large role for reduced capital deepening in accounting for the UK productivity shortfall up to 2012.



(a) Aggregate factor contributions

(b) Capital/Labour and relative factor prices

Figure 7: Reduced capital deepening and relative prices

productivity) in response to a rise in labour supply.

2.4 A summary

We summarise the following stylised facts about the UK's labour productivity shortfall:

- Labour productivity growth slowed by an average of 1.5pp per year between the years preceding the financial crisis and the 2010s. For the market sector, it slowed by somewhat more.
- The slowdown was quite broad-based, applying in 14 of 18 sectors.
- The slowdown preceded the global financial crisis by 1-2 years, beginning in 2006 (and was very likely intensified by the crisis).
- Reduced capital deepening accounted for between one-quarter and one-third of the slowdown in labour productivity growth. Reduced TFP growth was the larger factor.
- A lower aggregate capital/labour ratio was associated with a falling relative price of labour to capital. In the 2010s, the relative price of labour (to capital) was around 10% lower than its pre-crisis average.

- The 2010s saw a historically rapid rate of labour force expansion.[11]
- At a descriptive level, larger labour input expansions are associated with a lower contribution from capital per worker to productivity growth.

3 Rising Labour Supply

We now describe key features of the UK's rising labour supply, amid reduced capital deepening and the productivity shortfall.

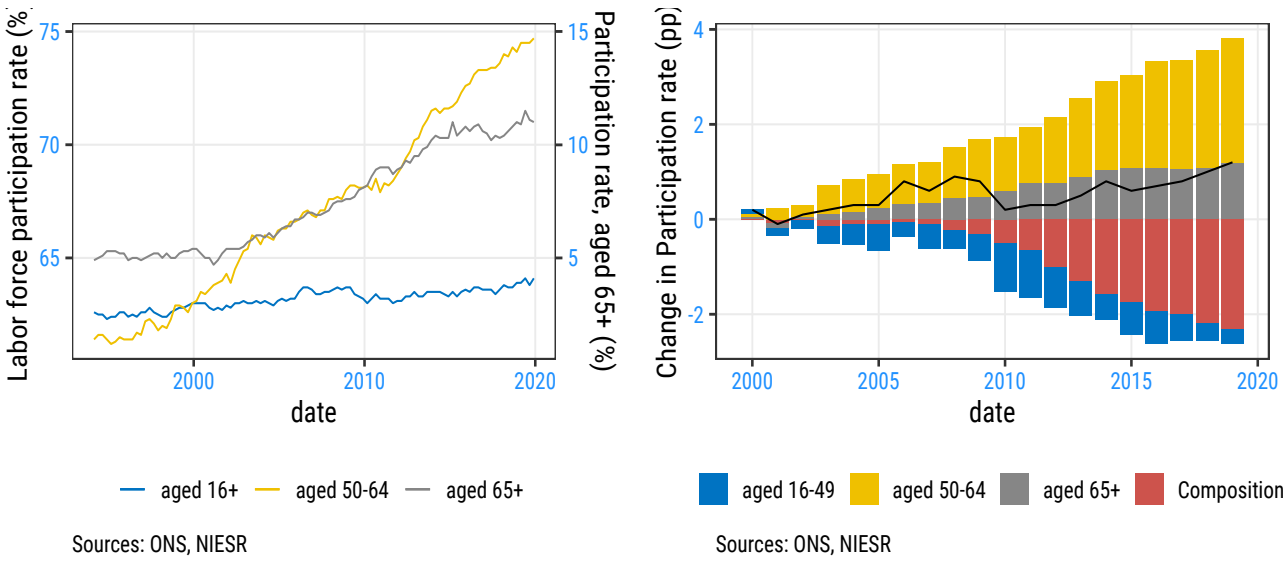
3.1 Domestic labour supply

Since 2005, the UK labour force has expanded by 3.8 million, or 12.5%.

We discuss population changes below, alongside net migration. In tandem, the 16+ labour force participation rate rose by around 1pp from 2005 and similarly from its 2010 low (Figure 8). That is equivalent to a rise of around 310,000 in the labour force. While that aggregate change may make the rise in participation appear modest, it masks the profound changes in participation at older ages. It also understates the underlying shift in labour supply at a time when real wages had stagnated or fallen.

The rising participation rate is significant for three reasons. First, it is a symptom of a positive labour supply shock as it coincided with a historically large squeeze in real wages. With a positively-sloped labour supply curve, only a labour supply curve shifting 'to the right' can reconcile falling real wages with a higher participation rate. Second, a rising participation rate is historically unusual after a downturn. The participation rate fell quite notably following the recessions of the early-1980s and early-1990s. There is evidence that increased labour supply is a household response to financial pressures. Benito and Saleheen (2013) find that negative financial shocks are followed by an increased incidence of participating in the labour market and increased desired working hours. Blundell *et al* (2016) find that families self-insure adverse shocks through increased labour supply. They find that families do this much more often than they use credit markets, the traditional

[11] Based on Bank of England data, this was the UK's most rapid labour force expansion since the 1940s.



(a) Participation rates

(b) Contributions to changing participation

Figure 8: Older persons' participation rates and rising aggregate participation

means of adjustment emphasised in models of household behaviour that take labour supply as given.

Third, the rise in participation rate has occurred despite the drag from a rising incidence of older persons with below-average participation rates. This compositional effect was a drag on participation, especially from 2010. A large behavioural effect (from higher participation rate at a specific age, especially among older persons) more than offset the increased incidence of older persons to result in the higher participation rate.[12] Figure 8 illustrates this point. The behavioural effect among those aged 50-64 contributed +3pp to a rise in participation, with an additional 1pp contribution from those aged 65+.[13]

High immigration was another source of labour force expansion, including from Central and Eastern Europe as the A8 countries joined the EU from 2004 (Portes, 2016; Oulton, 2018). Unlike most of the EU, the UK chose not to apply transitional controls on migration from the A8 accession countries. In much of Western Europe these transitional controls

[12]Benito and Bunn (2011).

