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WHAT DRIVES FIRM AND SECTORAL PRODUCTIVITY IN THE UNITED KINGDOM AND IN SELECTED EUROPEAN COUNTRIES?

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Abstract/Résumé

What drives firm and sectoral productivity in the United Kingdom and in selected European countries?

This paper examines the link between barriers to trade and investment and productivity performance, in the United Kingdom and selected European countries using both firm-level and sectoral data. Barriers to trade and investment appear to be a robust determinant of productivity in the long term. Control variables such as spending on R&D and human capital also play a role, though their effects depend on the way they are measured or on the sample. The results are robust across a range of productivity measures as well as to changes in the sectoral coverage and the set of controls.

Keywords: productivity, firm-level, sectoral, barriers to trade and investment.

JEL Classification: C23, D24, F13

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Quels sont les facteurs expliquant la productivité des entreprises et des secteurs de services au Royaume-Uni et dans certains pays européens?

Ce document examine le lien entre les barrières au commerce et à l'investissement et la productivité au Royaume-Uni et dans certains pays européens à l'aide de données sectorielles et d'entreprise. Les entraves au commerce et à l'investissement sont estimées être un facteur déterminant de la productivité à long terme. Des variables de contrôle comme les dépenses en R & D et le capital humain jouent également un rôle, même si leurs effets dépendent de la manière dont ils sont mesurés ou de l'échantillon. Les résultats sont robustes à l'utilisation de différentes mesures de productivité ainsi qu'à des changements dans la couverture sectorielle et dans le choix des variables de contrôle.

Mots Clefs: productivité, données d'entreprises, données sectorielles, barrières au commerce et à l'investissement.

Classification JEL : C23, D24, F13

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What drives firm and sectoral productivity in the United Kingdom and in selected European countries?

By Eun Jung Kim, Annabelle Mourougane and Mark Baker[1]

Introduction

There is a consensus amongst economists that productivity matters for long-run growth. Despite good policy frameworks and a favourable business environment, productivity growth in the United Kingdom has consistently underperformed relative to expectations and relative to developments in many other OECD countries, since at least the financial crisis, leading to the so-called productivity puzzle (OECD, 2020a). The UK level productivity gap vis-à-vis the United States is also large (OECD, 2019). Looking forward, the UK exit from the EU Single Market is expected to raise barriers to trade and investment and could hamper long-term productivity and growth. There is already evidence that the announcement of Brexit has had detrimental effects on productivity (Bloom et al., 2019).

Economic theory points to a positive relationship between trade and productivity, with models focussing on the effect of trade on competition and subsequently on productivity. According to this strand of the economic literature, higher exposure to traded goods increases competition among heterogeneous firms. This leads to a reallocation of resources towards more productive firms, while the least productive companies are forced to exit the market (Melitz, 2003). Increased competition from imported products also encourages firms to upgrade their technology. On the export side, the possibility to expand into larger markets provides incentives to improve the efficiency or quality of production, thereby boosting productivity within firms (ECB, 2017).

This paper investigates the link between barriers to trade and investment and productivity in the United Kingdom and some European countries. Both labour and multi-factor productivity have been used in the analysis and a set of controls has been tested, in particular measures of human capital and R&D spending. One originality of the work is that it relies on a range of data granularity and regional coverage using both firm-level and sectoral data, for the United Kingdom and for a sample of European countries. A wide range of tests helps to assess the robustness of the empirical work.

The main findings are as follows:

- Barriers to trade and investment appear to be a robust determinant of productivity in the long term (Table 1). The magnitude of the impact is estimated to differ across sectors, depending on the degree of openness. The effect is found to be stronger in the service sectors, although the difference with other sectors is quantitatively small.

[1] The authors work at the OECD Economics Department and the Bank of Canada. They are grateful to Christophe André, Sebastian Barnes, Sebastian Benz, Jarmila Botev, Oliver Denk, Balazs Egert, Alexander Jaax and Valentine Millot for useful comments and discussions and to Michelle Ortiz for excellent technical assistance.

Table 1. Long-run determinants of productivity growth

	UK – Firm-level data (ORBIS)		UK – Sectoral level (ONS)		OECD Sectoral level (STAN)
	Labour Productivity	MFP	Labour Productivity	MFP	Labour Productivity
Barriers to trade and investment	-0.766**	-0.557***	-0.137**	-0.165**	-0.146**
R&D spending	0.032***'	0.029***	..	..	0.098**
Human capital	..	..	0.265**	0.298**	0.218**

Note: MFP stands for multi-factor productivity. Estimates at the firm and sectoral levels are not comparable. ** represents significance at the 95th percentile, *** represents significance at the 99th percentile. In almost all cases, the captured effect is indirect (via an interaction term).

- The firm-level and cross-country sectoral estimates appear to be robust to changes in the sectoral coverage or the presence of a time-fixed effect. The results also continue to hold with changes in the set of controls. Spending on R&D plays an important role in explaining productivity developments, although only an indirect effect (via an interaction term) was estimated. The impact of human capital is found to vary, depending on how the variable is measured. This is likely to reflect the shortcomings of the measures, which capture only some of the "quality" dimensions of human capital. The UK sectoral estimates rely on a limited set of observations and appear to be very fragile. Those results should therefore be interpreted with care.

The paper is organised as follows. First, it reviews the recent literature on determinants of productivity in the United Kingdom and in OECD countries, focusing on the link between productivity and the policy levers examined in this paper. Second, the empirical approach is presented, followed by a brief description of the firm and sectoral datasets used. Third, the main estimation results are described and a last section concludes.

Literature review

The drivers of productivity growth across countries and across firms have been a major research topic for some time. Most OECD countries have experienced a fall in productivity growth since the financial crisis, with the fall sometimes pre-dating the crisis. But there is still a wide disparity across countries, sectors and firms. Productivity has been particularly lacklustre in the United Kingdom, despite good policy frameworks and business conditions. Existing analyses have failed to explain this puzzle. This review focuses on the determinants of productivity that are examined in the paper. A more comprehensive discussion of the factors behind the productivity weakness in the United Kingdom can be found in OECD (2020a).

At the international level, measurement errors have been put forward as a possible explanation, but overall their impact remains limited (Byrne, Fernald and Reinsdorf, 2016; Syverson 2017, Ahmad, Ribarsky and Reinsdorf, 2017). In the same vein, reallocation from high to low-productive sectors is also estimated to have played a marginal role (Barnett et al., 2014; Kierzenkowski et al., 2018; Riley, Rincon-Aznar and Samek, 2018; Sorbe et al., 2018). By contrast, poor productivity growth reflects poor within sector productivity performance, stemming from low investment and innovation rates and/or poor reallocation of resources across firms in the same sector (OECD, 2015; OECD, 2020a).

The role that policies can have in either enhancing or hampering productivity growth has been explored in recent years, with a focus at the firm level. Andrews, Criscuolo and Gal (2016) showed how different policy settings could be playing a role in limiting the productivity convergence between leader and laggard firms within a country.

The reduction of tariff and non-tariff trade and FDI barriers are found to have a significant positive impact on productivity growth (Ahn et al., 2019; Melitz, 2003). According to the former paper, a 1 percentage point decline in input tariffs is estimated to increase multi-factor productivity by about 2%. It also found

suggestive evidence of complementarities between trade and FDI liberalisation in boosting productivity. Policy barriers to services trade have been found to have a negative effect on productivity in other downstream sectors of the economy (Beverelli, Fiorini and Hoekman, 2017; Bourlès et al., 2013).

There is a strong consensus in the literature on the positive impact human capital has on different measures of productivity growth. The positive link between human capital and productivity dates back to work by Becker (1964) and is considered to be one of the fundamental drivers of long-run economic growth (Jones, 2016). Empirically the direct contribution of workforce skills is found to be relatively limited, given the difficulty to measure skills and to account for the complementarities between skills and other production factors (Timmer et al., 2010; Kirby and Riley, 2008). Recent research, that uses rates of return to education with increased inter-country variability, shows the strong positive relationship between human capital and productivity growth across OECD countries at the aggregate level (Botev et al., 2019).

Higher spending on R&D also appears to be correlated with better productivity performance. The positive link between R&D investment and productivity growth dates back to Griliches' (1973) pioneering work, with a recent meta-analysis confirming the positive link but also highlighting the heterogeneity of the effects across different firms (Ugur et al., 2018). Overall the microeconometric literature has provided robust evidence of a positive and significant impact of R&D on productivity at the firm-level, with an elasticity ranging from 0.05 to 0.25 (Mohnen and Hall, 2013). Guellec and Van Pottelsberghe de la Potterie (2004) show quite high returns to foreign R&D (with a long-term elasticity of 0.45) and meagre returns to private domestic R&D (0.13) when compared to public R&D (0.29). Their estimates for the elasticity of foreign R&D are somewhat higher than past estimates from Coe and Helpman (1995). Castellani et al. (2019) also found a higher elasticity of foreign R&D. Luca Bruno et al. (2019) suggest that, while R&D and embedded R&D investments in purchased equipment and machinery are key factors explaining productivity gaps in the European Union, there is no complementarity between these two modes of technology acquisition. Finally, different policies and the degree of innovation intensity and openness can amplify the positive impact of increased R&D spending (Égert and Gal, 2017).

Existing analyses usually rely on one category of data, firm, sectoral or macro-level data. While micro-data such as firm-level data may offer better identification for the direct effect of policies, they are not always representative of what is occurring at the economy-wide level and can miss some reallocation and spillover effects. At the same time, macro-analyses may fail to capture aspects that are only visible at the firm level. Looking at different levels of granularity can help to address these concerns and test the robustness of some of the results.

Approach

The approach adopted in this paper is broadly similar across the three levels of granularity (firm-level in the United Kingdom, sectoral level in the United Kingdom and sectoral levels in a sample of 12 European countries). Productivity is expressed as a function of a number of policy and performance variables, including barriers to trade and investment, human capital and R&D spending. Productivity developments is assumed to follow a standard error-correction model.

In the long term, productivity levels depend on the variable of interest and a set of control variables:

$$prod_{l,t} = \beta X_{l,t} + \sum_m \delta^m \, control_{l,t}^m + D_l^{lt} + D_t^{lt} + \epsilon_{l,t} \quad [1a]$$

Some dynamics are added to capture the short-term dynamics, with productivity converging gradually to its long-term equilibrium as defined by equation [1a] to give the relationship that underpins the estimation in this paper:

$$\Delta prod_{l,t} = \delta * \epsilon_{l,t-1} + \alpha \Delta X_{l,t} + \sum_m \theta^m \, \Delta control_{l,t}^m + D_l^{st} + D_t^{st} + \vartheta_{l,t} \quad [1b]$$

Where prod is either multi-factor productivity or labour productivity in logarithms. l is the level of aggregation, firm, sectoral or country and t is the time dimension.

X are barriers to trade and investment.

Control is a set of controls such as human capital or R&D spending, the size of the firms or a measure of the business cycle. m is the number of controls.

D_l, and D_t are firms (resp sectoral/country) and time fixed effects in firms (resp. sectoral) equations.

The factors influencing productivity developments are estimated using the dynamic OLS (DOLS) estimator in two steps. This technique accounts for endogeneity resulting from short-run changes and serial correlation (Stock and Watson, 1993). Leads and lags of 1 year in the variables in the right-hand side are used in the specification.

A first set of regressions uses firm-level ORBIS data for the United Kingdom. The baseline specification includes all firms. The equation includes firm and time fixed effects. The main advantage of the approach is that it relies on a large set of observations and allows for a better identification process (see below). The drawback is that it is difficult to identify the impact of policies that are only available at the national or sectoral levels. The latter will be captured in the fixed effects or will need to be interacted with other firm-specific determinants following Rajan and Zingales (1998). In the latter case, only an indirect effect of the measure can be identified. When interaction terms are introduced the indicator which is used to interact is also introduced separately.

A second set of estimates rely on cross-country sectoral data. It also applies DOLS but along three dimensions: country, sectoral and time dimensions. The analysis is restricted to 12 European countries for which long time series are available. The sectoral coverage is provided in Table 2. Estimates are restricted to sectors where sufficient data were available. Sector and time fixed effects have been introduced in the analysis. As for the firm-data estimation, interaction terms are sometimes introduced for sector-invariant policies.

Table 2. Sectoral breakdown used in the cross-country sectoral estimates

Agriculture, forestry and fishing
Mining and quarrying
Manufacturing
Electricity, gas, steam, and air conditioning supply
Water supply; sewerage, waste management and remediation activities
Construction
Wholesale & retail trade, repair of motor vehicles and motorcycles
Transport & storage
Accommodation & food services
Information & communication
Finance & insurance
Real estate activities
Professional, scientific and technical activities
Administrative and support service activities
Government services

The main advantage of this approach is that relying on a larger set of countries increases substantially the number of observations, raises the variability of the sample and should therefore lead to more robust results than the sectoral analysis focussing on the United Kingdom. The drawback is that resulting elasticities will be cross-country average and not specific to the United Kingdom. In addition, it will not be possible to introduce some country-specific variable (such as the ONS measure of human capital) as those indicators will not be available for the other countries in the sample.

A third set of estimates relies on a panel of 17 UK sectors over the period 1998-2017 from the National Statistical Office, ONS. The panel is unbalanced: sectoral coverage and time sample vary depending on data availability. As the number of observations is limited, this set of regressions is only considered to test the robustness of the results.

Data

Productivity

Firm-level data

Firm-level estimates rely on UK data from ORBIS, covering between 140 000 to 320 000 firms depending on the different specifications. The dataset has been cleaned from outliers. Data cover the period from 2000 to 2016. The coverage of UK firms in the ORBIS data is good and the implicit sectoral structure is in ORBIS relatively close to the one depicted by national accounts (Table 3). Several sets of productivity measures have been computed: labour productivity in real terms, multi-factor productivity, following either the Wooldridge formula (Wooldridge, 2009) or using a simple Cobb-Douglas function. Table 4 provides some basic statistics. Overall there are small differences between the basic statistics of real labour productivity and the Wooldridge measure of multi factor productivity. Differences are much larger between the two measures of multi-factor productivity.