[13]The state retirement age for women increased gradually from 60 to 65 between 2010 and late-2018, putting it in-line with men's state pension age. From March 2019, the state pension age rose (for both women and men) by a further year to 66 in September 2020. Micro evidence suggests raising women's retirement age also raises men's retirement ages, and participation rates overall, as older couples time their retirement decisions jointly.

did not end completely until May 2011.

3.2 Net migration and older persons' participation rates

Net inward migration has been historically high since the mid-1990s. From 2005 to 2019, net inward migration totalled 3.8 million based on the International Passenger Survey. This compares with the contribution to population growth coming from births less deaths that totalled 2.7 million.

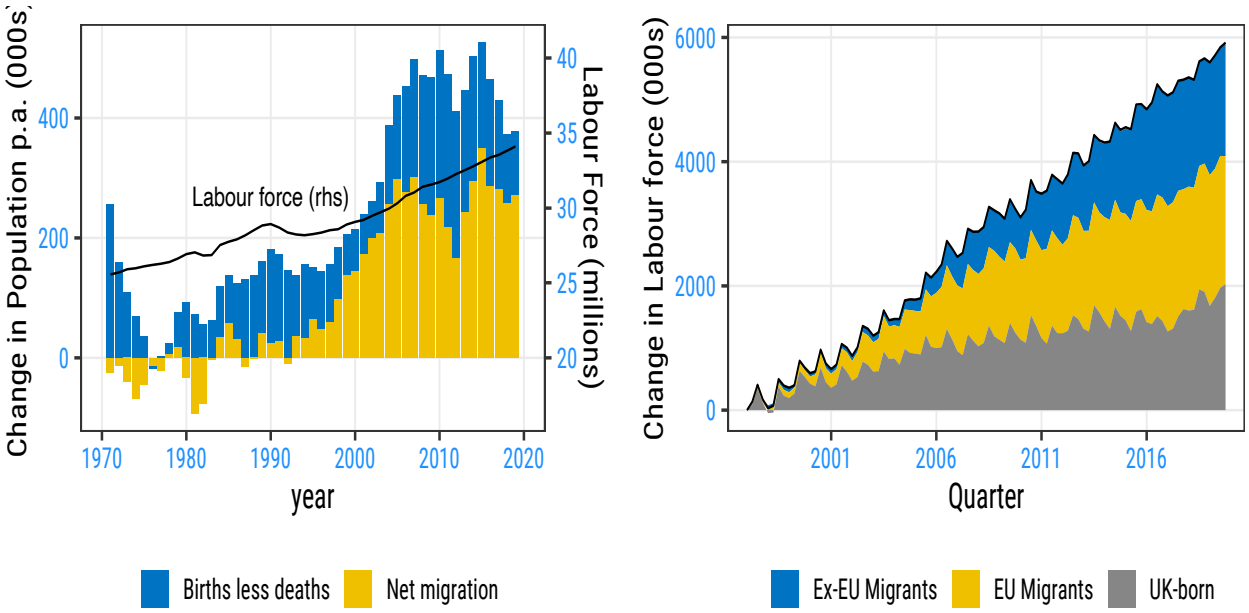
Around one-half of migrants (both inbound and outbound) participate in the labour force. Expansion in the labour force since the mid-2000s owed predominantly to migrants (Figure 9, based on the Labour Force Survey from 1997Q1 to 2019Q4). From 2005, migrants contributed 3.2mn to the expansion in the labour force and those UK-born contributed 1.1mn. Since the 2016 Brexit vote, the proportions of inward migration that has been of EU citizens has fallen.

The increase in labour force that one can attribute to older persons is about one-third as large as that resulting from net inward migration. The rise in the participation rate since 2005 of those aged 50+, which pushed up on the aggregate participation rate by almost 4pp, implied a 1.1 million rise in labour force.

Global labour supply and China

It is also worth noting a potential role for global labour supply as part of China's integration into the global trading system from the early-2000s. This may have encouraged the UK's specialisation in labour-intensive services (and higher value-added manufacturing) as it imported more manufactured goods. Although UK manufacturing output rose by 0.6% between 2000 and 2007, hours worked fell by 25.8%. Between 2010 and 2019, manufacturing output rose slightly, by 4.4%, but so too did hours worked, by 2.2%, as sector productivity has stagnated.

Autor *et al.* (2016) report that import growth from China between 1999 and 2011 led to an employment reduction of 2.4 million workers in the US, primarily in manufacturing. Pessoa (2016) finds that some trade shock effects are comparable in the UK as the US.



(a) Population growth and migration

(b) Labour force and migration, cumulative

Figure 9: Population growth, the labour force and migration

4 The macroeconomic impact of labour supply shocks

4.1 The long-run

One interpretation of our growth accounting exercise is that the observed reduced rate of capital deepening is a *response* to the slowdown in TFP growth associated with the financial crisis. This is a natural interpretation in a standard growth model in which the capital stock is determined by the usual first order condition requiring the marginal product of capital to equal the real interest rate. Under constant returns to scale, both productivity and the capital/labour ratio are independent of the size of the labour force.[14]

To illustrate this point, consider a Cobb-Douglas production function which implies the following for labour productivity (y-l).

$$y - l = a + b(k - l) \tag{1}$$

[14]Our simulation exercise avoids this interpretation since it explicitly considers the economy's response to a labour supply shock.

where y = log output, l = log labour force, k = log capital stock, a = log TFP, b = capital share. This has the following first-order condition:

$$(1-b)(l-k) = log(r/b) - a \tag{2}$$

with r = discount rate. This leads to:

$$y - l = a + [b/(1-b)][a - log(r/b)] = a/(1-b) - [b/(1-b)].log(r/b) \tag{3}$$

implying that labour productivity $(y-l)$ is independent of the quantity of labour supplied (l). In the long-run, and given diminishing marginal returns to labour (and capital), rises in the size of the labour force do not affect labour productivity as the optimum capital stock will increase in line with labour supply in equilibrium.