Table 3. Comparison between ORBIS and National Accounts for the United Kingdom

2016, Sectoral breakdown (NACE Rev.2)

	Firm-level			National Accounts
	Number of firms	(Percent)	Share of value added (Percent)	Share of value added (Percent)
Mining and quarrying	251	0.7	4.1	1.1
Manufacturing	6751	17.7	16.7	10.1
Electricity, gas, steam and air conditioning supply	132	0.3	1.7	1.8
Water supply; sewerage, waste management and remediation activities	294	0.8	1.1	1.0
Construction	2096	5.5	3.5	6.0
Wholesale & retail trade; repair of motor vehicles and motorcycles	5232	13.7	9.4	10.5
Transportation & storage	1337	3.5	6.4	4.4
Accommodation & food service	1650	4.3	2.4	3.0
Information & communication	2368	6.2	7.8	6.4
Finance & insurance	2485	6.5	20.7	7.4
Real estate activities	609	1.6	1.0	14.0
Professional, scientific and technical activities	3239	8.5	12.4	7.6
Administrative and support service activities	3399	8.9	7.2	4.8
Public administration and defence; compulsory social security	75	0.2	0.1	4.7
Education	4205	11.0	2.1	6.0
Human health and social work activities	2179	5.7	1.4	7.6
Arts, entertainment and recreation	815	2.1	0.9	1.5
Other service activities	1117	2.9	1.1	2.1
Total of the above	38234	100.0	100.0	100.0

Source: ORBIS (2018) and OECD (2019), OECD National Accounts Statistics (database).

Table 4. Basic statistics on firm-level data, 2000-16

Logarithm, Industry level

	Average	Median	Minimum	Maximum	Standard deviation
Real labour productivity	11.04	11.02	0.76	20.97	0.87
MFP (Wooldridge)	11.29	11.27	0.26	21.06	0.99
MFP (Cobb-Douglas)	6.05	6.20	0.00	18.11	3.20

Note: MFP (Cobb-Douglas) is computed using a standard Cobb-Douglas production function. MFP (Wooldridge) estimates labour and capital elasticities to production using the Instrumental Variables method.
Source: ORBIS (2018).

Cross-country sectoral data

Two measures are considered: labour productivity and hourly labour productivity, with nominal labour productivity being computed as gross value added (in USD, current PPPs) per person employed and for hourly productivity, per hour worked. Underlying data come from Eurostat and OECD STAN databases. Given the lack of reliable sectoral data on capital and labour shares, it was judged preferable not to compute and test measures of multi-factor productivity.

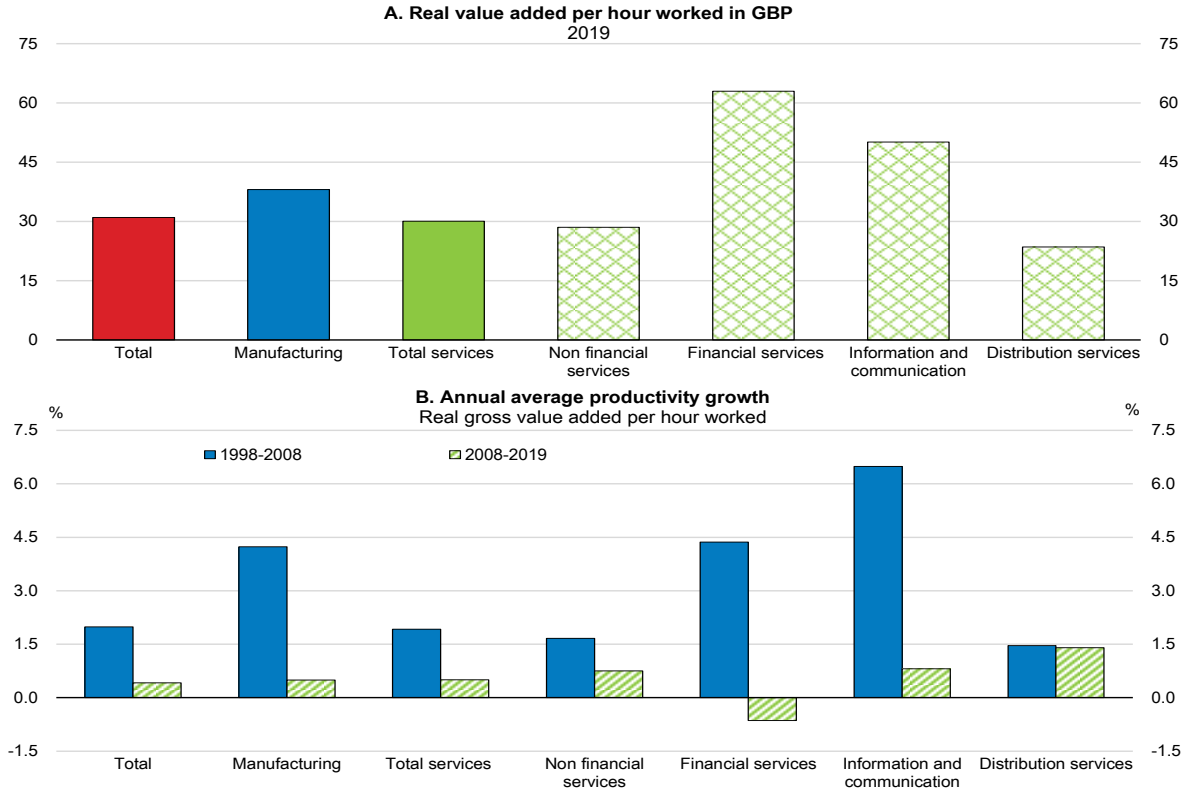
The reliability of those data varies across sectors. While productivity developments are generally well-captured in sectors like manufacturing, measurement issues can arise in service sectors. The measurement of financial services productivity has significantly improved thanks to changes in evaluating and allocating financial services indirectly measured (FISIM). Still, open questions remain such as how to measure prices in financial services (Mersch, 2008; OECD, 2013). Difficulties in measuring productivity in real estate are also well known. The lack of imputed rent data in OECD countries makes it very difficult to correct the data, contrary to what was done for ONS data.

UK sectoral data

Sectoral data on nominal and real labour productivity have been calculated using nominal and real gross value-added and hours worked from ONS. Data are usually available from 1998 to 2017. Real labour productivity is obtained by dividing gross value-added by hours worked. Data on multi-factor productivity have been calculated using a Cobb-Douglas production function approach and ONS data on production, labour and capital stock, and the averages of sectoral labour shares over the period 1998-2017. Imputed rents have been excluded from value added in real estate.

Productivity levels are heterogeneous across sectors in the United Kingdom. Real labour productivity has grown at below pre-crisis trend rates in all the sectors except real estate activities, administrative and supports and other services (Figure 1). Comparable developments can be observed for multi-factor productivity growth.

Figure 1. Recent developments in real labour productivity



Note: Services sector's real value added is computed aggregating individual service sectors. It excludes real value added for imputed rents. The results may be different to official aggregate data due to chain-linking methodology.
Source: OECD calculations based on ONS (2020), "GDP output approach – low-level aggregates", May, and "Productivity jobs, productivity hours, market sector workers, market sector hours", April.

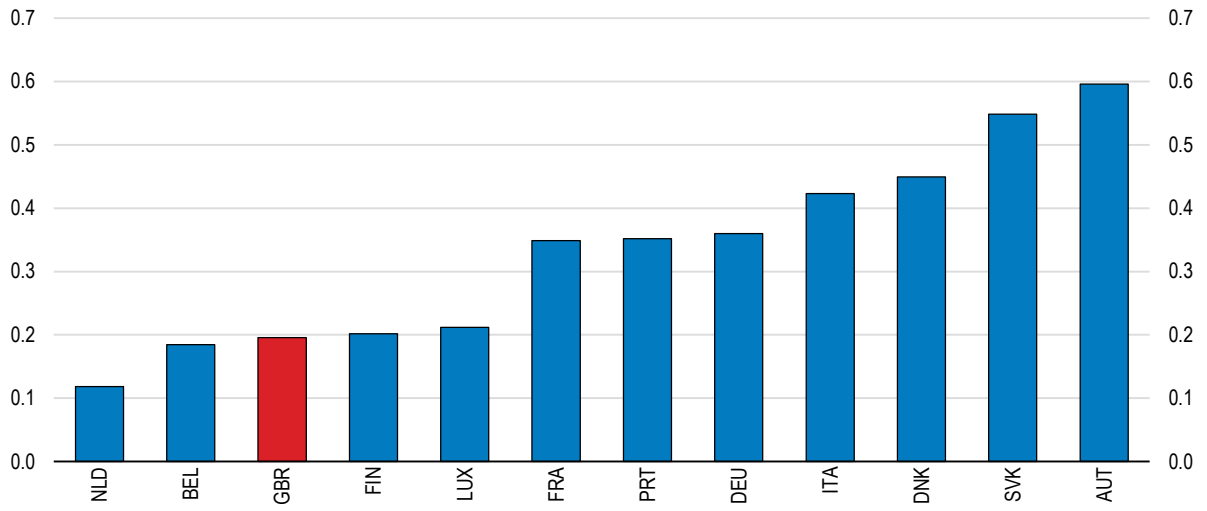
Policy levers and controls

The main policy variable that is tested is the OECD measure of barriers to trade and investment, which is a component of the OECD Product Market Regulation (PMR) indicator. The data are derived from a questionnaire filled in by country experts from national administrations. Sub-indicators are aggregated using equal weights. Those barriers vary widely across countries (Figure 2). They are found to be less stringent in the Netherlands, Belgium and the United Kingdom than in other European countries. Those data are economy-wide measures and have been interpolated in-between dates for which the data is available.

In addition, estimates are also presented using the OECD Service Trade Restrictiveness indicator for the service sectors where it is available, with the PMR barriers to trade and investment being used for the remaining non-service sectors. The OECD STRI provides information on services regulation in 22 sectors across 46 countries between 2014 and 2019 (Figure 3, OECD, 2017; OECD, 2020b). It is based on information on national and EU laws. The methodology follows the principle of the most-favoured nation (MFN), recording applied regimes with respect to countries that do not benefit from preferential treatment. The STRI varies between 0 and 1. For estimation purposes, a rescaled variable has been constructed so that it has a comparable unit to the PMR barriers to trade and investment, and elasticities associated with those variables can be directly comparable.

Figure 2. Barriers to trade and investment

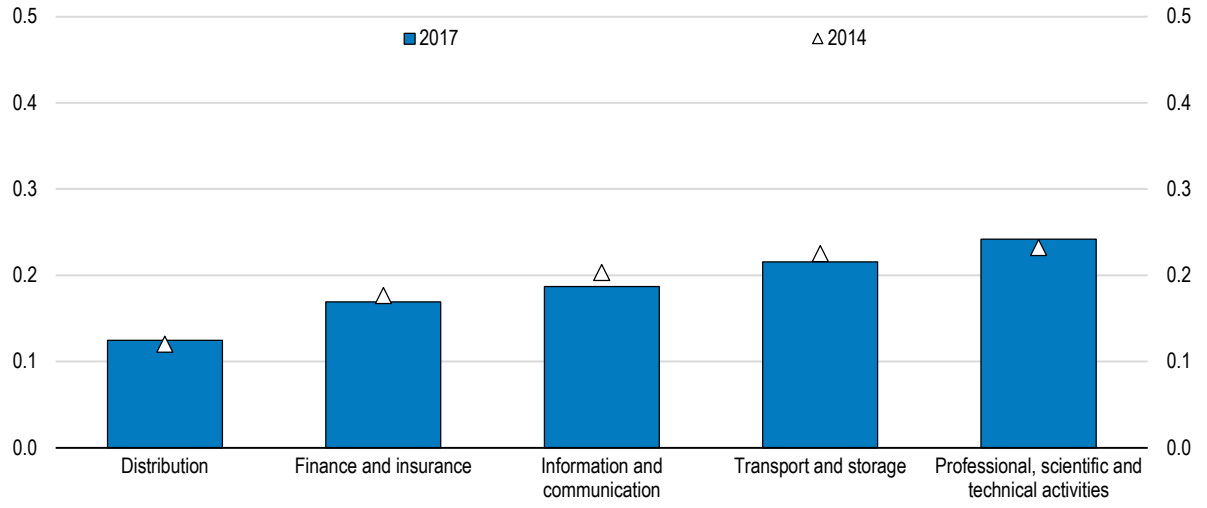
Index scale from 0 (least restrictive) to 6 (most restrictive), 2013



Note: Based on Product Market Regulation (PMR) score.
Source: OECD (2013), OECD Product Market Regulation Database.

Figure 3. Barriers to trade and investment in the service sectors in the United Kingdom

Index scale from 0 (least restrictive) to 1 (most restrictive), 2014 and 2017



Note: Based on Services Trade Restrictiveness Index (STRI). A sectoral value is aggregated by its weighted components using value added shares in the sector.
Source: Authors' calculations based on OECD (2019), "Service Trade Restrictions Index by services sector" in OECD Industry and Services Statistics (database).