From (2), a negative TFP shock (a) also implies reduced capital deepening. This means that in the long run, the labour productivity shortfall no longer results from reduced capital deepening and a labour supply shock. Instead, the evolution of total factor productivity alone determines the productivity shortfall. In the long run, as Prescott (1998, p.526) puts it, "Total factor productivity determines labor productivity, not only directly, but also indirectly by determining capital per worker."

Our interpretation is that this applies after the economy and labour market have fully adjusted to higher labour supply. The role of stronger domestic labour supply is, therefore, best seen as a view of the 'medium-run'.[15] But this is important because adjustment does not occur instantaneously.

In standard macroeconomic analysis, a positive labour supply shock shifts the long-run aggregate supply curve 'to the right' and causes actual output to rise in line with increased potential. In the short run, greater availability of labour pushes down on real wages and, by reducing marginal costs, encourages imperfectly competitive firms to lower prices and thereby stimulate demand, output and employment. With capital tending to be slow to

[15]As an example of capital deepening affecting labour productivity during an extensive period, Oulton (2020) cites the case of post-War reconstruction. Post-war reconstruction raised labour productivity during an extensive, post-war period. We think of the role of the labour force expansion since the mid-2000s as being the mirror image of that post-war capital deepening.

adjust, higher employment is associated initially with reduced capital deepening and lower labour productivity. Yet, with a lower capital/labour ratio pushing up the marginal product of capital, firms have an incentive to increase investment until the capital/labour ratio rises back to its original level and the economy returns to its balanced growth path.

In the new, long-run equilibrium, output and the capital stock will have risen proportionately to increased labour supply and labour productivity will ultimately be unaffected by the labour supply shock (e.g. Borjas, 2019).

The key practical question is how long this adjustment process takes to complete and relatedly its impact on labour productivity in the meantime. In an influential analysis of immigration in the US, Ottaviano and Peri (2012) explicitly take capital adjustments into account. They note that 'the recent growth literature usually estimates a 10% speed of convergence of capital to the own balanced growth path for advanced (OECD) economies (Islam, 1995; Caselli *et al* 1996)'. They estimate a similar rate of convergence based on US data, 1960-2004.

According to Dustmann *et al* (2008), "this adjustment speed means that, instead of reducing the capital/labour ratio by 11% and consequently average real wages by 3.6%, the immigrant inflows to the US between 1990 and 2004 only reduced the capital/labour ratio by 3.4%, which in turn implies a much smaller negative effect of only 1.1% on average wages in the economy. Basically, the faster capital is able to adjust, the smaller will be the effect on average wages in the economy."[16]

Our own assessment is that adjustment could be considerably slower than this in the UK context, resulting in an extended period of weak productivity. This largely reflects the apparent slow adjustment of fixed investment to its determinants. Some of the key channels of adjustment may have been especially impaired in the aftermath of the financial crisis.

We employ an empirically-based macroeconomic model that has been calibrated to recent UK quarterly national accounts data.[17] The model highlights the possibility of an

[16]See also Furlanetto and Robstad (2019).

[17]The Dynamic Sectoral Model is a prototype sectoral model that has been developed at NIESR. It is an open-economy New Keynesian model where output is largely demand determined in the short run and supply determined in the long run. The sectoral model has now been fully integrated into the National

extended period of weak productivity growth following an increase in labour supply, and illustrates the key channels involved.

4.2 A simulation exercise

The underlying macroeconomic structure is a standard (but non-DSGE) open-economy, New Keynesian model based around an IS curve, a Phillips curve and a description of monetary policy behaviour. The model includes the following features:

- A well-specified production function linking factor demands and aggregate potential output to the net capital stock, labour supply and labour augmenting technical progress. The model disaggregates production into eight industrial sectors. [18] Each sector has its own production function and differs in terms of the estimated factor shares, underlying productivity trends, exposure to international competition and its use and consumption of intermediate goods.
- A forward-looking investment function that relates the investment rate to the difference between the marginal product of capital (determined by the production function) and the cost of capital. The equation used in each sector is:

$$I_{it}/K_{it-1} = \beta_{i0} + \beta_{i1}(\partial Y_i^V/\partial K_i - u_{it} - \phi_{it}) + \beta_{i2} I_{it+1}/K_{it}$$

In theory, β_{i1} is determined by the cost of adjusting the capital stock — the larger the adjustment cost the smaller is β_{i1} — and $\beta_{i2} \approx 1-\delta_i$, the proportion of the capital stock that survives from one period to the next. The term $\partial Y_i^V/\partial K_i - u_{it} - \phi_{it}$ is the marginal product of capital less the user cost adjusted for a time-varying premium reflecting uncertainty and borrowing restrictions not already included in the user cost. The values $\beta_{i1} = 0.013$ and $\beta_{i2} = 0.9$ are imposed in each sector. These values are based on estimation results for the manufacturing sector.

Institute Global Econometric Model (NiGEM), see Lenoel and Young (2021).

[18] The 8 sectors are: mining and quarrying, manufacturing, construction, private traded services, private non-traded services, financial services, public sector and an energy sector comprising agriculture, electricity and water. Imputed rent is also treated as a separate industry.