Other measures of product-market competition have also been tested, such as the OECD measures of the stringency of regulations in network industries. However those measures appear to be highly correlated

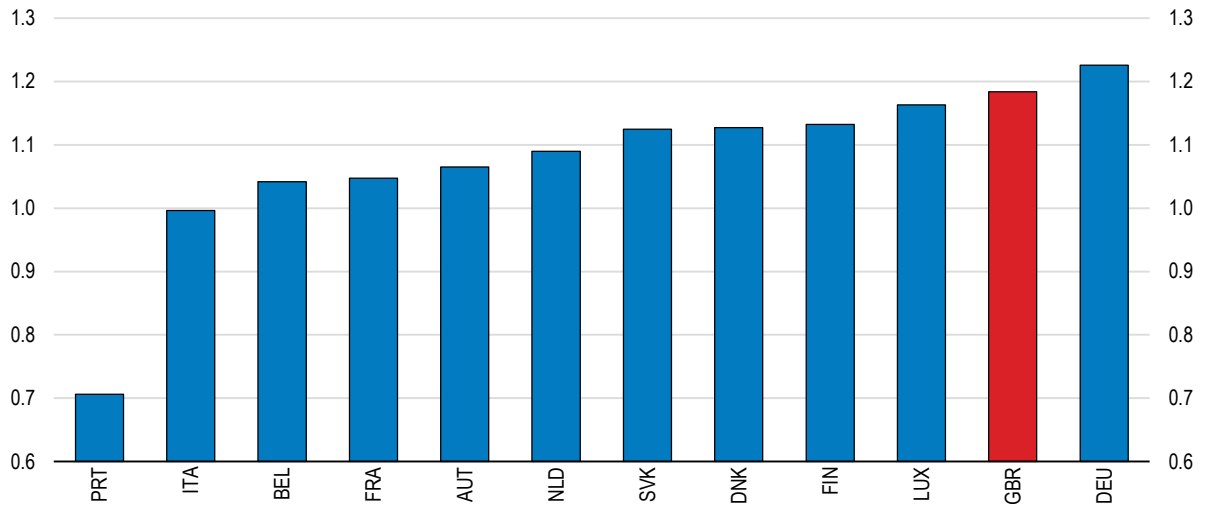
with the measure of barriers to trade and investment, increasing the fragility of estimates when both variables are included at the same time. Results are thus not reported in the paper.

In the firm-level estimates, barriers to trade and investment are interacted with a dummy variable that captures whether or not the firm is exporting. In the UK sectoral estimates, they are interacted with the degree of openness of the sector. When these interaction terms were tested, the export dummy or openness has also been introduced in the equation. Endogeneity is accounted for by using DOLS and by lagging openness and the export dummy by one. Trade data, including both imports and exports have been used to compute sectors' openness. Data are taken from the Bilateral Trade in Goods by Industry and End-use (BTDIxE), ISIC Rev.4 in OECD STAN database and the OECD Balanced International Trade in Services databases (EBOPS 2002, EBOPS 2010).

A number of controls have been introduced in the regressions. The first one is the measure of human capital per worker (in logarithms), developed by the OECD (Botev et al., 2019; Figure 4). The measure is calculated as mean years of schooling adjusted with time-varying three-period returns to education for five groups of countries following Goujon et al. (2016). Returns have been computed using Mincer equations and are on average increasing over time and by level of education. The UK's human capital gap relative to the other European countries in the sample can be explained essentially by differences in mean years of schooling. As the measure of human capital is invariant across sectors, it has been interacted in the sectoral estimates with a measure of the average skills in the sector using the PIAAC indicator developed by the OECD. In addition, the variable is interacted with the sector's share of employment to capture the extent to which the sector is labour intensive. The intuition is that a sector which would predominantly rely on capital would not be affected by the quality of human capital as much as a more labour-intensive labour sector.

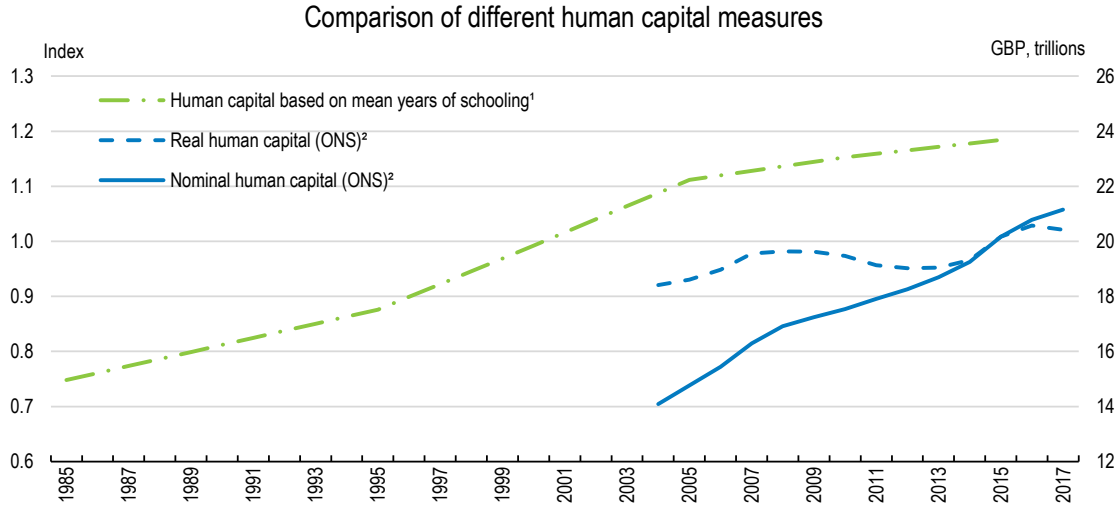
Figure 4. Human capital is on average relatively high in the United Kingdom

Wage premium for the average worker relative to a worker with no education (in natural logarithms), 2015



Note: Based on mean years of schooling adjusted for rate of return to education.
Source: Botev et al. (2019).

Figure 5. Developments in human capital in the United Kingdom



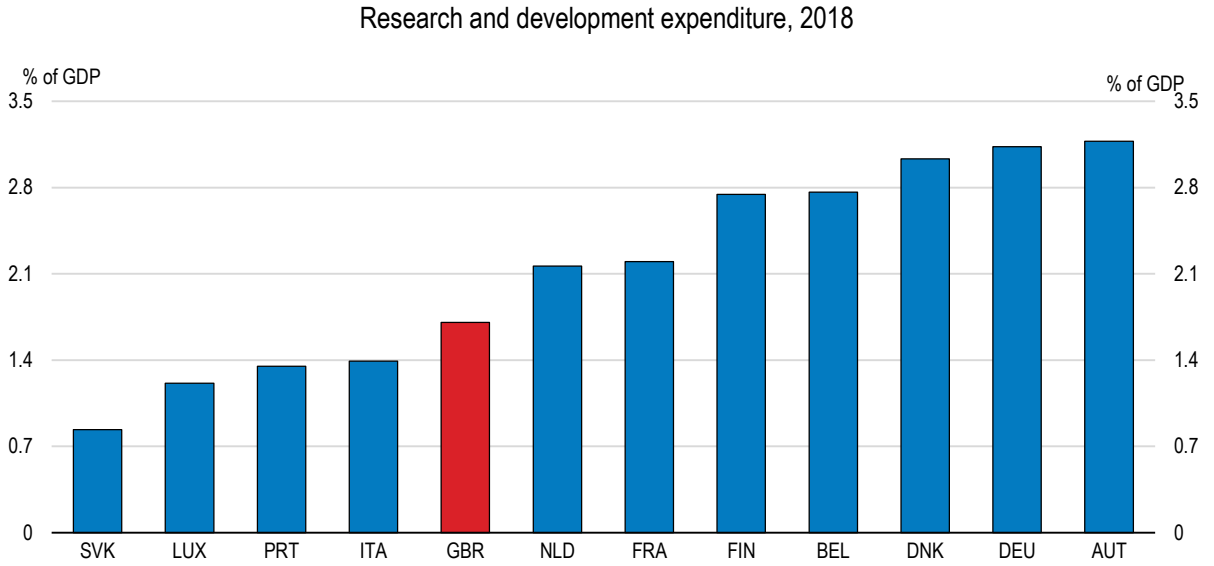
1. Adjusted for the rate of return to schooling. The index indicates wage premium for the average worker relative to a worker with no education (in natural logarithms).
2. Human capital is measured as the total potential future earnings of the working age population aged 16-65 years-old. Imputed potential earnings for unemployed are computed based on earnings incomes of similar employed people in terms of age, sex, and highest qualification. Real data in constant 2015 prices, deflated using the consumer prices index.
Source: ONS (2018), "Human capital estimates, UK: 2004 to 2017", October, and Botev et al. (2019).

In the UK sectoral estimates, an alternative measure of human capital stock developed by the ONS has also been tested. The ONS nominal measure appears to be well correlated with the OECD measure for the United Kingdom, whereas it is very different from the ONS real measure (Figure 5). Estimates are constructed by computing the total potential future earnings of the working age population aged 16-65-years-old based on a number of assumptions such as labour productivity growth (2.5 %) or the age of retirement (at 65 years). In principle, this would cause endogeneity in the regression. However, in practice, as the measure has been constructed under the assumption of a constant labour productivity growth, this is not a major issue in the empirical work. This measure is also time-invariant and has been interacted with skill and employment share, similarly to the OECD measure.

In the case of the United Kingdom, both measures display similar developments (Figure 5), with a gradual increase over time. The OECD measure of human capital in the United Kingdom increased considerably from 1995 to 2015, reflecting a large increase in estimated rates of return. Measured in volumes, human capital is estimated to have been broadly stable over the period 2005-17.

The level of R&D spending was also tested as controlling factors for productivity. Data are from the STAN database in the sectoral analysis and include R&D funded from abroad, but exclude domestic funds for R&D performed outside the domestic economy. In the firm level analysis, R&D spending is captured by a dummy which is equal to one when the firm engages in R&D investment. In the sectoral estimates, R&D data, which are invariant across sectors, have been interacted with the degree of openness of the sector (lagged by one period). The idea is that open sectors are more vulnerable to competition and will rely more on R&D to keep or increase market shares compared to other sectors. There is also evidence that improved access to imported inputs promotes R&D investment (Boler et al., 2015). The variable has also been interacted by the level of skills in each sector to account for the complementarity between R&D spending and skills. R&D spending, as a per cent of GDP, varies widely across European countries (Figure 6).

Figure 6. Spending on research and development varies a lot across countries



Source: OECD (2020), Main Science and Technology Indicators (MSTI database).

In addition to these policy measures, controls take the form of the size of the firms, measured in terms of gross output (lagged by one period to control for endogeneity) in the case of firm-level data. In the sectoral estimations, a variable to measure the cyclical gap, expressed in terms of export or import relative to their trend in each sector, has been introduced to correct for the world business cycle. A similar measure was also tested in the firm-level work in the robustness tests reported in the Annex A.

Results

Barriers to trade and investment are found to be detrimental to productivity performance

In the baseline specification, labour productivity developments are a function of barriers to trade and investment, with controls such as R&D spending, human capital and other firm or sectoral specificities. Table 5 presents results for the three levels of granularity: firm-level data in the United Kingdom, sectoral data in selected European countries and sectoral data in the United Kingdom. A more complete set of estimation outcomes together with a range of robustness tests are presented in Annex A.

Barriers to trade and investment appear to affect negatively and significantly productivity developments. The intuition is that decreasing barriers to trade and investment help to improve the reallocation of resources. This result holds both for firm-level and sectoral data and whether the estimation is performed for the United Kingdom only or on a sample of European countries. This is consistent with Égert and Gal (2017), which is based on aggregate productivity across a wider set of OECD countries. When the analysis is restricted to the United Kingdom, however, only an indirect effect was estimated, as those barrier measures are firm or sectoral invariant. The impact is stronger the more exposed the firm or sector is to international trade.

The difference in magnitude between the firm-level and the sectoral level should not be overstated as it essentially reflects a difference in units in the computation of labour productivity and the difference in the variables used for the interaction. Underlying data and concepts are not strictly comparable across the

different degrees of granularity. In addition, while firm-level data are usually better to identify productivity levers, they do not account for spillovers across firms. This may also explain the difference between sectoral and firm-level estimates.

Table 5. Baseline productivity equations

	Labour productivity		
	Firm-level UK data	Sectoral level UK data	Sectoral data Europe
Long term			
Constant	10.127***	4.624**	4.382**
Barriers to trade and investment	-0.766***	-0.137**	-0.146**
R&D spending	0.032***	-	0.098**
Human capital		0.265**	0.218**
Speed of adjustment	-0.709***	-0.254**	-0.093**
Other controls	yes	yes	yes
Adjusted R-squared	0.309	0.203	0.211
Country/sectors/firms fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	247417	151	1690

Note: * means significant at 10%, ** at 5% and *** at 1%. Coefficients are not comparable across the different types of estimations. Standard errors are clustered by country, sector and years for the cross-country estimates and by sector or firms and years for the UK estimates. Real productivity for firm-level and UK sectoral data, nominal for European sectoral data.
Source: Authors' calculations.

Estimates do not seem to be driven by a specific sector (Annex A). In the same way, the presence of time fixed effects does not alter the results.

Results are also robust to different controls. Human capital is found to be a significant driver of productivity developments, when interacted with the number of jobs or hours and skills in the sectors. However, this effect does not seem to be very robust and depends on the way human capital is measured. While a significant effect is found in the UK sectoral estimates when using the ONS data, there is not such an impact using the OECD measure, based on mean years of schooling. The latter appear however significant in the cross-country sectoral estimates.

R&D spending is estimated to be correlated positively with productivity developments in firm-level and cross-country sectoral analyses, when interacted with the degree of openness. The lack of evidence for the estimates relying on UK sectoral data may reflect the limited number of observations and underline the fragility of those estimates.

Other controls are not reported as they vary depending on the granularity of the estimations and are not always significant. Full estimation results are reported in Annex A. For instance, different measures of the business cycles have been tested in the sectoral estimates. Human capital and R&D spending have also been interacted with a range of alternative measures, including hours or the number of jobs. While this alters the significance of human capital or R&D spending measures, the barriers to trade and investment remain a key determinant of productivity performances in all cases.

Finally those results are generally robust to different measures of productivity. Table 6 presents the baseline specifications for multi-factor productivity and other productivity measures at different degree of data granularity. Barriers to trade and investment continue to be negatively correlated with productivity developments in all the reported regressions. Results regarding human capital and R&D spending continue to be more fragile.