- A forward-looking consumption function that relates spending to expected permanent non-property income, net financial wealth and real interest rates. Expected permanent non-property income is determined by the discounted value of expected future non-property income adjusted for population growth.
- A wage and price system that ensures that unemployment and the output gap settle at equilibrium values in the medium term. Domestic prices (the GDP deflator) are determined in the long run by unit labour costs, average earnings are determined by productivity and expected producer prices (GDP deflator). Consumer prices are determined by producer prices and import prices, with lagged pass-through.
- Exports and imports are determined by international and domestic demand and by prices in the UK relative to other countries. The nominal exchange rate is determined by uncovered interest parity.
- Monetary policy determines the nominal interest rate which is set to follow a backward-looking feedback rule that targets consumer price inflation.
- Balance sheet equilibrium is ensured by feedback within different sectors. In particular, excess government debt leads to higher household taxes, excess company debt leads to lower dividend distributions and so lower household receipts, lower household net wealth leads to lower consumption.

Simulation results

We use the model to simulate the effects of a 12.5% increase in the population of working age, corresponding roughly to the increase in UK labour supply that occurred between the financial crisis that began in 2007 and 2019. In the main case we allow for an increase that occurs smoothly over a twelve-year period (labelled "staggered labour supply"). We contrast this with a variant where the increase occurs smoothly over three years ("front-loaded labour supply").

Employment increases quickly in response to the rise in labour supply (Figure 10). This owes to the extra labour supply pushing down initially on wages and domestic prices leading to increased demand for UK output, and hence employment via the production

function. The demand increase is driven by the internationally traded sectors, manufacturing, financial services and other private traded services, where exports rise sharply in response to increased competitiveness. It spills over to other sectors via greater demand for intermediate outputs and as domestic output expands. But domestic demand rises quite sluggishly in comparison. This is partly because of short-term yet persistent weakness in real household income reflecting lower real wages weighing on consumers' expenditure.

Domestic-facing, non-traded sectors such as construction and private non-traded services thereby respond more weakly than the internationally traded sectors. The marginal product of capital increases as output rises ahead of the capital stock and this leads to higher fixed investment (Figure 11). But fixed investment increases only moderately leading to a slow expansion in the capital stock. The net effect is that the capital-labour ratio declines and labour productivity is lowered by around $4\frac{1}{2}\%$ at its peak effect (Figure 11). Even after 30 years, labour productivity remains around 2% lower than otherwise, absent the increase in labour supply.

The model simulations show that the faster the labour supply shock occurs the larger the short-run adjustment will be, particularly for wages and prices, but the ultimate adjustment is broadly the same.

The labour supply increase is modelled as a common shock that has a heterogeneous impact on different sectors reflecting the main channels of adjustment. Since additional labour supply pushes down on wages and prices and boosts real demand largely through increased international competitiveness, the largest increases in output are in the traded sectors (manufacturing, finance and private traded services) with less impact on construction and non-traded services (Figure 12, assuming the labour supply shock is staggered over time).

The impact on sectoral productivity is more similar across sectors than the impact on sectoral output (Figure 12). In the 12-year period when labour supply is increasing, labour productivity falls in each sector by a similar amount of around 4% relative to base. Subsequently, productivity begins to recover as capital intensity returns to its baseline. But this occurs at a different pace in each sector reflecting differences in the marginal product