Table 6. Baseline productivity equations – different measures of productivity

	MFP (Cobb Douglas)		MFP (Woolridge)	Hourly productivity	Nominal labour productivity
	Firm-level	Sectoral level – UK data	Firm-level	Sectoral Europe	Sectoral level – UK data
Long term					
Constant	4.301***	4.778**	7.870***	4.399**	4.617**
Barriers to trade and investment	-0.297***	-0.165**	-0.557***	-0.206**	-0.079**
R&D spending	0.002	-	0.029***	0.102**	-
Human capital		0.298**		0.22**	0.071
Speed of adjustment	-0.599***	-0.149**	-0.752***	-0.088**	-0.282**
Other controls	Yes	yes	yes	yes	yes
Adjusted R-squared	0.258	0.234	0.315	0.243	0.127
Country/sectors/firms fixed effects	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	yes
No. of observations	165179	117	230480	1703	151

Note: * means significant at 10%, ** at 5% and *** at 1%. Coefficients are not comparable across the different types of estimations. Standard errors are clustered by country, sector or firms and years.
Source: Authors' calculations.

Table 7. Long-term effect on productivity of an increase in the stringency of barriers to trade using cross-country estimates

0.1 point increase in the stringency of barriers to trade and investment

	Wholesale & retail; trade, motor trade, motor vehicle repair	Transport & storage	Information & communication	Finance & insurance	Professional scientific and technical activities
Baseline	-1.3	-1.5	-0.9	-1.2	-1.5
without financial sector	-1.5	-1.8	-1.0	-1.4	-1.8
without manufacturing	-1.3	-1.6	-0.9	-1.3	-1.6
without real estate	-1.3	-1.5	-0.9	-1.2	-1.5
without public	-1.5	-1.7	-1.0	-1.4	-1.8
without time fixed effect	-1.3	-1.5	-0.9	-1.2	-1.5
Human capital (employment)	-2.4	-2.8	-1.6	-2.2	-2.9
Human capital (wage)	-2.3	-2.8	-1.6	-2.2	-2.8
Gap import	-1.3	-1.5	-0.9	-1.2	-1.5
No gap	-1.3	-1.5	-0.9	-1.2	-1.5
pmr/stri	-1.8	-2.1	-1.2	-1.7	-2.1
pmr/stri intra	-2.0	-2.4	-1.4	-1.9	-2.4
RD spending (employment)	-1.3	-1.6	-0.9	-1.3	-1.6
RD spending (hours)	-1.3	-1.5	-0.9	-1.2	-1.6
Maximum	-2.4	-2.8	-1.6	-2.2	-2.9
Minimum	-1.3	-1.5	-0.9	-1.2	-1.5

Note: the barriers to trade and investment indicator varies between 0 and 1.
Source: Authors' calculations.

Table 7 reports illustrative shocks to barriers to trade and investment to help to gauge the economic significance of those barriers in explaining productivity developments, using the cross-country sectoral

analysis. The impact is found to have sizeable effects on productivity ranging in general between -0.5 and -2 % in the different sectors for a 0.1 point increase in the stringency of the barriers to trade and investment. The difference reflects difference in the impact across sectors. The estimates are probably a lower bound as they do not account for any spillovers across countries or sectors and the coefficients from this exercise are lower than in the other estimates used in this paper, sometimes by a large margin.

Barriers to trade and investment play an important role in the service sectors

This section examines whether the impact of the barriers to trade and investment on productivity is stronger or smaller in the service sectors. For this purpose, the STRI indicator was used in sectors where it exists, and barriers to trade and investment were measured by PMR indicator of barriers to trade and investment in the remaining (mostly manufacturing) sectors.

Barriers to trade and investment continue to dampen productivity developments in all the regressions (Table 8). The magnitude of the coefficient is found to be slightly larger in the service sectors compared to the average of all the sectors in the three types of estimates, but the difference is small and unlikely to be statistically significant.

Table 8. Sensitivity to the measures of barriers to trade

	Labour productivity					
	Firm-level	Firm-level	Sectoral level – UK data	Sectoral level – UK data	Sectoral Europe	Sectoral Europe
Long term						
Constant	10.127***	10.223***	4.624**	4.719**	4.382**	4.26**
Barriers to trade and investment (PMR)	-0.766***		-0.1375**	-	-0.146**	
Barriers to trade and investment (PMR/STRI)		-0.780***	-	-0.150**		-0.204**
R&D spending	0.032***	0.028***	-	-	0.098**	0.089**
Human capital			0.265**	0.274**	0.218**	0.361**
Speed of adjustment	-0.709***	-0.716***	-0.254**	-0.271**	-0.093**	-0.09**
Other controls	yes	yes	yes	yes	yes	yes
Adjusted R-squared	0.309	0.315	0.203	0.231	0.211	0.218
Country/sectors/firms fixed effects	yes	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	yes	yes
Number of observations	247417	143582	151	109	1690	1053

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Conclusion

This paper relies on both firm and sectoral data to examine the extent to which barriers to trade and investment are a key driver of productivity developments, in the United Kingdom and other European countries. The originality of the analysis is to make use of various degrees of granularity in the data: firm-level and sectoral data. Barriers to trade and investment, and to a lesser extent R&D spending and human capital are found to be closely associated with productivity developments. Results appear to be robust to a range of tests and do not depend on the sectoral coverage. They have important policy implications as they identify levers to boost productivity and in turn living standards in the long term. In particular resisting pressure to raise barriers to trade and investment is expected to be associated with stronger productivity.

As common in empirical analyses, results need to be interpreted with care. In particular, some of the productivity data used, for instance those related to financial or real estate sectors, suffer from important measurement limitations. The measure of human capital also imperfectly captures its quality. In addition, the empirical approach sheds light on insightful associations but does not identify causal relationships, which could be investigated using instrumental variables or other quasi-experimental methods. Additional determinants of productivity could also be tested and further work could investigate the existence of non-linearities in the relationship between productivity and policy levers and/or whether the relationship has changed recently, with the rapid digitalisation of the economy. Finally, the work could also account for the existing interactions between sectors and the blurred boundaries between manufacturing and services.

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Annex A. Additional results

This annex presents additional robustness tests.

Sensitivity to sectoral coverage

UK Firm level estimates

Table A.1. Sensitivity to the sectoral compositions and without time fixed effect

	Labour productivity				
	Total economy	Service	Total without finance	Total without public	Total (without time fixed effect)
Long term					
Constant	10.127***	10.002***	10.145***	10.105***	10.056***
Barriers to trade and investment	-0.766***	-0.697***	-0.755***	-0.818***	-1.172***
R&D spending	0.032***	0.022***	0.032***	0.033***	0.051***
Size of the firm	0.059***	0.063***	0.056***	0.063***	0.063***
Speed of adjustment	-0.709***	-0.670***	-0.709***	-0.663***	-0.710***
Adjusted R-squared	0.309	0.365	0.311	0.360	0.286
Firm fixed effects	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	no
No. of observations	247417	166595	235018	232026	247417
No. of sectors	18	13	17	15	18

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Cross-country sectoral level estimates