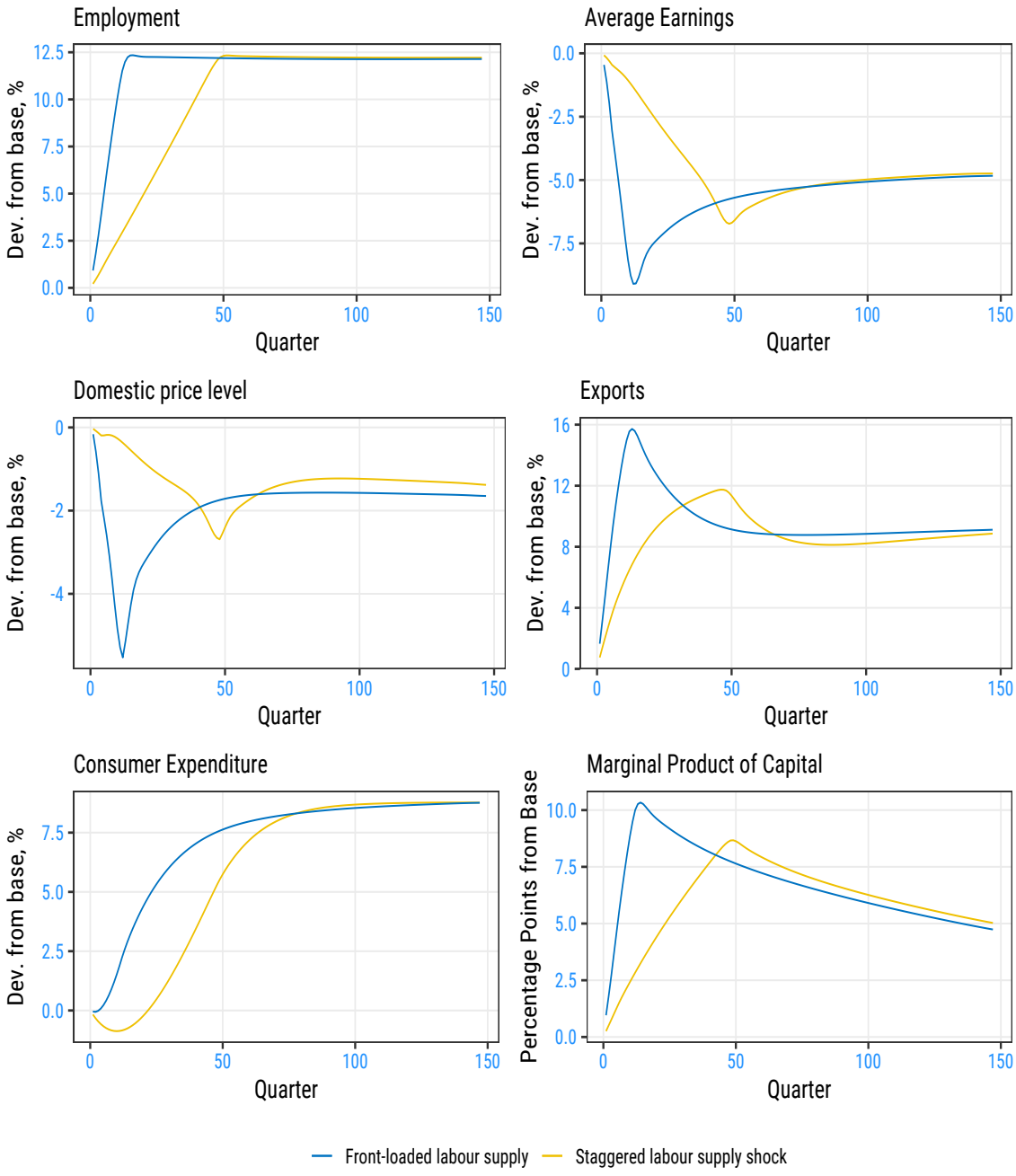


Figure 10: Simulation results [1]

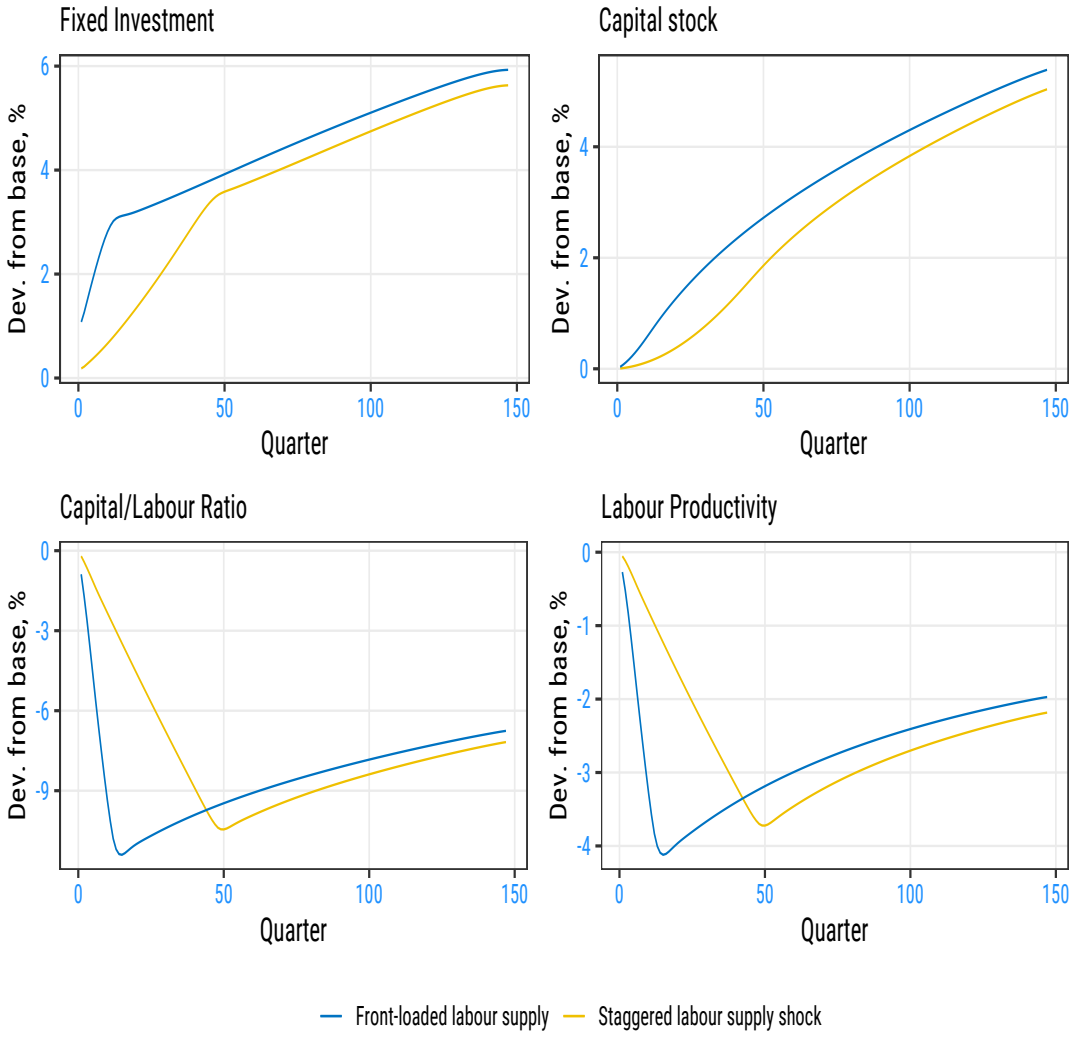


Figure 11: Simulation results [2]

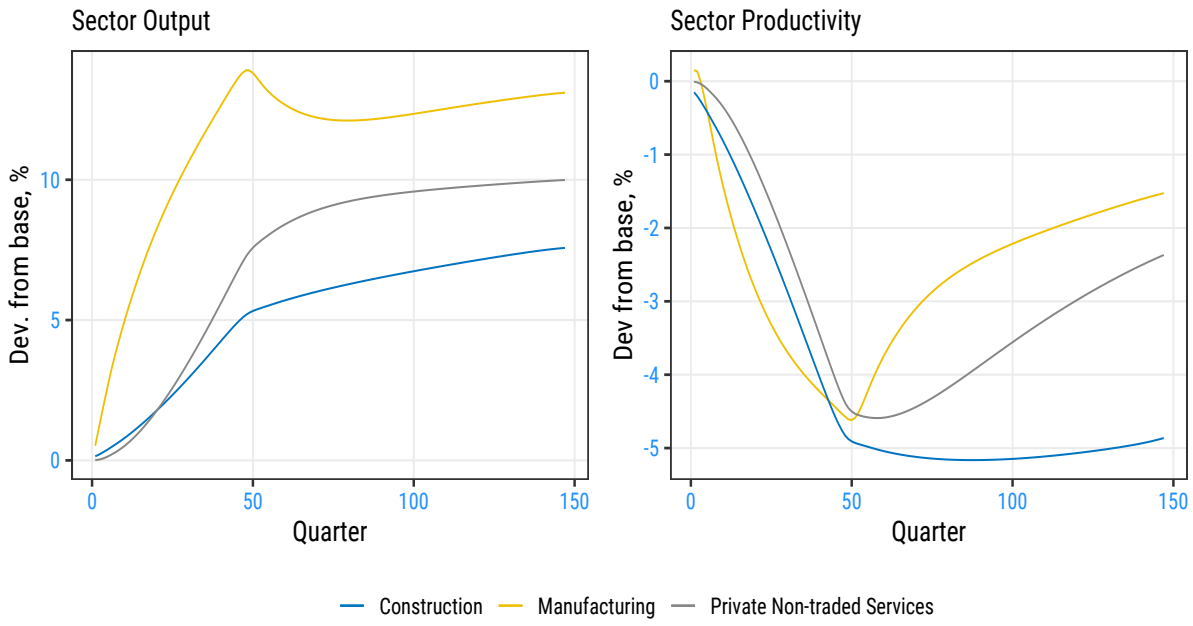


Figure 12: Simulation results [3]

of capital which rises the most in the traded sectors.

In summary, the simulation evidence suggests that a labour supply shock of a similar size to the labour supply increase observed in the UK between 2007 and 2019 could reduce the level of labour productivity temporarily by around 4%. This effect is close to the size of the reduced contribution of capital deepening to the productivity slowdown over that period.

How plausible is this simulation evidence? Inevitably, the modelled effect is sensitive to the various assumptions underlying the empirical relationships in the model. Of key importance are the investment relationships that lie behind the small adjustment of fixed investment and the capital stock to an increase in the marginal product of capital. Greater investment sensitivity would reduce the estimated effect on labour productivity, but there is little empirical evidence of such an effect. In fact, as documented in Section 2, recent trends at the aggregate level and in individual sectors support a reduction in capital intensity since the financial crisis, consistent with the simulation evidence. Impaired capital markets following the financial crisis could have made capital adjustment more difficult than implied by the model.

It is also worth noting that other adjustment processes to increased labour supply may also have been impaired in the years following the financial crisis. One of the important adjustment channels in the model is by improved international competitiveness generating extra international demand for UK goods and services. But euro area weakness and latterly the Brexit vote may have made such adjustment more difficult than implied by the model.

4.3 Cross-country evidence

We complement our earlier analysis with some cross-country evidence on productivity growth. We use The Conference Board's Total Economy Database to explore cross-country links between labour productivity growth and population (or labour force) growth. From the database, we select its 25 countries in Western Europe, North America, Oceania and Japan for the period from 1960.

Average annual productivity growth correlates inversely with (average annual) population growth in the 60-year period (Figure 13). High productivity growth economies over this extended period have tended to have lower population growth. This is similar to the cross-country relationship highlighted by Beaudry and Collard (2002) up to 1997. Dividing the sample period by decade indicates that the cross-country relation is strongest in, and largely driven by, the 1960s experience. A generalised productivity slowdown across industrialised countries over time is also apparent.

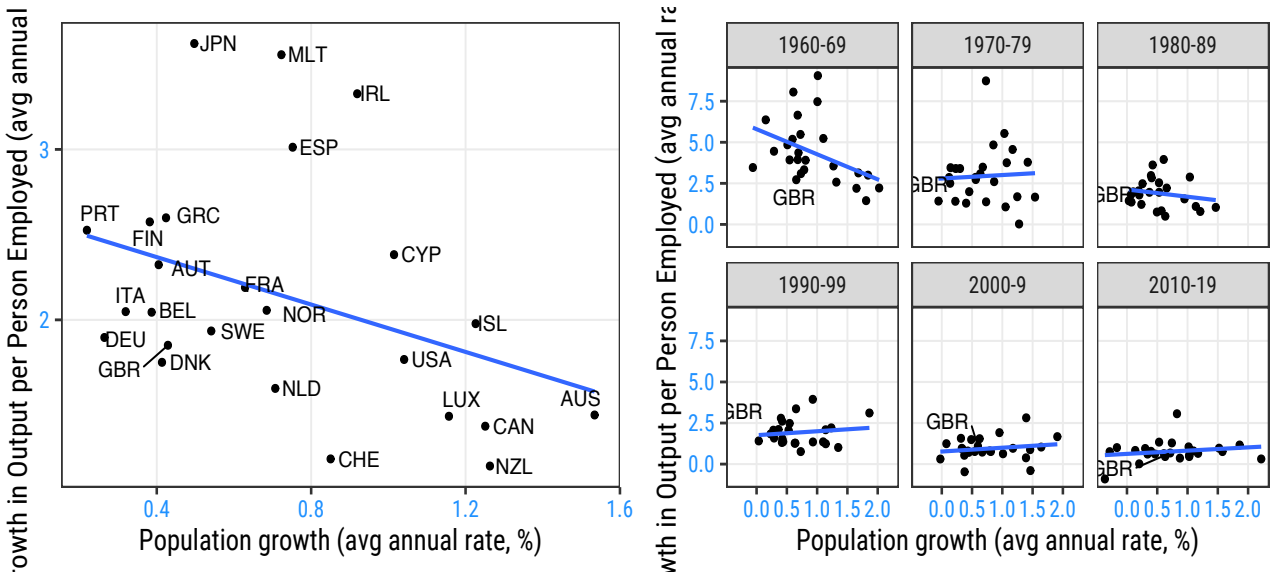
We exploit the cross-country variation in each year by regressing country-level average productivity growth (in a 20-year window up to that year) on its population growth and initial level of productivity, allowing also for convergence.[19]