Table A.2. Sensitivity to the sectoral compositions and time fixed effect

	Labour productivity					
		without financial sector	without manufacturing	without real estate	without public	without time fixed effect
Long term						
Constant	4.382**	4.345**	4.399**	4.382**	4.372**	4.382**
Barriers to trade and investment	-0.146**	-0.171**	-0.153**	-0.146**	-0.168**	-0.146**
Gap export	-1e-06**	-1e-06**	-1e-06**	-1e-06**	-1e-06**	-1e-06**
RD spending	0.098**	0.089**	0.121**	0.098**	0.1**	0.098**
Human capital	0.218**	0.259**	0.216**	0.218**	0.238**	0.218**
Speed of adjustment	-0.093**	-0.092**	-0.094**	-0.093**	-0.093**	-0.093**
Adjusted R-squared	0.211	0.219	0.211	0.211	0.21	0.211
Country and sectoral fixed effects	yes	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	yes	no
No. of observations	1690	1569	1552	1690	1431	1690
No. of countries	12	12	12	12	12	12
No. of sectors	15	14	14	14	14	15

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

UK sectoral level estimates

Table A.3. Sensitivity to the sectoral compositions and without time fixed effect

	Real labour productivity				
		without financial sector	without manufacturing	without real estate	without time fixed effect
Long term					
Constant	4.624**	4.607**	4.721**	4.624**	4.804**
Barriers to trade and investment	-0.137**	-0.137**	-0.234**	-0.137**	-0.082**
Gap export	-0.001	-0.001	-0.0002	-0.001	-0.001
Human capital	0.265**	0.274**	0.234**	0.265**	-2.10E-02
Speed of adjustment	-0.254**	-0.251**	-0.292**	-0.254**	-0.238**
Adjusted R-squared	0.203	0.197	0.314	0.207	0.23
Sectoral fixed effects	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	no
No. of observations	151	140	140	149	151
No. of sectors	17	16	16	16	17

Note: * means significant at 10%, ** at 5% and *** at 1%. There is not enough observations to remove the public sector.
Source: Authors' calculations.

Sensitivity to different controls

UK Firm level estimates

Table A.4. Sensitivity to the measure of the gap

	Labour productivity	
Long term		
Constant	10.127***	10.127***
Barriers to trade and investment	-0.766***	-0.767***
R&D spending	0.032***	0.031***
Size of the firm	0.059***	0.059***
Gap gross output		-1.5E-05
Speed of adjustment	-0.709***	-0.709***
Adjusted R-squared	0.309	0.310
Firm fixed effects	yes	yes
Time fixed effects	yes	yes
No. of observations	247417	247417
No. of sectors	18	18

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Cross-country sectoral level estimates

Table A.5. Sensitivity to the measure of the gap

	Labour productivity		
Long term			
Constant	4.382**	4.382**	4.383**
Barriers to trade and investment	-0.146**	-0.146**	-0.145**
Gap export	-1e-06**		
Gap import		-1e-06**	
RD spending	0.098**	0.098**	0.097**
Human capital	0.218**	0.218**	0.218**
Speed of adjustment	-0.093**	-0.093**	-0.092**
Adjusted R-squared	0.211	0.211	0.21
Sectoral and country fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	1690	1690	1691
No. of countries	12	12	12
No. of sectors	15	15	15

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

UK sectoral level estimates

Table A.6. Sensitivity to the measures of gap

	Real labour productivity		
Long term			
Constant	4.624**	4.724**	4.741**
Barriers to trade and investment	-0.137**	-0.152**	-0.163**
Gap export	-0.001		
Gap import		-0.001	
Human capital	0.265**	0.321**	0.328**
Speed of adjustment	-0.254**	-0.15**	-0.131**
Adjusted R-squared	0.203	0.24	0.23
Sectoral fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	151	117	117
No. of sectors	17	13	13

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Sensitivity to alternative measures of human capital or barriers to trade

Cross-country sectoral level estimates

Table A.7. Sensitivity to the measures of barriers to trade and investment

	Labour productivity		
Long term			
Constant	4.382**	4.26**	4.287**
Barriers to trade and investment (PMR)	-0.146**		
Barriers to trade and investment (PMR/STRI)		-0.204**	
Barriers to trade and investment (intra)			-0.231**
Gap export	-1e-06**	-1e-06**	-1e-06**
RD spending	0.098**	0.089**	0.067
Human capital	0.218**	0.361**	0.345**
Speed of adjustment	-0.093**	-0.09**	-0.096**
Adjusted R-squared	0.211	0.218	0.227
Country and sectoral fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	1690	1053	1075
No. of countries	12	12	12
No. of sectors	15	15	15

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Table A.8. Sensitivity to the measures of human capital

	Labour productivity		
Long term			
Constant	4.382**	4.503**	4.51**
Barriers to trade and investment	-0.146**	-0.272**	-0.27**
Gap export	-1e-06**	-1e-06**	-1e-06**
RD spending	0.098**	0.122**	0.123**
Human capital	0.218**		
Human capital (interact with employment)		-0.408**	
Human capital (interact with wage)			-0.545**
Speed of adjustment	-0.093**	-0.076**	-0.084**
Adjusted R-squared	0.211	0.122	0.119
Country and sectoral fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	1690	1534	1677
No. of countries	12	12	12
No. of sectors	15	15	15

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Table A.9. Sensitivity to the measures of R&D

	Labour productivity		
Long term			
Constant	4.382**	4.372**	4.374**
Barriers to trade and investment	-0.146**	-0.153**	-0.15**
Gap export	-1e-06**	-1e-06**	-1e-06**
RD spending (trade)	0.098**		
RD spending (employment)		-0.171**	
RD spending (hours)			-0.227**
Human capital	0.218**	0.254**	0.253**
Speed of adjustment	-0.093**	-0.094**	-0.098**
Adjusted R-squared	0.211	0.23	0.226
Country and sectoral fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	1690	1540	1683
No. of countries	12	12	12
No. of sectors	15	15	15

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

UK sectoral level estimates

Table A.10. Sensitivity to the measures of different ways of computing barriers to trade

	Real labour productivity		
Long term			
Constant	4.624**	4.719**	4.684**
Barriers to trade and investment (PMR)	-0.137**		
Barriers to trade and investment (PMR/STRI)		-0.15**	
Barriers to trade and investment (PMR/STRI) intra			-0.15**
Gap export	-0.001	-0.002	-0.002
Human capital	0.265**	0.274**	0.274**
Speed of adjustment	-0.254**	-0.271**	-0.271**
Adjusted R-squared	0.203	0.231	0.231
Sectoral fixed effects	yes	yes	yes
Time fixed effects	yes	yes	yes
No. of observations	151	109	109
No. of sectors	17	17	17

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.

Table A.11. Sensitivity to the measures of human capital

	Real labour productivity			
Long term				
Constant	4.624**	4.599**	5.14**	4.577**
Barriers to trade and investment	-0.137**	-0.156**	-0.265**	-0.138**
Gap export	-0.001	-0.001	-0.0002**	-0.001
Human capital (ONS,nominal, job)	0.265**			
Human capital (ONS,real, jobs)		0.31**		
Human capital (OECD,3-year return)			0.405	
Human capital (ONS, real, hours)				0.312**
Speed of adjustment	-0.254**	-0.244**	-0.118**	-0.246**
Adjusted R-squared	0.203	0.217	0.133	0.205
Sectoral fixed effects	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes
No. of observations	151	151	159	151
No. of sectors	17	17	13	17

Note: * means significant at 10%, ** at 5% and *** at 1%.
Source: Authors' calculations.