As in Beaudry and Collard (2002), we show the evolution of the rolling coefficients on population growth and for convergence. This allows us to assess how the cross-country link between productivity growth and population growth varies over time, while controlling for convergence effects.

[19] As an exercise in cross-country data description, this involves estimating:

$$\Delta log(Y_{it}/L_{it}) = \alpha_{0,t} + \alpha_{1,t} log(Y_{i0}/L_{i0}) + \alpha_{2,t} \Delta Pop_{it} + \epsilon_{it}$$

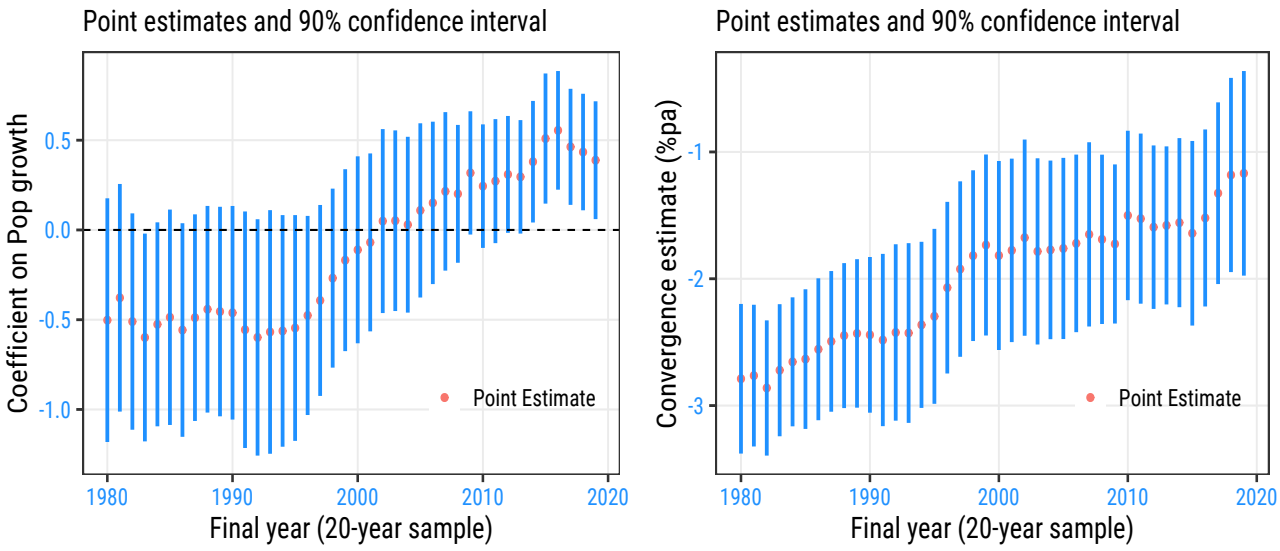
where *'i'* indexes countries i = 1,2..35 and *'t'* indexes years, t = 1980,1981...2019.



(a) Averages 1960-2019

(b) By Decade

Figure 13: Cross-country evidence: Productivity and Population growth



(a) Population growth

(b) Estimated Convergence

Figure 14: Estimated Effects from Population Growth and Speed of Convergence

Our estimates confirm that an inverse cross-country relation between productivity growth existed up to the 1980s and mid-1990s. In that era, higher growth economies tended to have lower average rates of population growth. Yet, this estimated relationship has since changed sign. More recently, in our sample of 25 countries higher productivity growth economies have tended to have higher population growth, also controlling for productivity convergence.

While our estimates also provide evidence of convergence in our sample of advanced economies, the estimated rate of productivity convergence has slowed quite notably since the early-2000s and in the post-crisis period. Compared with an estimated 2.5%pa annual speed of convergence up to the 1980s, this has slowed to a little over 1%pa by 2019.

Beaudry and Collard (2002) argue that productivity growth in the 1970s was slower in economies where labour force growth was high, specifically, after the adoption of a general purpose technology. This owed to reduced capital deepening. They also suggested that this relationship was changing by the end of their sample period which ran to 1997. Our evidence is consistent with, and extends, that view.

This raises the possibility that UK experience, in its era of rising labour supply and productivity slowdown, was not typical of this cross-country pattern.[20]

5 Conclusions

Reduced capital deepening accounts for between one-quarter and one-third of the UK's large productivity shortfall since 2008. That means that around 4 log points of the 25 log point shortfall in labour productivity that has emerged since 2008 is due to capital shallowing. The evidence we have presented suggests that this temporary shift could have been caused by the slow adjustment of the economy to a pronounced increase in labour supply.

Our perspective has been both sectoral and aggregate (including cross-country). The macro perspective suggests that while micro-based evidence of the impact of immigration

[20]The cross-country evidence (based on rolling 20-year samples for each country) is also likely to capture long-run effects which we expect to be more neutral for productivity as capital intensity adjusts.

on local labour markets points to small long-run effects, this may understate macro effects in the medium-run that owe to reduced capital deepening. Our macroeconomic simulation evidence suggests that 6 log points of the productivity shortfall could be attributed to stronger labour supply, and we speculate that this effect could be even stronger in a period of impaired capital markets and weak international demand.

How quickly the capital stock adjusts becomes critical for this macro channel. It is plausible to believe that this pace of adjustment was slowed down since the financial crisis – and the aggregate impact on productivity of stronger labour supply increased – through credit market imperfections and heightened risk aversion.[21]

At the sector level, our analysis suggests that the impact on sector-level productivity is more similar across sectors than the impact on sector output. This is consistent with sector-level data suggesting broad-based reductions in capital-deepening and labour productivity across sectors.

Nonetheless, other shocks have clearly been central to the productivity slowdown accounting quantitatively for most of the shortfall. Some idiosyncratic shocks have applied in the finance and energy sectors. In manufacturing, weak international demand may have also played a role. To some extent these show up in total factor productivity and in relative prices. We leave for future research to address whether some of these factors are reversed or intensified by Covid-19 and the policy responses to it.

[21]Barnett *at al* (2014) and Hsieh and Klenow (2014).

References

Amior, M. and Manning, A., (2021), 'Monopsony and the Wage Effects of Migration', CEP Discussion Paper No. 1690.

Autor, D.H., Dorn, D. and Hanson, G.H., (2016), 'The China Shock: Learning From Labor Market Adjustment to Large Changes in Trade', *Annual Review of Economics*, 8, 205-40.

Barnett, A., Broadbent, B., Chiu, A., Franklin, J. and Miller, H., (2014), 'Impaired Capital Reallocation and Productivity', *National Institute Economic Review*, No. 228, 835-48.

Bean, C. (2016), *Independent Review of UK Economic Statistics*, London, HMSO.

Beaudry, P. and Collard, F. (2002), 'Why Has the Employment-Productivity Trade-off Among Industrialized Countries Been So Strong?', NBER Working Paper 8754.

Benito, A. and Bunn, P. (2011), 'Understanding Labour Force Participation in the United Kingdom', *Bank of England Quarterly Bulletin*, Winter, 36-42.

Benito, A. and Saleheen, J., (2013), 'Labour Supply as a Buffer: Evidence From UK Households', *Economica*, 80, 698-720.

Blundell, R., Pistaferri, L. and Saporta-Eksten, I., (2016), 'Consumption Inequality and Family Labor Supply', *American Economic Review* 106(2), 387–435.

Borjas, G.J., (2019), 'Immigration and Economic Growth', NBER Working Paper 25836.

Cette, G., Fernald, J. and Mojon, B., (2016), 'The Pre-Great Recession Slowdown in Productivity Growth.' *European Economic Review* 88, 3-20.

Crafts, N. and Mills, T.C.,(2020), 'Is the UK Productivity slowdown Unprecedented?', *National Institute Economic Review*, R47-R53.

Dustmann, C., Glitz, A. and Frattini, T.,(2008), 'The Labour Market Impact of Immigration', *Oxford Review of Economic Policy*, 24(3), 477–494.

Furlanetto, F. and Robstad, O., (2019), 'Immigration and the Macroeconomy: Some New Empirical Evidence', *Review of Economic Dynamics*, 34, 1-19.

Goldin, I., Koutroumpis, P., Lafond, F. and Winkler, J. (2021), 'Why Is Productivity Slowing Down?', Oxford Martin School Working Paper 2021-6.

Hsieh, C.T. and Klenow, P.J. (2014), 'Misallocation and Manufacturing TFP in China and India', *Quarterly Journal of Economics*, 124, 1403-48.

Lenoel, C. and Young, G. (2021), 'Modelling the impact of Covid-19 on the UK economy: an application of a disaggregated New-Keynesian model', NIESR Discussion Paper, August 2021.

Muggeo, V.M.R. (2003), 'Estimating Regression Models with Unknown Breakpoints', *Statistics in Medicine* 22, 3055–3071.

Ottaviano, G. I., and Peri, G. (2012), 'Rethinking the Effects of Immigration on Wages', *Journal of the European Economic Association*, 10, 152-197.

Oulton, N., (2020), 'Measuring Productivity: Theory and British Practice', *Centre for Macroeconomics* Discussion Paper 2020-02.

Oulton, N., (2018), 'The UK and Western Productivity Puzzle: Does Arthur Lewis Hold the Key?', *Centre for Macroeconomics* Discussion Paper 1809.

Oulton, N. and Sebastia-Barriel, M.,(2016), 'Effects of Financial Crises on Productivity, Capital and Employment', *The Review of Income and Wealth*, 63, S90-112.

Pessoa, J.P. and Van Reenen, J., (2014), 'The UK Productivity and Jobs Puzzle: Does the Answer Lie in Wage Flexibility?', *Economic Journal*, 124, 433–52.

Pessoa J.P. (2016), 'International Competition and Labor Market Adjustment'. Discussion Paper 1411, CEP, LSE.

Portes, J., (2016), 'Immigration After Brexit', *National Institute Economic Review*, 238, R13-21.

Prescott, E.C., (1998), 'Needed: A Theory of Total Factor Productivity', *International Economic Review*, 39, 525-551.

Riley, R., Rincon-Aznar, A. and Samek, L., (2018), 'Below the Aggregate: A Sectoral Account of the UK Productivity Puzzle', *ESCoE Discussion Paper* 18-06.

Riley, R. Rosazza-Bondibene, C. and Young, G., (2015), 'The UK Productivity Puzzle 2008-13: Evidence From British Businesses', *Bank of England Working Paper* No.531.

Tenreyro, S., (2018), 'The Fall in Productivity Growth: Causes and Implications', speech given at Queen Mary University of London.